NBS SPECIAL PUBLICATION 552

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Research and Innovation in the Building Regulatory Process

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The National Bureau of Standards was reorganized, effective April 9, 1978.

RESEARCH AND INNOVATION IN THE BUILDING REGULATORY PROCESS

Proceedings of the Third Annual
NBS/NCSBCS Joint Conference

Held in Annapolis, Maryland on
September 12, 1978, in conjunction
with the Eleventh Annual Meeting of the
National Conference of States on Building
Codes and Standards, Inc. (NCSBCS)

Patrick W. Cooke, Editor

Building Economics and Regulatory
Technology Division
Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

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PREFACE

The papers contained in these proceedings were selected for presentation at the Third Annual NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process. The conference was held on September 12, 1978, in conjunction with the Eleventh Annual Meeting of the National Conference of States on Building Codes and Standards, Inc. (NCSBCS) in Annapolis, Maryland.

This event marked the third time that NCSBCS and NBS have worked together to provide a forum within the building community for the exchange of research findings and to report on innovative practices among regulatory agencies. The first such conference was conducted in 1976 in Providence, Rhode Island, and was reported on in NBS Special Publication 473[1/]. The following year, the research conference was held in Bozeman, Montana. NBS Special Publication 518[2/] contains the papers presented at that session. The success of these first two conferences provided the background for an annual event of this type. This annual conference is intended to inform and assist decision-makers in the regulatory area by reporting on building regulatory developments that advance or retard technological change. This is necessary because regulatory policy is too often made and enforced without the benefit of objective knowledge on the impacts of those policies on the building community and whether those policies are in fact achieving the desired effect.

The Proceedings represent the papers selected for presentation at the various technical sessions and include the opening remarks and Keynote Address. The program for the conduct of the conference corresponds to the Table of Contents of these Proceedings. It is hoped that these Proceedings will serve both to illustrate some of the latest approaches in regulating the construction and occupancy of buildings as well as to stimulate the development of additional new concepts in the future.

[1/] See NBS Special Publication 473, "Research and Innovation in the Building Regulatory Process," available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 003-003-01775-2, Price $6.00.

[2/] See NBS Special Publication 518, "Research and Innovation in the Building Regulatory Process," available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 003-003-01960, Price $6.00.

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The editor wishes to thank all of those staff personnel from the National Bureau of Standards (NBS) and the National Conference of States on Building Codes and Standards, Inc. (NCSBCS) who contributed to the successful conduct of the conference and the publication of these Proceedings. Special appreciation is extended to the following NCSBCS State Delegates and members of the NBS staff who so ably served as moderators for the technical sessions at the conference.

NCSBCS Delegates

Mr. Robert Berntsen (New Mexico)
Mr. Robert C. Hilprecht (Michigan)
Mr. Donald T. MacRae (Indiana)
Mr. James W. Shields (Pennsylvania)

NBS Staff

Mr. James R. Harris
Mr. Charles T. Mahaffey
Mr. James H. Pielert

Special recognition and appreciation are extended to Mrs. Mary Chaney of NBS for successfully coordinating the publication of these Proceedings.

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OTHER RESEARCH PAPERS SELECTED FOR PUBLICATION

SI Conversion Units

The following list of conversion factors for the most frequently used quantities in building design and construction may be used.

QUANTITY	INTERNATIONAL (SI) UNIT	U.S. CUSTOMARY UNIT	APPROXIMATE CONVERSION	
LENGTH	meter (m)	foot (ft)	1 m	= 3.2808 ft
	millimeter (mm)	inch (in)	1 mm	= 0.0394 in
AREA	square meter (m^2)	square yard (yd^2)	1 m^2	= 1.1960 yd^2
		square foot (ft^2)	1 m^2	= 10.764 ft^2
	square millimeter (mm^2)	square inch (in^2)	1 mm^2	= 1.5500 x 10^{-3} in^2
VOLUME	cubic meter (m^3)	cubic yard (yd^3)	1 m^3	= 1.3080 yd^3
		cubic foot (ft^3)	1 m^3	= 35.315 ft^3
	cubic millimeter (mm^3)	cubic inch (in^3)	1 mm^3	= 61.024 x 10^{-6} in^3
CAPACITY	liter (L)	gallon (gal)	1 L	= 0.2642 gal
	milliliter (mL)	fluid ounce (fl oz)	1 mL	= 0.0338 fl oz
VELOCITY, SPEED	meter per second (m/s)	foot per second (ft/s or f.p.s.)	1 m/s	= 3.2808 ft/s
	kilometer per hour (km/h)	mile per hour (mile/h or m.p.h.)	1 km/h	= 0.6214 mile/h
ACCELERATION	meter per second squared (m/s^2)	foot per second squared (ft/s^2)	1 m/s^2	= 3.2808 ft/s^2
MASS	metric ton (t) [1000 kg]	short ton [2000 lb]	1 t	= 1.1023 ton
	kilogram (kg)	pound (lb)	1 kg	= 2.2046 lb
	gram (g)	ounce (oz)	1 g	= 0.0353 oz
DENSITY	metric ton per cubic meter (t/m^3)	ton per cubic yard (ton/yd^3)	1 t/m^3	= 0.8428 ton/yd^3
	kilogram per cubic meter (kg/m^3)	pound per cubic foot (lb/ft^3)	1 kg/m^3	= 0.0624 lb/ft^3
FORCE	kilonewton (kN)	ton-force (tonf)	1 kN	= 0.1124 tonf
		kip [1000 lbf]	1 kN	= 0.2248 kip
	newton (N)	pound-force (lbf)	1 N	= 0.2248 lbf
MOMENT OF FORCE, TORQUE	kilonewton meter (kN•m)	ton-force foot (tonf•ft)	1 kN•m	= 0.3688 tonf•ft
	newton meter (N•m)	pound-force inch (lbf•in)	1 N•m	= 8.8508 lbf•in
PRESSURE, STRESS	megapascal (MPa)	ton-force per square inch ($tonf/in^2$)	1 MPa	= 0.0725 $tonf/in^2$
		ton-force per square foot ($tonf/ft^2$)	1 MPa	= 10.443 $tonf/ft^2$
	kilopascal (kPa)	pound-force per square inch (lbf/in^2)	1 kPa	= 0.1450 lbf/in^2
		pound-force per square foot (lbf/ft^2)	1 kPa	= 20.885 lbf/ft^2
WORK, ENERGY, QUANTITY OF HEAT	megajoule (MJ)	kilowatthour (kWh)	1 MJ	= 0.2778 kWh
	kilojoule (kJ)	British thermal unit (Btu)	1 kJ	= 0.9478 Btu
	joule (J)	foot pound-force (ft•lbf)	1 J	= 0.7376 ft•lbf
POWER, HEAT FLOW RATE	kilowatt (kW)	horsepower (hp)	1 kW	= 1.3410 hp
	watt (W)	British thermal unit per hour (Btu/h)	1 W	= 3.4121 Btu/h
		foot pound-force per second (ft•lbf/s)	1 W	= 0.7376 ft•lbf/s
COEFFICIENT OF HEAT TRANSFER [U-value]	watt per square meter kelvin ($W/m^2•K$) [= ($W/m^2•°C$)]	Btu per square foot hour degree Fahrenheit ($Btu/ft^2•h•°F$)	1 $W/m^2•K$	= 0.1761 $Btu/ft^2•h•°F$
THERMAL CONDUCTIVITY [k-value]	watt per meter kelvin (W/m•K) [= (W/m•°C)]	Btu per square foot degree Fahrenheit ($Btu/ft^2•°F$)	1 W/m•K	= 0.5778 $Btu/ft^2•°F$

NOTES: (1) The above conversion factors are shown to three or four places of decimals.

(2) Unprefixed SI units are underlined. (The kilogram, although prefixed, is an SI base unit.)

REFERENCES: NBS Guidelines for the Use of the Metric System, LC1056, Revised August 1977;
The Metric System of Measurement, Federal Register Notice of October 26, 1977, LC 1078, Revised November 1977;
NBS Special Publication 330, "The International System of Units (SI)," 1977 Edition;
NBS Technical Note 938, "Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction," Revised edition June 1977;
ASTM Standard E621-78, "Standard Practice for the Use of Metric (SI) Units in Building Design and Construction," (based on NBS TN 938), March 1978;
ANSI Z210.1-1976, "American National Standard for Metric Practice;" also issued as ASTM E380-76[ε], or IEEE Std.268-1976.

ABSTRACT

The third NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process was held in Annapolis, Maryland on September 12, 1978. The proceedings of the Joint Conference include the opening remarks, the Keynote Address and the 24 papers presented at the technical sessions dealing with various aspects of building regulatory research and innovative administrative application of building codes and standards. The eight technical sessions were organized around the following themes:

- Regulatory Aspects of Fire Safety
- Standards Development Activities and the Building Regulatory Process
- Accommodating Provisions for the Elderly and Handicapped in Building Regulations
- Implementation of Energy Conservation Building Regulations at the State Level
- Application of Computers and Information Systems for Building Regulation and Construction
- Energy Conservation, Solar Energy and the Built Environment
- Issues Concerning the Intent, Formulation and Economic Impact of Regulations
- Metrication, Industrialized Building and Complex Structures

In addition, three other research papers covering Lighting, Tax Shelters, Resource Zoning, and Land Use Planning are also included.

Key Words: Administrative procedures; buildings; building codes; building regulations; construction; economic impacts; environmental considerations; innovative practices; regulatory research; standards development.

INTRODUCTION TO NBS/NCSBCS JOINT CONFERENCE

by

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It gives me pleasure to welcome you, on behalf of the National Conference of States on Building Codes and Standards and the National Bureau of Standards, to this Annual Conference on Research and Innovation in the Building Regulatory Process. This is the third annual conference. The first was held in Providence, Rhode Island, two years ago, September; the second in Bozeman, Montana, last fall; and this one in Annapolis. Proceedings from each of the first two have been published and have been mailed to attendees and many other interested people. We will also publish the proceedings of this conference, and a copy will be sent to all registered attendees.

The exchange during the conferences and the proceedings have proven to be very valuable to people concerned with building regulations and the regulatory process. Regulators have told us that the information received has helped them do their job better. Industry has said it helps them understand the building regulatory process and work with the people participating in that process. It has encouraged designers, architects and engineers to participate in improving the process at the local level and at the national level. Universities have used the first proceedings as required text for graduate courses and as reference material for professional practice courses. Researchers have found the results stimulating and useful to them in their work. We increasingly see the papers cited by others in the open literature.

I want to express appreciation to those that have made this possible. First of all, to the authors who have prepared some 75 papers. Indeed, there was a great deal of effort that went into each of these, and we all owe them thanks for this effort. Also, we want to express our gratitude to the moderators and others who have actively participated in each of the conferences; to the Codes Administration Committee of the National Conference of States on Building Codes and Standards, who have advised on the development of this conference; and to the staffs of the National Conference of States on Building Codes and Standards and to NBS for their support and assistance in putting it together. Particularly, I want to recognize Pat Cooke, who has led the planning, has carried out the management for each of the three conferences, and has edited the proceedings so ably.

The purpose of this conference remains the same as the first one. The principal purpose is to exchange information, particularly new ideas, research results, and innovations; secondly, to provide a forum where successes can be offered to others, where concepts can be tried and questioned, and hopefully for stimulation of further research.

In these past two years the building regulatory community has made much progress. We can point out many developments to show that there is great progress taking place. The energy conservation standards, for example, now are being applied in almost all States on a uniform technical basis--that basis being ASHRAE 90. There are more uniform statewide regulatory programs, and there are more of these programs based upon model codes. The training and certification programs that are under development by NACA, obviously, are going to be greatly beneficial. The single most impressive achievement, in my view, is the growing awareness and embracement of the concept of consensus. The one and two family dwelling code is now being revised annually under a process which encourages participation by all representative interests. The National Conference of States on Building Codes and Standards, this past year, adopted a firm and well stated policy encouraging the use and development of consensus standards. The Office of Management and Budget of the Federal Government has drafted a circular which encourages the Federal Government to use consensus standards and Federal Government employees to participate in their development The National Institute of Building Sciences has just released a policy statement which states in part: "The Board of Directors of the National Institute of Building Sciences (NIBS) passed a resolution endorsing the use of voluntary consensus standards by all levels of State and Federal Government. Chairman of the Board David Miller said that the use of a single process will eliminate confusion to the benefit of government, industry, and consumers at every level." I think this is extremely important, as it will encourage many more people to actively participate in the development of building regulations and the technical standards upon which they are so heavily dependent.

There are several areas on the near horizon which will affect the regulatory interests and the lives of the American public. I think our keynoter will cover most of them, but let me mention some of the areas: a solar regulatory system, new earthquake provisions, regulatory guides for building rehabilitation, and metrication will offer some new opportunities. NBS has a number of laboratory-based research efforts underway which will lay the foundation for further application of the performance concept both in development of criteria and test methods. These include solar criteria and standards. A recent comprehensive NBS report on plumbing criteria is now available. There is work going on in development of performance standards for foundations and excavation that will provide the technical basis for a new ANSI Standard A56. The NBS is planning for further revision of the Standard A58, "Design Loads for Buildings and Other Structures in the Area of Seismic Design Provisions," and we are gaining in the development of reliable test methods on the performance of materials so that more accurate prediction of the performance of materials over time will be improved. So there is much progress and many opportunities before us.

Dr. James Wright was invited to give the keynote address here today, an invitation that he accepted with enthusiasm. As some of you know, he was involved with the development of the National Conference of States on Building Codes and Standards from the beginning. An active supporter, he told me that up until the last few years he attended every annual conference. Dr. Wright, as a building researcher (first on a laboratory bench basis, then as the Chief of the Building Research Division, then as Director of the Center for Building Technology, and as the Deputy Director of the Institute for Applied Technology, and now Deputy Director of the new NBS Engineering Laboratory), has continually supported the work of this conference. However, as frequently happens to people in high management positions within government, he had his plans preempted and had to attend another meeting. He sends his regrets and wishes the best for this conference and for the annual meeting of the National Conference of States on Building Codes and Standards. He requested Gene Rowland to give his remarks. Gene is certainly not a stranger to most of you. However, there may be some of you that are new to the National Conference of States on Building Codes and Standards and may not know Gene's background. Gene was at the exploratory meeting in Wisconsin when the National Conference of States on Building Codes and Standards was first discussed. At that time, he was working for the State of Wisconsin as a Commissioner of the Wisconsin Department of Labor and Industry. He was elected as the first president of the National Conference of States on Building Codes and Standards. He then left Wisconsin and came to the National Bureau of Standards, where he became the first NCSBCS executive secretary. He has since moved on, and is currently the Director of the Office of Engineering Standards at NBS. Gene is active in many engineering standards organizations and many organizations and committees dealing with metrication. Gene, please take the podium.

KEYNOTE ADDRESS

A PERSPECTIVE ON NBS AND NCSBCS RESEARCH AND ASSISTANCE TO THE BUILDING REGULATORY COMMUNITY

by

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Introduction

It is a pleasure for me to keynote this conference because over the last 10 years the relationship that most people did not expect between NCSBCS and NBS has evolved. Many of you remember Doug Whitlock, one of the leaders in the construction associations, had great reservations about where NCSBCS was going to go in its early days, and its relationship with the Federal Government. I think this concern of his, even though he is deceased some years now, really was not necessary because it was the intention of the National Bureau of Standards in its original conception of working with the States through building regulations and related research to eventually spin-off from NCSBCS in a manner in which NCSBCS could be self-supporting and could really reflect the basic ideas and concepts of the States. There are about four continuous members that are still strong participants in NCSBCS that made sure that this was going to happen. People like Kern Church, Sutton Mullen, Glen Swenson and Del Thurber, were some of the early people who kept fighting to keep that flame going and helped me as Executive Secretary until NCSBCS could become a viable self-supporting entity.

In 1976, the turn in relationships between NCSBCS and NBS really took place, and now there is an Agreement of Understanding between the two organizations for NBS to be responsive and continue the research necessary to fill some of the voids in the regulatory system.

I am really wearing two hats this morning. It is interesting that one cannot really get away from building codes and regulations. After I arrived in Washington, Ed Rovner, the NCSBCS Maryland Delegate, and Secretary of the Department of Economic and Community Development, appointed me as a public member of the Advisory Commission in Maryland, where I still serve in assisting Bill Bryant in his work with the building regulatory area of Maryland, as well as, supporting him in his activities with NCSBCS. So I would like to say as a Marylander, "welcome," and also, as an NBS employee, "welcome."

Going through my old NCSBCS files, I came across a letter that would be of interest to this group: it was dated March 29, 1971. It was addressed to me at the time but it said, "I would like to commend the National Bureau of Standards for the work done in providing a forum whereby the States can come together and discuss codes and the ways of achieving greater cooperation among themselves." He then goes on and explains he has done something in his own State in bringing about uniformity and a minimum State building code in housing, plumbing, electrical, and air-conditioning. Then he concludes, "let me assure you of my deep interest and support of the work being done by the members of the conference and the National Bureau of Standards," signed Jimmy Carter, Governor of Georgia. So, there was an early supporter then, and I think he still is a supporter of the States working in the area of building regulations with the support of the Federal Government. He then filed several later letters that I have in the files reflecting continued support of this group, and now as President of the U.S., I am sure it still stands as far as the Federal Government and its relationship with the States.

The National Bureau of Standards has been in the building research business since its founding. The Act which established the Bureau calls for "determination of properties of building materials and structural elements and encourage their standardization and effective use." It was because of this long involvement in building research that NBS and NCSBCS established and continue to enjoy a close working relationship. That relationship has matured to the point where it would be appropriate to reflect on its past accomplishments and its new roles.

We are very pleased with the significant progress that NCSBCS has made as a recognized institution in our Nation's building community. As a research organization, the Bureau needed an institution such as NCSBCS to convey its research findings into the regulatory environment.

Origins of NCSBCS

NCSBCS had its beginnings in Wisconsin as the result of a meeting at NBS in the spring of 1967. The first annual meeting of NCSBCS was held at NBS on May 6-7, 1968. This meeting was for the purpose of establishing objectives, approving the proposed organizational structure, electing officers and committee members, and outlining NCSBCS' initial programmatic directions.

In 1969 the first organizational constitution and by-laws were approved by 36 States at NCSBCS' second annual meeting, in Hollywood Beach, Florida. The next year all 50 States, the District of Columbia, and two territories through their respective governors' offices endorsed the concept and scope of NCSBCS and named delegates to the body. While depicted as a forum for the discussion and resolution of problems, NCSBCS in the final analysis was designed to counter the proliferation of building code jurisdictions with their varying requirements. These jurisdictions numbered at least 5,000 with a potential of thousands more.

Enhancing the climate for new technology through the building regulatory system has been the intent of the Bureau's service to NCSBCS. This service enables the States to describe more uniformly their regulatory requirements and to more accurately evaluate new construction materials and techniques, paving the way for the natural evolution of a market area sufficiently large and rewarding to stimulate industrial innovation. In turn, the consumer's choice range is widened. It is the consumer who is the ultimate beneficiary of an improved regulatory climate.

LEAP

The Laboratory Evaluation and Accreditation Program had as its backdrop a trend toward greater industrialization through State-level certification of manufactured buildings and toward interstate reciprocity in the certification of buildings and components. Assurance to the building official of the caliber of the laboratories and agencies performing the evaluating and compliance assurance functions for manufactured buildings was subject to some question, however. A way of assessing the capabilities of these organizations on a uniform, interstate basis was needed if evaluations made by one State were to be confidently accepted by another.

NCSBCS, in 1970, asked the Bureau to develop a program to accredit laboratories. The need for such a program was recognized, and NBS initiated LEAP in January 1971, to develop the criteria by which laboratories could be evaluated against ANSI Standard A119.1, "Standard for Mobile Homes."

LEAP produced four research reports which NCSBCS and NBS turned over to ASTM for processing as national consensus standards. Two ASTM committees, E32, "Criteria for Evaluating Agencies Concerned with Systems Analysis, Testing, and/or Compliance Assurance of Manufactured Buildings," and E36, "Criteria for the Evaluation of Testing and/or Inspection Agencies," were established to process the documents. The E32 Committee produced a standard which in time (1975) was to win consensus agreement--ASTM E541, "Criteria for Evaluating Agencies Engaged in Systems Analysis and Compliance Assurance for Manufactured Buildings." The E36 Committee, meanwhile, pressed ahead with the development of generic criteria for the evaluation of testing laboratories.

Using LEAP evaluation criteria and methodology, pilot efforts were undertaken by the State of Massachusetts to demonstrate the benefits of a LEAP approach to building regulation. The results of these demonstrations, along with the on-going deliberations of the ASTM committees, were expected to advance the industrialization of the building process. This project also laid the groundwork for the Department of Commerce's Naval Facilities Engineering Command (NAVLAP) Program. NAVLAP is a voluntary program intended to serve the needs of industry, consumers, government and others by accrediting the Nation's testing laboratories.

CES

The Coordinated Evaluation System (CES) project was directed toward the fostering of regional or national markets for manufactured buildings through consistency of regulatory procedures and documentation.

CES was undertaken in response to two requests, one from NCSBCS and another from the Executive Office of the President. Its purpose was to develop, in conjunction with the States, consistent informational documents as a means of facilitating the acceptance of new technology.

Among the project's products was a four-volume preliminary report entitled, Model Documents for the Evaluation, Approval and Inspection of Manufactured Building and the final report in NBS Building Science Series 87

This and other output from the project were endorsed by NCSBCS and adopted for use by several States and a number of independent laboratories.

Model State Legislation

The National Conference of States on Building Codes and Standards and NBS agreed that model legislation in certain building-related areas was needed. NCSBCS and NBS began the development of the models out of an awareness of the multiplicity of proposals before State legislatures and of the need to upgrade building code programs. Kern Church played a very active role in this area and credit should be given to him for completion of this work.

NBS formed four balanced working groups to develop as many legislative models--a Manufactured Building Act, Mobile Home Act, State Building Code Act, and a Registration of Code Enforcement Officers Act. These groups were comprised of representatives of industry, States, local governments, model codes, the Federal Government and the general public. The models were endorsed by NCSBCS and all but the Registration of Code Enforcement Officers Act were included in the 1974 Suggested State Legislation package of the Council of State Governments, the Council believing that additional research was needed on the subject of registration. Several States have used the mode in developing their own legislation.

NBS' work in support of NCSBCS has drawn it close to--but not into--the arena of building regulation. Building regulation is the function of the States and their political subdivisions.

Mobile Homes

Manufactured housing, including most notably the mobile home, became an NBS research subject of major importance in the 1970's. Millions of Americans were turning to this form of shelter. By 1974 mobile homes were accounting for 40 percent of all new housing in the United States irrespective of cost.

The effectiveness of mobile homes in providing safe, adequate, and low-cost shelter was questioned, however, by consumer groups, members of Congress, and others. In a project sponsored by HUD, building researchers sought to identify the performance problems of mobile homes and to link these with the provisions of the ANSI A119.1 Standard for Mobile Homes. More than 30,000 problems were identified in the 4105 mobile homes evaluated during the study. Most of these units were purchased by HUD for families made homeless by the 1972 Hurricane Agnes disaster.

During this period, as many as seven mobile home research projects were in progress at one time. Many of these projects were in support of HUD's Congressional mandate to produce and implement a Federal mobile home construction standard. This, of course, led to a landmark precedent for State-Federal relations in the building regulatory field when NCSBCS proposed its concept for interstate monitoring teams to evaluate enforcement of the Federal standard for HUD.

Energy Conservation

The criteria for energy conservation in new buildings, developed by the National Bureau of Standards at the request of the National Conference of States on Building Codes and Standards in February 1974, were based on performance requirements for the components of a building and its mechanical and electrical systems, because that approach appeared to be the practical limit in the application of the performance concept at that time. Using the NBS document as a framework, the American Society of Heating, Refrigeration, and Air-Conditioning Engineers subsequently developed ASHRAE Standard 90-75. This document served as an interim standard which could be adopted by the States while the guidelines were further developed into a national consensus standard.

Under DoE sponsorship, NCSBCS contracted with the three model building code organizations - BOCA, ICBO, and SBCC - to develop a Model Energy Conservation Code based on the technical provisions of ASHRAE 90-75. This project was successfully completed with the publication of the "Code for Energy Conservation in New Building Construction" in December 1977. This code has been since adopted by a number of States and other local jurisdictions.

Metric Conversion Activities

In recent years, the United States has taken two significant steps in bringing about the change to the modern metric system -- or SI, the international system of units. The first was the signing of the U.S. Metric Conversion Act of 1975 (Public Law 94-168) in December 1975, and more recently in March 1978, the appointment of the U.S. Metric Board.

In February 1975, the NBS Center for Building Technology was asked to assist and serve as Secretariat to the Construction Codes and Standards Sector of the American National Metric Council (ANMC). This request was initiated by NCSBCS, whose National Chairman at the time represented the States in the ANMC as Chairman of its Construction Codes and Standards Sector.

The significance of metrication, dimensional coordination and the international exchange of technical information was also recognized by NBS. In 1975 steps were taken at the Center for Building Technology to build a metric competence which would assist the construction community during its transition to metric measurement with suitable and correct technical information. During this period seven major publications have be developed and a variety of general and technical papers published along with assistance and technical advisory service to ANMC as requested by NCSBCS.

Joint Research Conferences

NBS/NCSBCS Joint Conferences on Research and Innovation have been held at the Providence, Rhode Island and Bozeman, Montana Annual Meetings of NCSBCS. We feel that these sessions contribute to a better understandin of the problems and issues that prevail in the building regulatory communit This is even more significant since regulation and more specifically regula tory reform are current national issues which attract much attention. Thes types of conferences and the associated publications provide the much neede visibility to this important influence on the evaluation of building practi

Memorandum of Understanding

With the full support of the Bureau, NCSBCS grew in both status and financial resources, achieving a maturity which suggested that the NBS secretariat role need not be extended beyond 1976. A close association with NCSBCS was expected to continue, however, with the Bureau providing such technical responses as are within the scope of the NBS mission. The extent of the relationship was formalized in a Memorandum of Understanding between the two parties in January of this year.

Reogranization of NBS

The first major reorganization of NBS in more than a decade was comple in early 1978. The new structure, however, will not change our relationshi with NCSBCS or the building community in general since the Center for Build Technology was affected very little. The Bureau is now organized along fun tional lines; technical competencies that had grown up over the years in various organizational units have been consolidated; and the number of form organizational units has been reduced.

CBT is now a component of the new National Engineering Laboratory (NEL NEL is made up of seven Centers drawing on most of the units formerly locat in the old Institute for Applied Technology plus some parts of the former Institute for Basic Standards. Within this new structure, NEL will apply technology to the solution of a broad range of national problems.

Ongoing Research Activities

1. The National Earthquake Hazards Reduction Program

The purpose of the National Earthquake Hazards Reduction Program -- in accordance with the Earthquake Hazards Reduction Act of 1977 -- is to reduce the risks of life and property from future earthquakes in the United States.

The Act (Public Law 95-124) directs the President .... to establish and maintain an effective earthquake hazards reduction program." To implement such a program, the President is to develop a plan, which shall "set year-by-year targets through at least 1980, and shall specify the roles for Federal agencies and recommend appropriate roles for State and local units of government, individuals, and private organizations."

To assist State and local governments, industry, and the public in developing construction standards, criteria, and practices, the National Bureau of Standards will work with the Department of Housing and Urban Development, other Federal agencies (particularly those performing research), NCSBCS, NIBS, professional organizations, model code groups, and State and local building departments. The Bureau will assist and cooperate with these groups in continuing the development, evaluation, and improvement of model seismic design provisions suitable for incorporation into local codes and practices. Incorporation of these seismic design provisions into local codes is, of course, voluntary, but the provisions must be flexible and give consideration to costs and benefits, regional variation of seismic hazard, and adaptation to local conditions. They must also be adequately tested. This will be a continuing responsibility of the Bureau.

2. Solar Regulatory Studies

NBS, DoE, and HUD have been exploring the best type of regulatory system to be developed to stimulate the use of solar energy. NCSBCS, along with other NBS contractors, has participated in a six month study of existing solar provisions, issues and concerns in developing a solar regulatory system, research needed, etc. As a result of this study and other efforts oriented toward this solar regulatory need, NCSBCS is expected to play a major role in developing solar provisions and planning for the implementation and training phase of the program.

3. Development of a Building Rehabilitation Standard

Increasing concern is being expressed throughout the United States with regard to the need for more fully utilizing our existing building stock. Presently NBS, NCSBCS, and a number of other organizations are working with the State of Massachusetts to develop interim provisions for alterations and additions to existing buildings which can be incorporated into the State Building Code. That project also aims to develop technical guides for regulatory application of the code provisions and seeks to come up with an improved regulatory management process for existing buildings.

The progress and direction of these efforts to develop building code provisions will be discussed October 30, 1978, at a conference to be held at the National Bureau of Standards.

It is expected that interim building code provisions of the type being explored by these groups will establish a process which the design professional, building owner, and State and local enforcement officials can use in evaluating proposed changes to existing buildings. The interim code provisions could later serve as a pattern for national application.

Future Research

The current state of knowledge for application of the performance concept is not sufficient for complete coverage of all aspects of building construction and regulation. Traditionally, performance levels are implicit in prescriptive specifications which describe acceptable materials and designs. The basis for the stated limits for prescriptive criteria has generally been derived from actual user requirements. There are other areas where little research has been done and the information at hand is so materials-oriented that performance criteria, flexible enough to allow new materials, have not yet been generated. In areas where the state-of-the-art does not allow realistic presentation of performance criteria, reliance is placed on existing standards. These, then, are not considered complete, and as the state-of-the-art of the performance concept advances, modifications or additions to these criteria will need to be made. We solicit the help of NCSBCS and others in identifying the needs to further refine the performance concept.

Conclusion

What does the future hold for us at NBS in working relations to you? I would say since 1976, the Bureau's new partnership and with Jim Gross' direct concern for your needs, we will continually support your identified regulatory research goals. In meetings like this, we hope we can assemble the state-of-the-art information that you can use today, while NBS moves ahead in advancing research to tomorrow's needs. I thank you for the opportunity of being here today. As Jim has said, the new OMB Circular will be a directive to all Federal agencies, DoE, HUD, and the rest of us, to fully participate in the voluntary standards system and where there is due process to get involved and support both administratively and by individual participation. We think NCSBCS has led the field directly toward consensus. I hope Kern Church will have a chance to talk about the new voluntary standards policy which we at the Bureau have been working indirectly with and are endorsing. This is a new way of setting standards policy for the private sector, while a directive of OMB to the Federal Government to participate in the voluntary sector satisfies a need on the other side. We think there is a good partnership now evolving towards meeting our national standards needs.

Thank you.

A DEFENSIBLE TECHNIQUE FOR DETERMINING CODE EQUIVALENCY IN BUILDINGS*

by

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New materials, construction methods, and contents are rapidly changing the nature and magnitude of the fire problem in the United States. These changes often provide a situation that is not covered explicitly in existing codes or that requires amendments to allow their installation. In some cases, these changes in construction or materials provide a safer environment. It is desirable to take advantage of these changes and to encourage similar advances within the framework of the codes. An important step in that direction is the development of rigorous procedures for objectively evaluating the equivalency of such changes to the accepted standards.

A systematic procedure for measuring the hazards of building fires has been developed as part of a project funded by the Department of Housing and Urban Development. This procedure, called the "Building Firesafety Model" incorporates data derived from actual fire tests to describe the rate of fire growth, the likelihood of entrapment, and estimates of structural damage.

It is expected that this tool will assist government officials, architects and engineers in evaluating the design (or rehabilitation) of buildings with regard to the level of firesafety. Such a tool could potentially be used to evaluate the comparative levels of firesafety implied by compliance with codes and to identify voids in fire test data. In addition, the model can be used for evaluating the allocation of fire service resources and pre-fire tactical planning.

Key Words: Building fires; equivalency; evaluation; firesafety; models; research; standards; systematic procedure.

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INTRODUCTION

Building codes are intended to provide a legal basis for ensuring a satisfactory level of safety for the general public. Firesafety requirements constitute a major part of most building codes in effect today throughout the U. S. These requirements are based, in a large part, on the best judgement of many technical experts regarding factors that are intended to reduce injury and to protect property.

Despite the fact that these codes are frequently updated, new materials, construction methods, and interior finishes often provide a situation that is not covered explicitly in such codes. In some cases, these changes in construction or materials provide a safer environment or at least seem to provide the same level of safety at less cost. It is desirable to identify those changes that improve the level of firesafety or reduce the cost of construction.

To enable the introduction of desirable changes within the framework of the existing codes, a practice of establishing code "equivalency" has been used. When faced with situations not explicitly covered in the code, local officials determine whether the proposed situation meets or exceeds the level of safety implied by the code. These officials use their professional judgement both to interpret the implications of the various sections of the code and to establish the relative performance of the new materials or design based upon the best available data.

The practice of code equivalency can lead to numerous problems relating to the efficiency and equity of such procedures. The process of granting variances often lacks uniformity even within the same local area. Further, the sparsity of the data precludes rigorous technical justification. This situation presents a difficult position for the code official who is legally responsible for enforcing the local codes and yet, must be responsible to the needs of the public for housing at a reasonable cost.

This paper describes a systematic procedure for measuring hazards of building fires. This procedure, called the "Building Firesafety Model" describes the rate of fire growth, the likelihood of entrapment, and the extent of structural damage. The modeling approach provides a systematic, flexible mechanism for quantifying firesafety objectives and for comparing the levels of firesafety in alternative building designs. Furthermore, the model incorporates actual fire test data instead of professional judgement as the primary source of input information. In addition, fire incident data can be used for partial validation of the results.

BUILDING FIRESAFETY MODEL

The Building Firesafety Model is a state transition formulation of fire behavior. The model describes the temporal and spatial characteristics of fire development and the associated combustion products. The states of the Building Firesafety Model correspond to critical stages in fire development and are termed fire "realms." Starting with a preburning condition, the realms describe the progressive stages of fire growth within the room of origin and the extension throughout the dwelling. Realms are defined by several measurable criteria such as flame height, heat release rate and upper room air temperature. Information about the severity of the fire, the rate that combustion products are generated, and the opportunities for suppression are considered when defining the realms.

Exhibit 1 represents current definitions for each realm in a single-family residence. Higher order realms are used to represent significant fire growth both in severity and spatially. As indicated by the realm definitions, extension of the fire is often considered at least as important as the fire development within the room of origin. However, the means of reaching a realm is no longer considered once it is reached. Fire development does not necessarily involve passing through all consecutive realms since transitions can represent both fire recession and growth. Furthermore, some rapidly growing fires such as explosions can in effect pass through several realms so quickly that is is inappropriate to isolate these intermediate stages of fire behavior.

Two types of statistical distributions are required to describe the transition of fire from one realm to another as illustrated in Figure 1. A discrete distribution indicates the conditional probability of transition from a particular realm to each of the other realms. A continuous distribution indicates the variation in the time a realm exists. Since the nature of the transition and time in a realm are usually interdependent, the characteristics of the temporal distributions are provided for each possible transition.

The characteristics of these statistical distributions can be based entirely on fire test data. Data from tests involving single items and full scale tests were analyzed to determine the transition descriptors illustrated in Table 1 for a smoldering couch fire in a standard size living room. For example, from Realm 3, there is a 75% chance of growth to Realm 4 and a 25% chance of recession to Realm 2. Also based on these data, normal and uniform distributions were selected to describe the temporal transitions between Realms 3 and 4, and between Realms 3 and 2, respectively. The transition descriptors are based on limited data from a variety of sources (Appendix A). While the process for obtaining the descriptors is well established, the values may change as more data become available.

Step functions are used to model the combined hazards due to the accumulation of one or more of the combustion products. The hazards created by the accumulation of the combustion products are described as causing either slight, moderate or extreme stress. The formation of stress levels reflects the uncertainty regarding the effects of the combustion products and the importance of perceived as well as actual hazards. A step function describing the time for the progression from one level to the next higher stress level depends on the type of material burning during each realm. Separate functions are used to describe the stress variation in different locations and the effect of features that influence the spread of the combustion products. Figure 2 illustrates a few step functions for two rooms in a typical single-family dwelling. This figure indicates that the combustion products will represent an extreme stress in the bedroom after 60 minutes even though the fire has not grown beyond Realm 2.

EXHIBIT 1

Realm Definitions for Single-Family Dwellings*

REALM 1: Preburning. Situations prior to ignition and following termination of a fire are represented by this realm.

REALM 2: Sustained burning. The fuel exhibits self-sustained burning which includes smoldering.

REALM 3: Vigorous burning. The heat release rate exceeds 2kW. It is expected that the flame height may be approximately 25cm and that the upper room air temperature has increased by 15°C above ambient temperature.

REALM 4: Interactive burning. The upper room air temperature exceeds 150°C. It is expected that the flame height may be approximately 120cm, and that the heat release rate may exceed 50kW.

REALM 5: Remote burning. The upper room air temperature exceeds 500°C. It is expected that the external heat flux returning to the fuel surface exceeds $5kW/m^2$. This realm also includes secondary ignitions beyond the room of fire origin with the change in upper room air temperature in this area less than 15°C.

REALM 6: Room involvement. There is flame involvement beyond the room of fire origin with the change in upper room air temperature in this area greater than 15°C.

REALM 7: Dwelling involvement. There is involvement beyond the room of origin with the upper room air temperature exceeding 150°C.

*These definitions are the result of discussions involving Geoffrey Berlin, Dave Russell and Robert Thompson of NFPA, John deRis of Factory Mutual, and Rexford Wilson of Firepro.

Table 1

TRANSITION DESCRIPTORS*

Fire Type: Smoldering Couch Fire with Cotton Cushions

Dwelling: Single-Family

Room of Origin: Living Room

Realm Transitions FROM	TO	Transition Probabilities	Temporal Distributions Type	Parameter values(min.)	
2	1	.33	Uniform	α =2	β=5
2	3	.67	Beta	μ =1.95	σ=.71
2	6	-			
3	2	.25	Uniform	α =1	β=2
3	4	.75	Normal	μ =7.58	σ=3.32
3	6	-			
4	3	.25	Uniform	α =1.5	β=9
4	5	.75	Beta	μ =204	σ=1.65
5	4	.08	Uniform	α =0.6	β=6.0
4	6	.76	Log-normal	μ=5.18	σ=4.18
5	7	.16	Log-normal	μ=1.48	σ=2.94
6	7	1.00	Log-normal	μ=1.48	σ=2.94

KEY

μ = mean
σ = standard deviation
α = lower bound
β = upper bound

*See Appendix A for references.

Figure 1

Realm Transition Descriptors

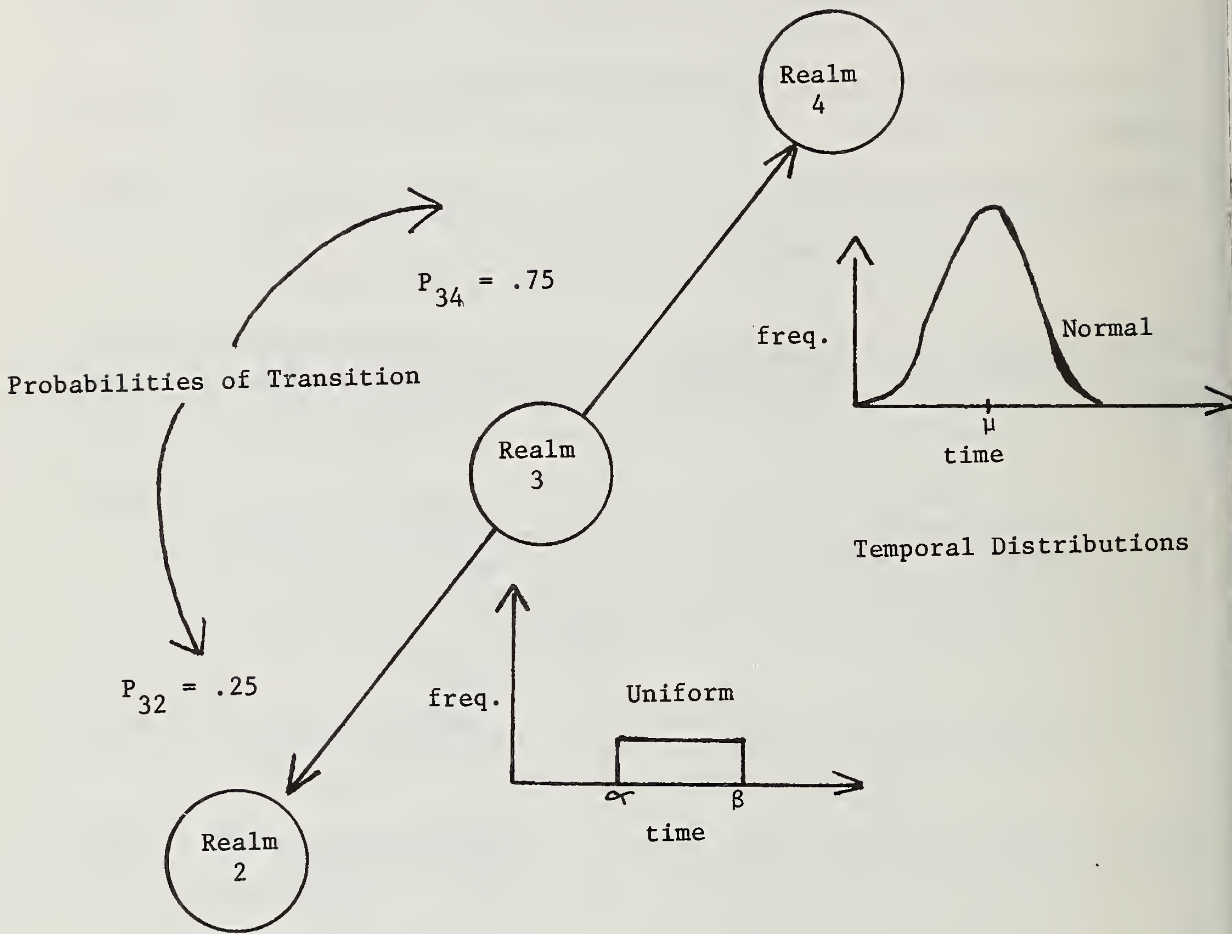
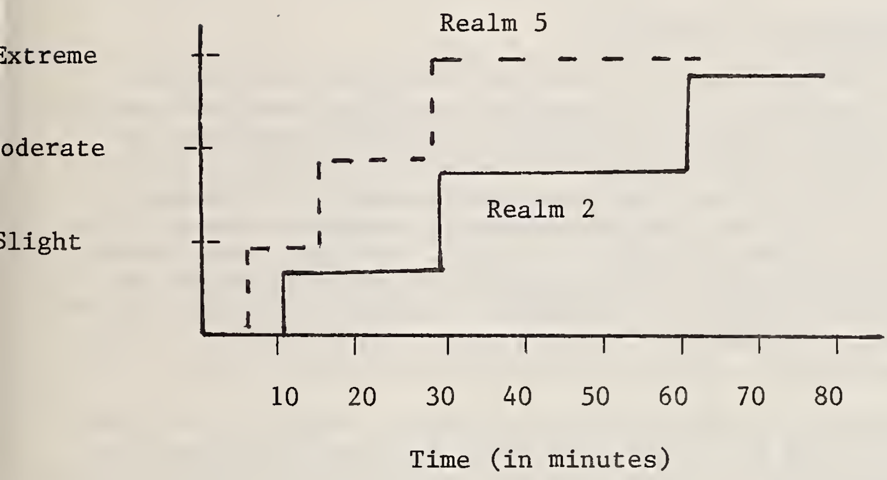


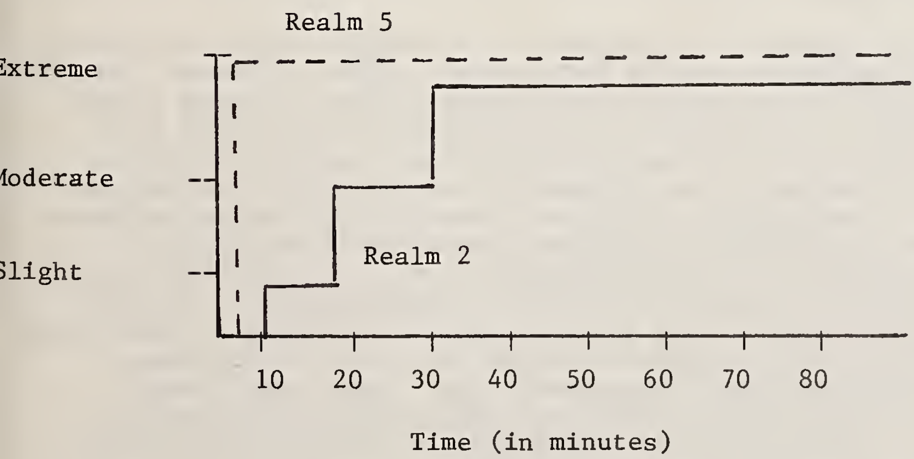
Figure 2

Stress Level Step Functions

- Single-Family Dwelling
- Fire Originating in Living Room
- Smoldering Couch Fire



Step Functions for A Bedroom



Step Functions for Living Room

A measure of escape potential is used to describe one effect of the combustion products (Berlin, 1978). For this project, escape potential is defined in terms of the routes available from any room to a location of safety. A tunnel, another fire compartment, or the outdoors can serve as a location of safety depending on the type of dwelling and mobility of the occupants. This technique is used to describe the susceptibility of routes to blockage by fire. Once the stress reaches or exceeds some predetermined level, all escape routes through or from this location are eliminated. This level may be based on information describing when the level of combustion products represents an untenable condition or when the occupants may perceive a room to be impassable.

MEASURABLE DESCRIPTORS OF FIRESAFETY

The model provides a tool for assessing the expected risks associated with building fires. Exhibit 2 identifies five possible measures for describing various aspects of firesafety. While this list is not exhaustive, it does indicate a format for presenting firesafety performance criteria. Four of these measures describe aspects of escape potential and the fifth describes the extent of structural damage. The measures that are included on future lists will identify those aspects of escape and property damage that are considered to be important in assessing the absolute level of firesafety. While these measures are the technical metrics of firesafety, the particular values for I, P, T, etc. in such measures indicate the politically accepted level of risk.

Three single-family dwellings were analyzed to obtain an indication of the values for each of the five firesafety measures with respect to a smoldering couch fire in the living room. These designs which meet the Minimum Property Standards for residential occupancies are presented in Figure 3. While the plans are in the same price range ($18,000-$26,000) and contain the same number of rooms and area, there are major differences in the room layout which effect smoke movement and the potential for escape in case of a living room fire.

Layout 1 is designed with bedrooms off a long hall which is the only area directly contiguous with the living room. Layout 2, however, has no separation between the living room and the dining area, creating a large contiguous area. The placement of the bedrooms is such that the two of them are as far from the living room as possible. Another difference between the two designs is the existence of an exit through the bathroom in Layout 2. A design which allows more protection of sleeping occupants is a two-story or split level arrangement where the living areas are located on the upper level and the sleeping areas are below. This design, while not generally practiced, provides the maximum separation when the stress level of an area is used as an indicator of entrapment. This occurs because the toxic products produced tend to be hotter than the ambient temperature in the house and consequently rise. Also, even in small structures, the stack effect causes the general flow to be toward the second story. The addition of a second stairway from the upper portion of the house can make this design much safer. A possible floor plan for such a structure is shown in Layout 3, Figure 4.

EXHIBIT 2

Initial List of Firesafety Objectives

1. The time in the initial stage of fire growth shall be greater than I.

2. The probability of growth beyond Realm 3 shall be less than P.

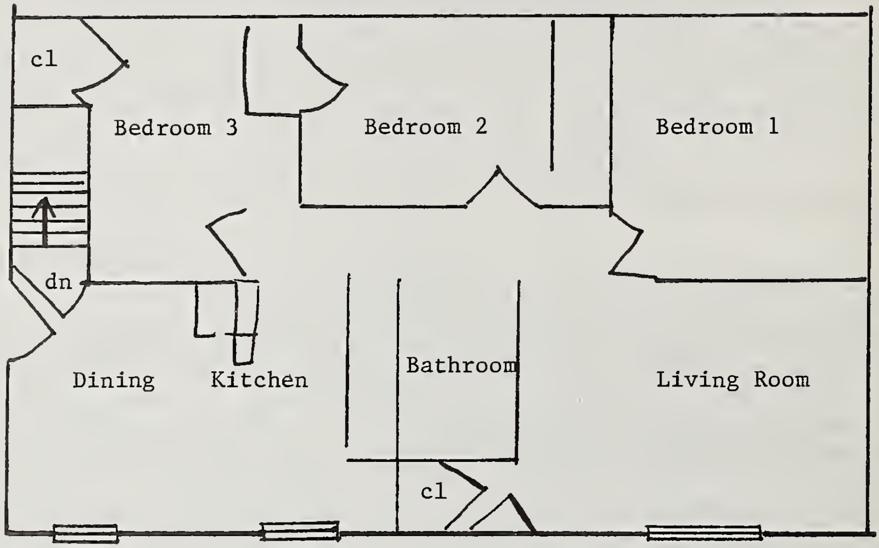
3. It shall take longer than T minutes before entrapment occurs in any room other than the room of fire origin.

4. Fires shall not exceed more than 30% of the time an occupant's suppression capability within S minutes.

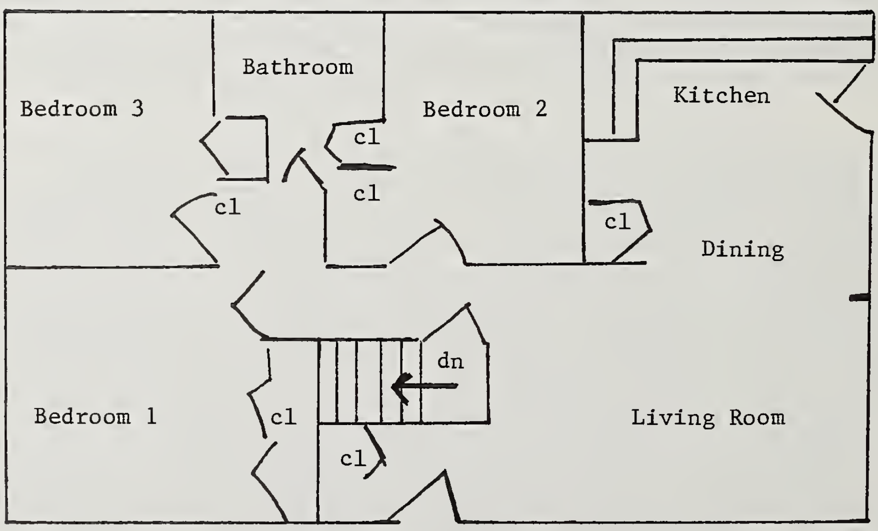
5. The extent of structural damage shall be less than X percent of its dwelling value.

Figure 3

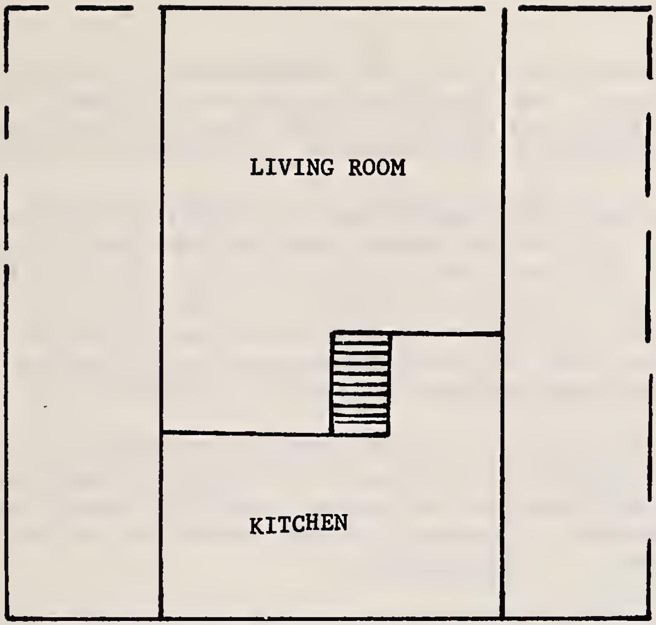
Alternative Single-Family Floor Plans



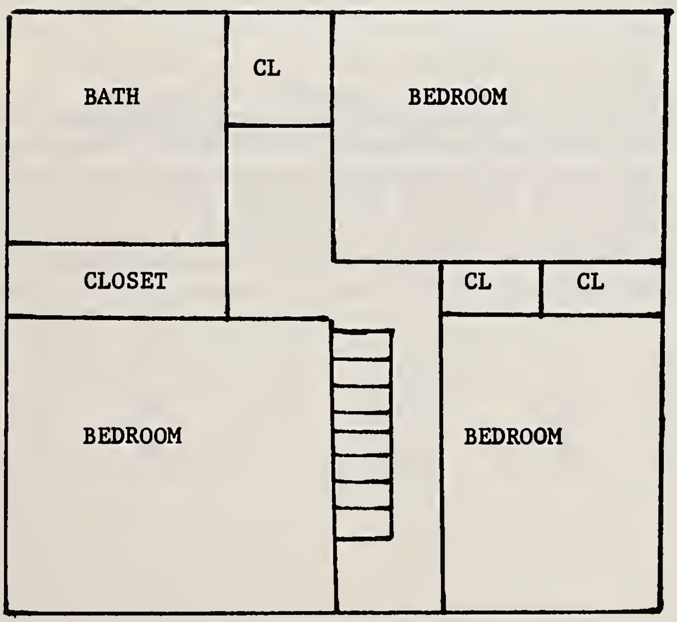
LAYOUT 1



LAYOUT 2



SECOND FLOOR



FIRST FLOOR

Figure 4

Alternate Design - 3 Bedroom Cape

Exhibit 3 presents the results of 500 simulated fires in each of these three dwellings. The transition descriptors in Table 1 were used for all three dwellings and only the stress level step functions and floor plans were changed.

If these dwellings were constructed in accordance with the code, then the values of the five firesafety measures indicate the firesafety levels embodied in the code. The possible form of the firesafety performance criteria given in Exhibit 3 is used to illustrate how the levels of firesafety embodied in the existing code might be determined. It may be necessary to analyze many dwellings before expected values and accepted ranges can be established for each measure.

The smoldering couch fire in the living room represents a single fire situation. The overall assessment of firesafety should be based on a number of fire situations reflecting other fire types, weather conditions, and perhaps, the expected effectiveness of available suppression systems.

Once specific firesafety objectives have been established for each fire situation and dwelling type, these objectives can be used to ensure at least a minimal level of firesafety, while at the same time, allow the architect and builder considerable freedom in how the performance requirements are achieved. However, the type of prescriptive guidelines that are now used in the codes can remain available to those who do not wish to exercise this freedom.

SUMMARY

This application of the Building Firesafety Model shows how the model can be used to develop performance measures of firesafety and to describe the variation in firesafety for different room configurations. While the input values are based on very sparse data, the application illustrates an approach to objectively describing firesafety. To increase confidence in the results, a refined model of smoke movement in single-family dwellings and additional full-scale testing are required.

EXHIBIT 3

Comparison of Alternative Single-Family Building Designs for the Protection of Sleeping Occupants

Fire Type: Smoldering Couch Fire   Room of Origin: Living Room

Measure	Description
A	- Percentage of total fire duration that at least one directed escape route is available from the bedrooms.
B	- Time when entrapment in any bedroom occurs with a probability of (0.33).
C	- Average time before fires grow beyond an occupant's suppression capability. (Time to reach Realm 4.)
D	- Percentage of fires that have not grown beyond an occupant's suppression capability in ten minutes. (Growth beyond Realm 3.)
E	- Estimated structural fire damage.

Design Description	A	B	C	D	E	Total Values
Ranch Layout 1	76.2%	32 min.	12.4 min.	77%	$11,642	$20,000
Ranch Layout 2	77.2	34	12.8	8C	11,985	20,000
Cape Layout 3	78.2	35	12.4	80	16,516	27,500

Appendix A

TRANSITION DESCRIPTORS

The transition descriptors are based on a subjective evaluation of fire test data from numerous sources and of actual response observation.

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THE LIABILITY OF MUNICIPALITIES AND MUNICIPAL OFFICIALS FOR NEGLIGENCE IN THE REGULATION OF BUILDINGS

by

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Building and fire codes and inspections have spawned lawsuits charging both cities and individuals with negligence. This paper explores the development of municipal liability, the elements of a negligence action, and specific defenses and immunities which are available to a city and individual. Special attention will be given to high risk activities of municipalities.

Key Words: Duty; liability; municipal corporations, negligence; sovereign immunity; tort.

In recent years, there has been a tremendous expansion in the number of legal actions filed against municipal officers and municipalities, which attempt to hold officers and cities liable for their acts and omissions which result in death of injury to others. This paper will explore the theories on which these actions are based, and the probable course of future decisions in this field.

It must be emphasized that, under the American legal system, it is possible for different areas of the country to have widely varying laws and judicial decisions, particularly on a topic such as municipal liability. This forces general comments rather than specific advice. However, the trend of municipal liability tends to move in the same direction all over the country; it simply moves faster in some areas than in others.

Any analysis of the liability of municipalities must start with the theory of sovereign immunity. This doctrine derives from the concept that the King of England could not be sued in the English courts as a matter of law. The basis for this decision is that the Sovereign may not be brought before the courts he created without his express consent. The original colonies imported this doctrine from England. Under the federal system in the United States, each of the states is a sovereign and has all the attributes of sovereignty except those which it has given up to the Federal Government, such as the power to print money. This sovereign power means that no state may be sued in its own court without its consent. When the Federal Government was established, jurisdiction over cases between states and citizens of another state was given to the Federal Courts in the U. S. Constitution. Controversy over allowing a state to be sued without its consent led to the 11th Amendment to the Constitution, withdrawing such jurisdiction.

Municipal corporations are creatures of state power. As such, there is a split among the states in how they are treated. In some states, they were considered arms of the state government and are covered by sovereign immunity. In other states, they are considered independent entities who are liable to be sued just as any other corporation. In early cases, the courts were unwilling to expose the municipalities to liability so they developed a rule known as "Governmental Immunity". This rule dates from the case of "Russel vs Men of Devon" in England in 1788. There, the court held that public policy required that the assets of the municipality be held for the municipal purpose and were not available to a private party to satisfy a judgment.[1] This rule gained wide acceptance in the United States. However, since this was a "judge made" rule, it is possible for courts to alter it if the situation changes. In fact, as cities began providing more and more services to the citizens, the courts saw a need to change the doctrine, introducing expanded liability in certain areas. The first such change is the distinction between "governmental" and "proprietary" activities of the municipality. Since a municipal corporation both functioned as an arm of the state government and carried on activities for the benefit of its inhabitants which were similar to private enterprise, it was thought unreasonable to cover profit-making activities with the umbrella of immunity, since, like any other profitable operation, the prices could be raised to cover any losses. Courts began dividing activities into the proprietary and governmental categories. Some of the classifications were reasonable; a police force was governmental, a warehouse was proprietary. Some activities often defied rational classification. Highway mainentance, for example, was considered proprietary and fire fighting governmental. Garbage collection has been classified both ways. This sort of division, while "logical" often led to absurd conclusions. A pedestrian, injured by a drunken city bus driver, could recover damages, while one injured by a drunken fire truck driver could not. (2)

An ultimate absurdity occurred in a case where a telephone repairman was electrocuted while climbing a city power pole. The pole carried two sets of inadequately insulated wires, DC street lighting current, a governmental function and AC house current, a proprietary function. The court determined that he had been electrocuted by the AC current, and therefore, the city was liable. (3)

In response, the courts focused on the actual negligent act itself, rather than the function that the individual was performing. These courts reasoned that the concept of immunity is designed to protect the essential operation of government, rather than its finances. These courts adopted, for the "governmental" functions, a devision between those acts which required the individual to do a specific task without exercising individual judgment--referred to as "ministerial acts", and those which required the individual to exercise the independent judgment which is the heart of governmental action--referred to as "discretionary acts". These courts have held the city subject to suit for ministerial acts but not for discretionary acts. The most common area for litigation is the difference between policy decisions (discretionary) and operative activities (ministerial). For example, if the city decides that all fire marshalls must pass the police academy before being issued a weapon, that would be a discretionary act. Checking that a particular fire marshal has passed the police academy would be a ministerial act. Therefore, a subordinate official would violate a ministerial duty if he gave out a weapon to an officer who had not passed the policy academy. There seems to be a steady trend toward classifying more and more acts as ministerial rather than discretionary though this trend seems most pronounced in those areas in which the individual officer is being sued instead of the minicipality.

The decision to prosecute the violator of a building code is a discretionary act. However, the classification of the building inspection itself depends on whether the inspector has been delegated the authority to permit exceptions or simply enforce it as written.

Once it has been determined that the city can be sued, the plaintiff must prove that the city is liable to him, in order to collect damages. Cities may be sued for a variety of reasons, e.g., contract disputes, violation of federal law or common law torts. A tort is a civil wrong in which a person violates a legally protected right of another. Torts are broadly classified into intentional and negligent torts. Most actions against cities are brought as negligence actions. A negligence action has the following characteristics:

1. An identifiable defendant commits an act or omission,
2. which violates a standard of care,
3. and "causes" injury,
4. to someone to whom the defendant owes a duty.

The first characteristic defines who can be sued. For our purpose, the alternatives are a) an individual, b) the city, as the employer of the individual, c) the city in its own right, and d) all of the above.

The second element, standard of care, determines whether what the defendant did was "negligent". In most negligence actions, the standard of care is that which a reasonable man would do under the circumstances. When the defendant is an expert or holds an expert position, he may be required to act as a reasonable expert would act. For example, would a reasonable fire inspector actually open all exit doors to make sure they are clear? If a reasonable fire inspector would, then a failure to do so violates the standard of care.

The third element, "causation", defines the train of events which lead from the negligence (i.e., the violation of the standard of care) to the injury. Defining or proving causation is often very difficult. For example, does the failure to inspect a fire trap "cause" the death of those who die in a subsequent fire? What if you inspect, but do not notice the fire trap, or notice and fail to follow up?

The fourth element is that the injury must be to one to whom the defendant owes a duty to act in a non-negligent manner. This concept of "duty" is at the heart of all negligence actions. Duty may be found in a statute, public policy or simple past custom. For example, normally a building owner owes no duty to the fire department personnel who respond to a fire, if the fire involves only the normal hazards of fire fighting. In the Moch Case, the private water company which had contracted to supply fire-fighting water to a city was held to be under no duty to an individual property owner to provide water, even though the water company's failure to use reasonable care led to a loss of water and distruction of the property. The water company's duty was solely to the city.(4)

Many courts now determine the liability of a municipality by examining whether the city owes the plaintiff a "special duty" to use reasonable care beyond that owed to the public in general.(5) Note the shift: sovereign immunity concentrates on the status of the defendant, while governmental proprietary and ministerial discretionary tests concentrate on the act which caused injury. A special duty analysis concentrates on the plaintiff. Usually a "special duty" analysis is only used when the act is governmental in nature, since the city is usually liable for any proprietary negligence. The general rule is that a duty owed to all the public in general creates no special duty to any particular person which will support an action in negligence. In most cities, this means that the duty to enforce the law, which is owed to all the public, will not support an action for negligent performance. In other words, a duty to all is a duty to none.(6) If there is no duty, there can be no recovery for negligence. However, many courts have found instances where, under certain circumstances, a special duty has been owed to an individual or class and have imposed liability for negligent performance of offical duties.(7)

Cities are permitted to use the defenses which are open to any defendant charged with negligence. The most important of such defenses are: 1) contributory negligence, 2) comparative negligence, and 3) assumption of risk.

Contributory negligence doctrine prevents any plaintiff from recovering if his own negligence leads to the injury. This normally prevents a building owner or operator from recovering against a city for a loss due to failure to properly enforce the code on his own building, since it was negligent for the owner not to bring the building up to code standards, even without compulsion by the city. Contributory negligence barred the plaintiff's lawsuit, even if his negligence was trivial, compared to the defendant's. The idea was that a court should not aid a negligent plaintiff. Application of this doctrine left plaintiffs without any remedy even if their negligence was trivial compared to the defendant.

For this reason, many states have switched to a comparative negligence standard which compares the negligence of the plaintiff to that of the defendant and reduces any judgment against the defendant by the percent of negligence attributed to the plaintiff. Assumption of risk barred a plaintiff's recovery, even if he was not negligent, if he knowingly, willfully encountered the know risk and was injured. A baseball fan is not negligent when he sits behind the first base foul line, but he has assumed the risk of being hit by a foul ball. In short, contributory negligence compares the action of the plaintiff to a reasonable man, while assumption of risk involves his actual knowledge of potential injury.

To this date, immunity from liability for negligence is the rule, rather than the exception for municipalities and municipal officers. Most often this immunity is grounded on either sovereign immunity or the absence of any special duty toward the injured plaintiff. However, the trend of decisions is towards liability. This is evidenced by the willingness of courts to find that public policy no longer supports the concept that it is better for the individual, rather than the city to suffer the consequences of negligence. The courts also tend to find that the state has waived sovereign immunity for its cities by permitting or requiring them to buy liability insurance. Some states and the Federal Government have accepted liability for employees' negligance. The federal act, however, makes the government liable only if its employees would be liable under local law. Therefore, the citizens' right to sue the U. S. Government varies state by state. (8)

This waiver of sovereign immunity has concentrated attention on the question of duty vs. special duty. Some courts have held that the governmental-proprietary and ministerial-discretionary tests are of no importance where the government has waived immunity, and they decide the question solely on a special duty analysis. With this general trend in mind, we can pinpoint specific areas which seem to be leading edges of the liability tide in the inspection area. Several particular areas deserve close scrutiny.

The first is where the governmental unit actually owns the property on which the injury occurs. Many municipalities are less than enthusiastic about the fire official who tells them that their own property is in a dangerous condition. Note that is is not just a question of meeting the code. Failure to meet the code is prima facie evidence of negligence, but meeting the code is not a defense to a lawsuit. At one time, the municipality would only be liable in its profit-making occupations, e.g., a civic center, but the modern trend is to hold them liable for all their property. The analysis is either that the municipality owes the usual special duty that any building owner owes to those who come on the property to transact business, or the building and use of structures is a typical proprietary act which renders the government liable.(9)

The second area for significant liability exposure is where an identifiable individual solicited the expert assistance of the municipal officer, and reasonably relied on the officer's judgment, in the context of his official duties, and was injured. A leading case in this area is the Smullen Case.(10) In that case, an official inspector negligently surveyed an excavation and told a workman that it was safe to enter. The workman entered, in the presence of the official, and was killed when the trench collapsed. The city was held liable, since it had voluntarily encouraged an individual to more from a place of safety to a place of peril. Building and fire officials who survey property after a fire must be sure that they have done a thorough and proper inspection before allowing anyone back into a structure, and on no account should they ever declare a structure "safe". The fire marshall or building officer is normally bound only to enforce the code, not to go beyond it. If he steps beyond the code, he may be inducing reliance on his expertise in fire safety.

Usually the plaintiff must prove that he individually relied on the government official and that that reliance was reasonable and caused injury. Reasonable reliance is often found when the government has taken over an activity and, for all practical purposes, interacts directly and continuously with the potential plaintiff. The classic examples are federal air traffic controllers. The Federal Government has been found repeatedly liable since the individual has no choice except to rely on the air traffic controllers' ability. On the other hand, as in the death of baseball player, Roberto Clemente, on a mercy mission to earthquake victims, the government was not held liable for the failure to inspect the plane, a duty require by FAA regulations. The basis for the decision was that the duty of the FAA inspector is to his superior and not to the general public.(11) A regulatory program which involves ongoing interaction and necessary reliance by the public would be likely to provide a basis for a case if the city was negligent.

One state, Alaska, has held the state liable for a negligent fire inspection on the theory that a preliminary inspection disclosed the hazard and the state therefore, assumed a duty to third parties to properly perform the statutory obligation to order the defect corrected.(12) I feel that this case is badly reasoned, wrongly decided and will not be followed by most jurisdictions. For a contrary view, a widely reported case in which the Village of Liberty, N.Y. was held liable by the lower court, was reversed on appeal, on the duty, special duty analysis. The court held that no duty was owed to the injured party.(13)

The third special case is where the individual may be held liable even though the municipality is immune. This is a very difficult area and has produced some surprising results. It was held in the 19th Century that the sovereign immunity of the state does not automatically apply to the individuals who carry out the state's orders and policies. Nor can a municipality immunize its employees from suit. Therefore, one of the earliest methods for using an immune sovereign was to sue the individual who had committed the negligent act. The employee then pressured the city to defend him and pay any judgment. Most courts used the ministerial/discretionary test to determine which individuals could be sued, since in theory at least, it aided rather then hindered the city by making ministerial employees more conscious of their duty to the citizens. The problem, as in a direct suit, is defining the ministerial duty, and deciding whether the duty was owed to the plaintiff.

Another rationale for suing the individual is that he has gone beyond the scope of his official duty and somehow injured the plaintiff. Since many municipal employees are thus potentially liable, they have successfully pressed for indemnification by the state if they are held liable. This has a "Catch 22" effect since the plaintiff is much more likely to sue if the resources of the state are the target rather than those of the individual.

There is an additional area of liability which I feel deserves close scrutiny by municipalities. Many local fire codes provide for a right of entry without a search warrant, contrary to the Federal Constitution as interpreted in the Camara (14) and See (15) cases and repeatedly affirmed.(16) It is not uncommon for local officials to insist on entry, using the local law as justification. They should be warned that a Federal Statute (42 USC 1983) makes the individual civilly liable for depriving an individual of a federal right under color of state law. The state law, rather than immunizing the officer, is the source of his liability.

Just this spring, the Supreme Court reversed a prior case and held that the city may also be sued for violating an individual's rights, if it does so by official policy, particularly in areas where the court has clearly defined the right.(17).

For example, it was held a violation of individual rights for the fire marshall to re-enter private property without a warrant after the fire department has extinguished the actual fire. Even though the officer had probable cause to search, the court insisted that he get a warrant even though there was no one on the property to object to his entrance.(18)

Other federal statutes provide civil remedies for racial discrimination by officials. A particular potential liability is where the fire department is lax in pursuing code violators in apartments occupied by minority tenants. A consistent pattern of inadequate inspection and enforcement in minority housing areas might lead to a prolonged and expensive court case. In fact, the earliest Supreme Court case on discriminatory prosecution involved a racially discriminatory enforcement of a city fire code.(19)

In the final analysis, the expansion of municipal liability is simply an outgrowth of a judicial trend that covers other fields, such as medical malpractice and product liability. In all these fields, injuries to innocent parties used to be thought of as the individual's misfortune. Increasingly, the society expects each activity of the society to bear the burden of the injuries it inflicts on individuals. Workman's Compensation and no fault insurance are products of the same philosophy and I feel that eventually there will be uniform statutory compensation for the victims of municipal negligence. Until that day we will continue with the current patchwork of liabilty and immunity.

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BUILDINGS ENGINEER EMERGENCY RESPONSE TEAM

by

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Code enforcement embraces the cycle of Construction-Crisis-Reconstruction.

Baltimore County has added a code enforcement team to its emergency forces. This allows both staff assistance to other county emergency forces as well as immediate participation in the reconstruction phase.

Key Words: Crisis; flood recovery effort; missing link; rebuilding.

A fire is raging at an apartment complex at 3:00 A. M.. The Building Inspector at the scene appears to be a firefighter as he continually surveys the structure. The inspector is examining fire walls, draft stops and protected corridors. Following his examination, the Building Inspector informs the Fire Chief of what can be anticipated in terms of the structure's ability to withstand the progression of the fire.

A Building Inspector working at a fire scene may be an uncommon occurrence, except in Baltimore County, Maryland. The knowledge the inpector had of the building while it was under construction is beneficial to the firefighting effort. The knowledge he will gain from the building's performance during the crisis will be advantageous to the eventual rebuilding of the fire damaged structure.

The charge of the Building Inspector in Baltimore County is to protect the public safety, health and welfare in relation to buildings and structures. Recognizing that the public's safety is the common goal for the Fire and Building Departments, B.E.E.R.T.--the Buildings Engineer Emergency Response Team was organized in January, 1977.

The original organization for the B.E.E.R.T. program was based on a plan submitted to County Executive Theodore G. Venetoulis by Baltimore County Fire Chief, Paul Reincke and the Director of the Department of Permits and Licenses, John D. Seyffert. The County Executive acknowledged that this team, perhaps the first of its kind, presented a service to the County without the burden of additional costs.

The B.E.E.R.T. team members, recruited from the ranks of the Building Inspection Division, perform their normal duties during working hours, but are prepared to handle emergencies 24 hours a day.

The Baltimore County Fire Academy Instructing in the Use of Self Contained Breathing Apparatus.

While members of the team have basic skills in building inspection and have proven track records in the Inspection Division, special B.E.E.-R.T. training was necessary. The training was provided by the Fire Department, Police Department and the Permits and Licenses Staff. Subjects included flooding and flood dynamics, civil defense and structural analysis subject to stress loading. The team was also field trained in the use of Fire Department apparatus, and during a controlled exercise, they were subjected to heat and smoke they would encounter during major conflagrations. Training, key to an operation such as B.E.E.R.T., remains an ongoing process with up-dated subjects being added monthly.

The team is equipped with mobile radio communications linking them directly to the County Office Building and the Fire Department. Each member is also assigned necessary firefighting turn-out gear, foul weather equipment and emergency type protection devices.

The team objective is to ensure safety to life and property during emergency situations incidental to buildings and structures; further, to be responsible for the disposition of all buildings and structures affected by any disaster.

B.E.E.R.T. Members are Differentiated from Firefighters by Distinctive Headgear and the Abbreviation of Buildings Engineer (Bldg. Eng.) on Turnout Coat.

Although the B.E.E.R.T. team is not limited to specific problem areas, the plan directs its efforts to fire, wind and water damage, building collapse and ground failure. While the majority of emergencies the B.E.E.R.T. team is called out on are fire or building collapse, a preparedness program for flood disaster has been established.

The team has analyzed each of the major flood plains in the County. Narratives on each flood plain have been written with probable areas that flood waters would inundate. A program has been initiated that would allow the team to inspect all flooded areas as soon as the damaging waters recede.

All building and structural units located in the flood area would be inspected and tagged by B.E.E.R.T. members. Houses would be marked with colored stickers indicating the unit to be "Safe", "In Need of Repair", or "Danger--Do Not Enter".

Inspected Structures are Tagged with Color Coded Placards.

In September of this year, the team was invited to Johnstown, Pennsylvania, to assist in their flood recovery effort. Inspectors relied upon construction judgement rather than absolute code criteria when examining structures. The inspectors' decisions on the buildings included primarily whether or not the structure was damaged beyond repair, or what repairs were necessary for restoration.

Since its inception, the team has been called out approximately 80 times. The initial callout is to a B.E.E.R.T. Inspector who is on duty 24 hours a day. A back-up inspector is also on call in the event of an emergency that would not allow the on-duty inspector to respond. If a problem develops beyond a specific stage, the Buildings Engineer and the Director of Permits and Licenses, both of whom are on the team, are called to assist the duty inspector.

Although the team has responded to emergencies where the inspector was not an integral part of the resolution of the problem, many times the B.E.E.R.T. Inspector has provided imperative assistance. A major restaurant facility at the County-City line was suffering severe structural damage during a fire. When questioned by the Fire Chief about whether the firefighters should stay inside the building or battle the blaze outside, the B.E.E.R.T. Inspector determined that the fire wall would hold and recommended the firemen remain inside. As a result, the fire was successfully extinquished with minimum additional damage and no personal injury.

Discussing Attack Plan.

Another recent example of the assistance a B.E.E.R.T. Inspector can provide came when a truck drove through a support column of a loading dock at a major shopping center. The inspector was able to advise the Fire Department of what steps were necessary for the safest possible extraction of the truck from the structure.

One of the unanticipated benefits of this program has been the opportunity for the Building Inspector to be involved with the reconstruction process as a result of his participation at the time of the crisis. When a structural bay collapsed in a warehouse building located near the Baltimore Beltway, the B.E.E.R.T. Inspector responded at six o'clock in the evening. At nine o'clock the next morning, the B.E.E.R.T. Inspector and the Buildings Engineer were meeting with the building owner to discuss alternative courses of action to resolve the problem.

At four o'clock that afternoon, at the Buildings Engineer's request, the owner's designated structural engineer was meeting with the Buildings Engineer who recommended steps to preserve the structural integrity of the building. Jerome Schuman, P.E., the structural engineer involved, indicated that by knowing exactly what the County's code required for the safety of the building, he was able to offer the owner appropriate counsel. This communication enabled the engineer to design a plan that met with the County's code and allowed the owner to begin the required operations immediately.

The B.E.E.R.T. team has been in existence approximately one year. The program has provided the missing link in the cycle of construction, building crisis and reconstruction. Statistically, a percentage of buildings will be subject to some type of failure. However, if a failure occurs due to design overload or human error, the B.E.E.R.T. team is a facility of Baltimore County prepared to help minimize the subsequent danger to individuals and the community.

Inspecting Damage After Fire Supervision.

THE DEVELOPMENT AND IMPLEMENTATION OF BUILDING STANDARDS IN FRANCE

by

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The systems available today in the U.S. for developing standards are being ubjected to much scrutiny and criticism. Many of the organizations involved n the standardization process are striving for better ways to produce standards. ttempts are being made to make the process more dynamic, more representative or general interest groups and better able to handle revisions and updatings.

One way to obtain a wide perspective of the options available is to examine tandards development practices in other countries. It is difficult to find a oreign country that has a well-developed standards promulgation system and nough points in common with the U.S.-- in the economic, political, geographic, nd technological areas--to be used as a reference.

The French standards system, discussed here, does not coincide exceptionally ell with the U.S. system. However, a study of the procedures used in France ight give some insight and suggest different ways of approaching the problem. opefully, elements of interest, and specific relevant procedures which might e adapted to U.S. practices will emerge.

ey words: Building standards; Foreign building standards; French building standards; French standards system; Types of French standards; Marking and certification.

OTE: Ms. Martinez is currently developing a comprehensive study relating to the structures of the standards development system in France. Publication of this study is expected in 1979.

I. THE STANDARDS ORGANIZATION: A SINGLE COORDINATING BODY

Standardization in France has a long tradition and history. The first efforts toward standardization emerged during the French Revolution. At that time the variety of weights and measures was enormous and it became necessary (and for the first time politically feasible) to declare legal the newly invented metric system.

During the second half of the 19th century, a variety of iron and steel products were standardized. But in France, as in many other countries, the prinicipal impulse to standardization was spurred by World War I. A legislative decree in 1918 instituted a Permanent Commission on Standardization, a purely governmental body. After innumerable problems, this commission was dissolved for lack of funds. In 1926, as part of an effort to organize standardization activities as a purely private activity, the present-day standards institute AFNOR (Association Francaise de Normalisation) was created as a non-profit private association.

These private standardization activities lacked official government recognition, and partly because of this, standards were not being effectively implemented. Several schemes to give standardization efforts some official backing were proposed and promulgated by various legislative decrees and ordinances between 1928 and 1941, but none were comprehensive enough and consequently did not have lasting effects. A public law, in 1941, finally designated, created and/or defined the structures and organizations that compose the French standards development and implementation system. With only minor modifications, this law is still valid today.

The 1941 law covers standards development and implementation as well as certification and marking. It gave increased emphasis to the national and official character of the standards activity and to the principal standards organization AFNOR, and recognized AFNOR as an independent institution where producers, manufacturers, users, testing and research organizations and government officials could compare and harmonize their points of view in a strictly neutral atmosphere.

The three major components of the French standards development system (see Figure 1) are the following:

1) The Commissioner, a government public servant having a small staff is appointed by the Minster of Industry. He oversees the standards process and gives general directives for standards development.

2) The standards institute AFNOR, a private non-profit association, is administered by a board of directors and managed by a general director. Although a private association, it is the only organization in France empowered by law to publish national standards. Its standardization committees write standards in many areas.

3) The third party to this system is the Standardization Bureaus, the technical arm for writing standards in many sectors of activities. They are created by official government decree but

are usually somehow attached to some other viable organization such as a trade association, a research center or a users group. They prepare the draft standards in areas not covered by AFNOR's committees and draw much of their expertise from the professional groups. Validation of consensus for draft standards prepared by Standardization Bureaus is the responsibility of AFNOR. The Standardization Bureaus are in a way similar to the American National Standards Institute's "accredited organizations" except that they have an officical character lacking in any of ASNI's dealings.

II. STANDARDS DEVELOPMENT

Standards are developed in France in much the same way as is customary in the United States (see Figure 2). A first proposal is developed either by an AFNOR committee or an individual designated by this committee or by a committee of a Standardization Bureau. It is then examined and modified as many times as necessary by a committee including all interested parties. After the draft is approved by the committee, it is submitted for public comment during which time the document is widely available to the public and interested groups. Comments and criticisms are studied by the committee and negative opinions are resolved. The final draft approved by the committee is submitted before publication to procedures clearly defined by law or by other official regulations. The prinicipal nature of these procedures is outlined below.

The one outstanding characteristic of this process is the lack of formal voting. Other European countries also prefer this unstructured procedure.

In lieu of voting, agreements are reached on the basis of consensus of all interested parties, and this consensus is manifested by tacit approval when no objections are voiced.

Besides the lack of formal voting at any of the stages of the standards development process, there are no formal membership rules and participation in committee work follows no established rules for achieving balance. Balance is obviously of serious concern and it is very much in the minds of all participants. Great efforts are expended in achieving balance, but it is the responsibility of the Secretariat of the committee (usually AFNOR) to assure balanced representation, and no written guidelines are available.

One other interesting characteristic of the French standards process is the fact that an approved draft standard may be issued as any one of four different types of publications. French standards published by AFNOR may be:

1) ratified standards,

2) registered standards,

3) experimental standards, or

4) information leaflets.

The steps to follow in order to publish each of these types of standards and their relative importance are described in a 1966 official decision of the Commissioner for Standardization.

When one looks at a French standard, the printed copy does not indicate who wrote it, or who participated in its development, and AFNOR appears simply as editor. Printed in the upper left hand corner of the document is the designation of the type of standard (ratified, registered, experimental or information leaflets), and this can give a clue to the way the standard was developed, the procedures that were used and probably the speediness of the development process. A typical cover page of a French standard is given in Figure 3.

Traditionally, there was only one kind of standard developed in France, the ratified standard (norme homologuee). In 1966, the standards community was searching for ways to speed up the development process. The major result of that effort was the creation of a new type of standard, named the registered standard (norme enregistree).

These two types of standards are the most important. The main difference lies in their respective implementation. After the period of public inquiry and the resolution of comments, the ratified standard is submitted for an additional 6 weeks to an inquiry in the ministries and other government agencies interested in the subject. The registered standard is not subjected to this further period of comments from governmental departments. The ratified standard must be used in all public contracting or whenever there are any government funds being used. The registered standard does not have to be used unless it is explicitly referenced in a public contract. However, in 1971, an official government circular recommended and encouraged the increased use of registered standards by government agencies.

The decision as to which type of standard will be published is entirely up to the committee. Tradition intervenes to a large degree here. For example, in the steel industry, all standards are registered. On the other hand, in the building community, the registered standard is considered "second class." It is thought that the extra 6 weeks of inquiry in government agencies are worth waiting. Also, there is often a percentage of public funds and/or public financing in most construction projects in France. By giving preference to the ratified standard, all parties involved in construction know beforehand the basic standards that must be followed.

The other two types of documents published by AFNOR are the experimental standard (norme experimentale) and the information leaflet (fascicule de documentation). As the name implies, the experimental standard is material usually not yet suitable to be officially sanctioned as a standard. Realizing that some more research is needed in the particular area, the committee has the option if it so wishes to use the mechanism of issuing the material and reaping the benefits of the opinions of a wide audience, before finalizing its decision. In fact, an experimental standard is a published draft standard, being submitted to a long period of public inquiry and comment. Usually, after 2 or 3 years, experimental standards are revised and published normally as ratified or registered standards.

Finally, there is the information leaflet, which is not a standard at all. The leaflets contain relevant information, useful to readers and users of standards, and carry a certain weight and prestige because they are published by AFNOR. Examples of this type of document are the interpretation of safety rules for elevators, design solutions and alternatives for doors and windows conforming to a ratified performance standard, and conversion factors for legal units of measurements.

III. BUILDING STANDARDS

There are currently Standardization Bureaus in many technical and industrial areas such as plastics, textiles, paper, computer sciences. When there are none (such as in the refrigeration industry, paints, acoustics, ergonomics), AFNOR sets up a committee and drafts a first proposal, usually with the help of professional groups.

The building community, however, has a special organization which does not fall into either of the two accepted modes--AFNOR committee or Standardization Bureau committee. Instead, there is a General Committee for Standardization composed of 13 different groups including AFNOR. Some of these groups are Standardization Bureaus (architecture, wood industry metallic construction), while others, such as trade associations and private inspection groups, are not.

This General Committee for Standardization is called "Group DTU"* and its secretariat is held by the Centre Scientifique et Technique du Batiment** (CSTB), a very important, all encompassing building research and development public institution, part of the Ministry of Equipment (Public Works).

The Group DTU, mainly a coordinating committee, meets every two months to assess progress on standards development and give administrative and procedural approval for processing drafts. Technical approval of draft standards is as for all standardization activities, the responsibility of the technical committee. The Group DTU also develops annual programs, with long and short range plans. Once the need to develop a standard is established, the Group DTU coordinates its development. One of their members is assigned the task of writing a first draft. Usually, this task is given to the organization requesting that a standard be developed. The same or another organization within the Group DTU is assigned to fulfill the more administrative-type duties, such as calling meetings, sending out documents and preparing the minutes of the meetings. Committees meet as often as necessary to approve a draft. Subsequently, AFNOR submits the draft to public inquiry and processes the document until publication.

This machinery seems complex, and it is. It does not alwas work smoothly, but like many other organizations, it functions only as well as the people involved want it to work.

Building standards in France cover a wide range of subjects and usually relate to terminology and vocabulary, definitions, methods of test and specifications of products. Installation guidelines and minimum standards for system design are not usually included in AFNOR standards, but are available in publications by CSTB.*** Installation guidelines are developed

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* DTU stands for "Documents Techniques Unifies," meaning Unified Technical Documents.

**Scientific and Technical Center for Buildings.

***These documents are called "Cahier des Charges DTU." "Cahier de charges" is the set of provisions prescribed at the awarding of a contract. This French expression may also be loosely translated as "specifications."

by CSTB committees, which include all interested parties, in very much the same way as standards and are under the authority of the Group DTU; but they are not subjected to the procedures for standards development, notably, they are not submitted to public inquiry. The lack of installation guidelines and system design specifications, however, is peculiar to the building industry and quite exceptional. In most other fields standards address all aspects of technology. As companion pieces to standards, they go hand in hand with them and are very much complementary.

Another peculiar trait specific to French building standards is that the standards cover only what is considered as "traditional," well-known products and methods. Only building products whose performance is proven through long field experience and whose characteristics are fully recognized are considered for French standards. For example, wood and metal windows are standardized with methods of tests, performance criteria, and construction characteristics, while plastic windows are not; not because time has been lacking, but because they are not yet considered traditional.

New products are treated differently, geared to more individual attention, rather than to the class to which they belong. New products undergo a procedure known as "Avis Technique," which means "technical opinion." This may also be know by its older name of "Agrement."

Whenever a manufacturer has a new product, it may be submitted to the appropriate Committee for Technical Opinions. These committees are managed by CSTB who tests the products, usually on the basis of available documents. The test results are submitted to a committee composed of manufacturers, users and other interested technical organizations who, on the basis of test results and any available data from the field, give a technical opinion on that particular product. The favorable technical opinions are published regularly and are valid for a relatively short period of time ranging from 1 to 3 years.

When a committee has gathered enough information over a period of time on a family of products and there is enough confidence in their performance, the new products start being considered "traditional" and standardization procedures may be started.

Since generally the same organizations serve on all the various building committees mentioned above, and CSTB is a focal point of all building activities in France, the information flows relatively easily. In addition, AFNOR staff serve on all committees developing installation guidelines, and, of course, on all standards developing committees, and are therefore able to efficiently coordinate all these building related activities.

IV. MARKING AND CERTIFICATION

AFNOR instituted the national NF* mark in 1938. The 1941 standardization law established the present organizational structures that govern the French certification system and sanctioned AFNOR as the only officially recognized body in France to run a national certification program.

When the NF mark is stamped on a product, it means that the product conforms to a ratified standard, or to a set of ratified standards. Therefore, only those ratified standards that cover all important characteristics of a product and show that the product is suitable for its intended use are permitted to qualify for a mark. Registered standards cannot be used as the basis for a certification program.

The NF mark is optional in most cases. It may be used under license only. The NF mark may be rendered mandatory by special government decree. This is most common when the corresponding standard is itself compulsory, or has been incorporated into regulation by reference, which is rare for building standards.

An NF mark may be authorized for foreign products, provided the products satisfy all of the requirements established for national products. It must also be possible to carry out effectively the same controls and verifications as in France, and satisfactory reciprocal conditions must exist. Foreign products have been granted the mark, most notably in areas where the mark is mandatory and thus indispensable for marketing the product in France, such as gas and electrical major household appliances.

Building materials and components make up about 50% of AFNOR's marking and certification activities, while about another 40% of the effort is devoted to domestic equipment, and the remaining to industrial equipment.

General guidance and oversight for certification programs are provided by a Directing Committee. Specialized Committees, dealing with categories of products, carry out the tasks of approving and licensing products and their decisions are based on laboratory test results. Specialized Committees are composed of producers, users and administrative agencies on a strict, balanced membership basis.

Decision to grant or revoke the privilege of using an NF mark are taken only during committee meetings, by consensus with no objections, on the basis of tests results and other related reports. The proceedings of certification committees are much more formal than their counterpart standardization committees, and even though there is seldom need for voting, rules for voting are included in the committee's by-laws. Membership in certification committees must comply with guidelines for achieving balance. In marked contrast to membership in AFNOR's standards writing committees, the rules are strictly enforced.

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* NF stands for "Normalisation Francaise," meaning French Standardization.

AFNOR, who has the management responsibility for all NF marks and certification committees, has no laboratories or test facilities. Therefore, a testing laboratory is selected for each individual mark created. Most often the choice is restricted to one laboratory that has the required qualifications to carry out the work. However, when more than one laboratory is available, an equitable distribution of testing activities is made. The decision is AFNOR's and it is reached after extensive consultation with interested parties. There is no formal program or plan for accrediting institutions, so no criteria have been developed.

The work of certification committees and the data they gather are of great importance to an effective standardization process, and crucial to updating standards to keep up with technological developments. It is in the actual day to day implementation of standards that the level of performance attained by a product can be appraised. Very often this accumulated knowledge leads to proposed modifications of a standard, sometimes relaxing its provisions. But more often than not, a product performs consistently better than originally anticipated and the standards can be upgraded correspondingly.

FIGURE 1

STANDARDIZATION LAW OF 1941

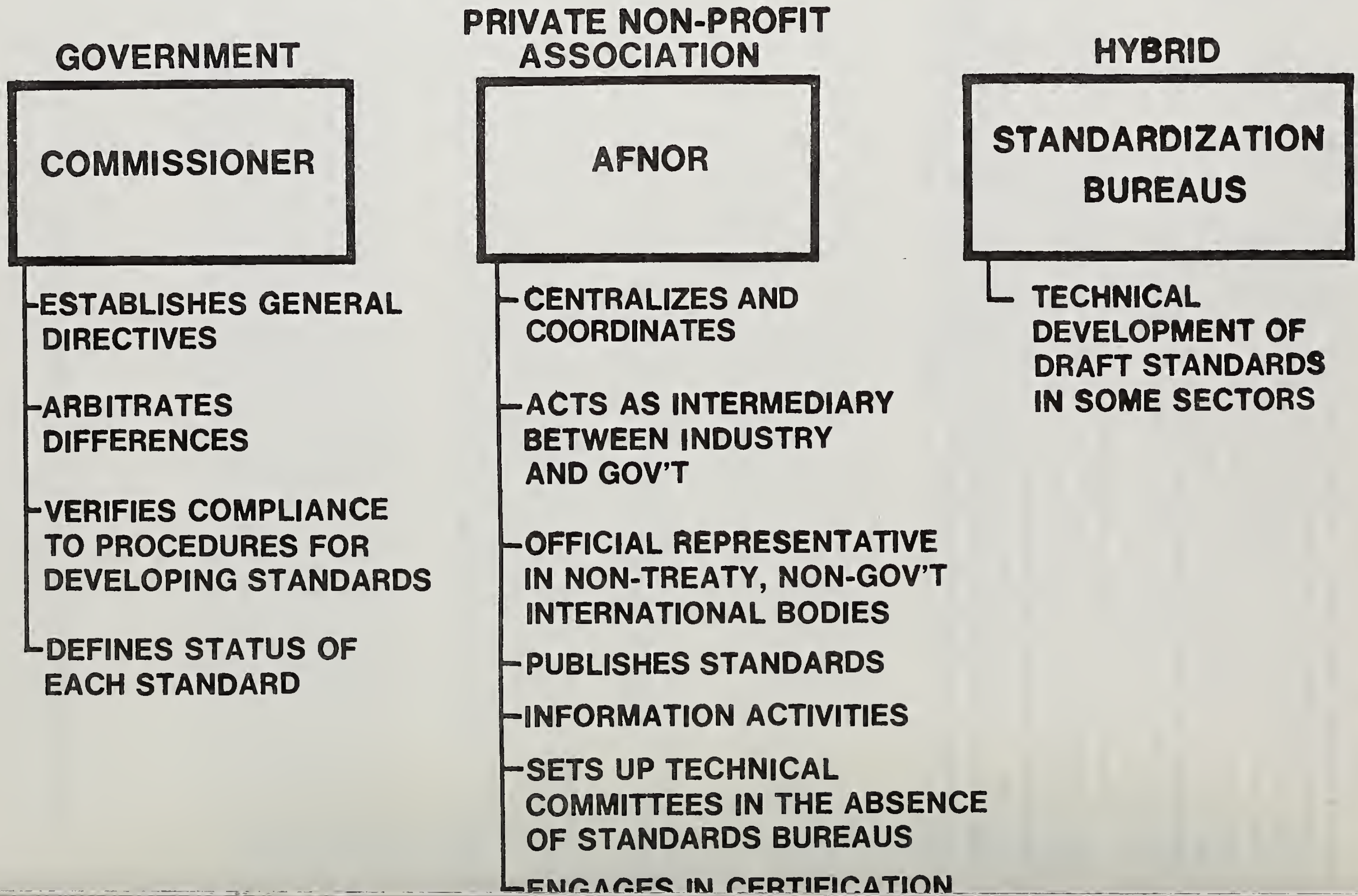


FIGURE 2

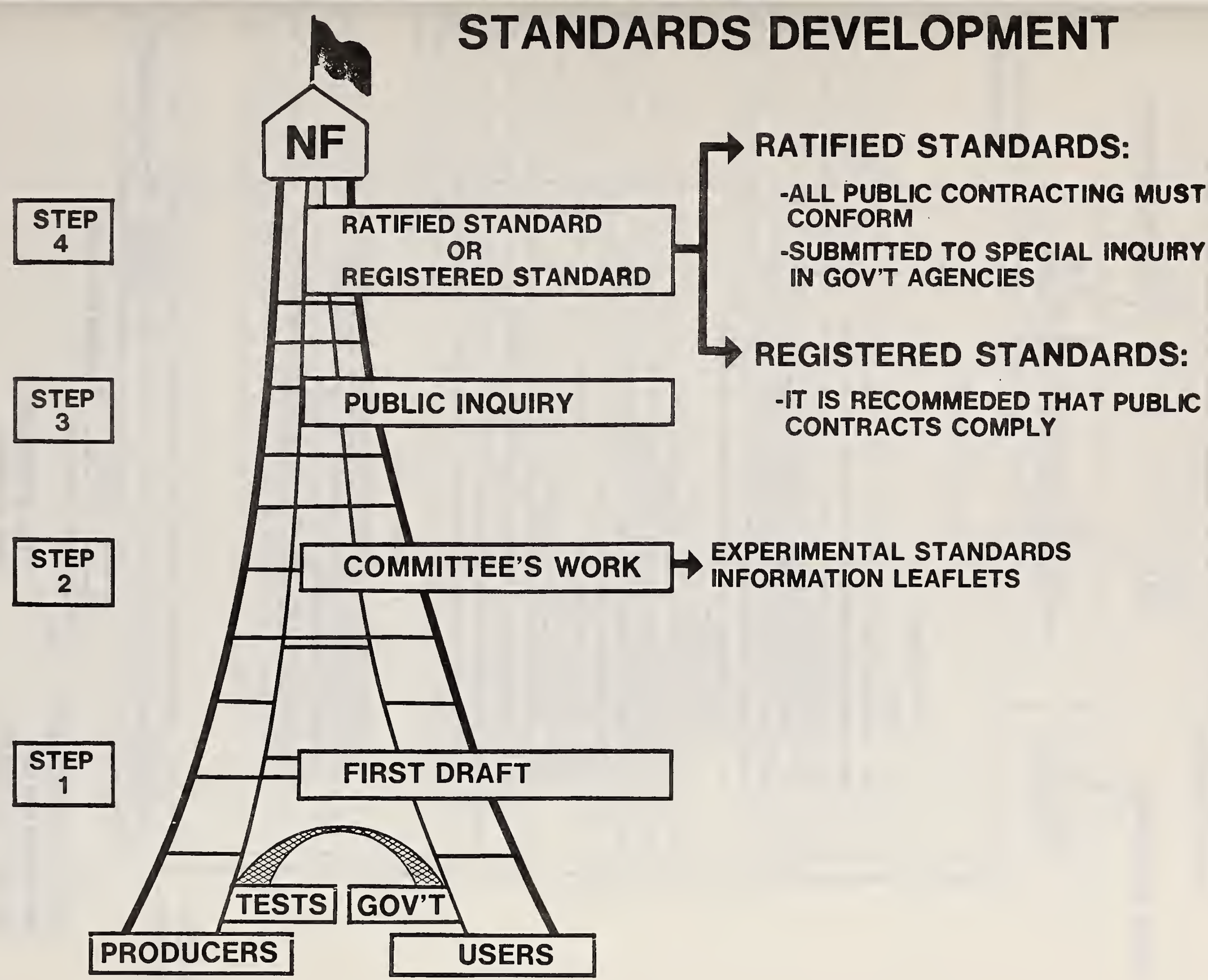
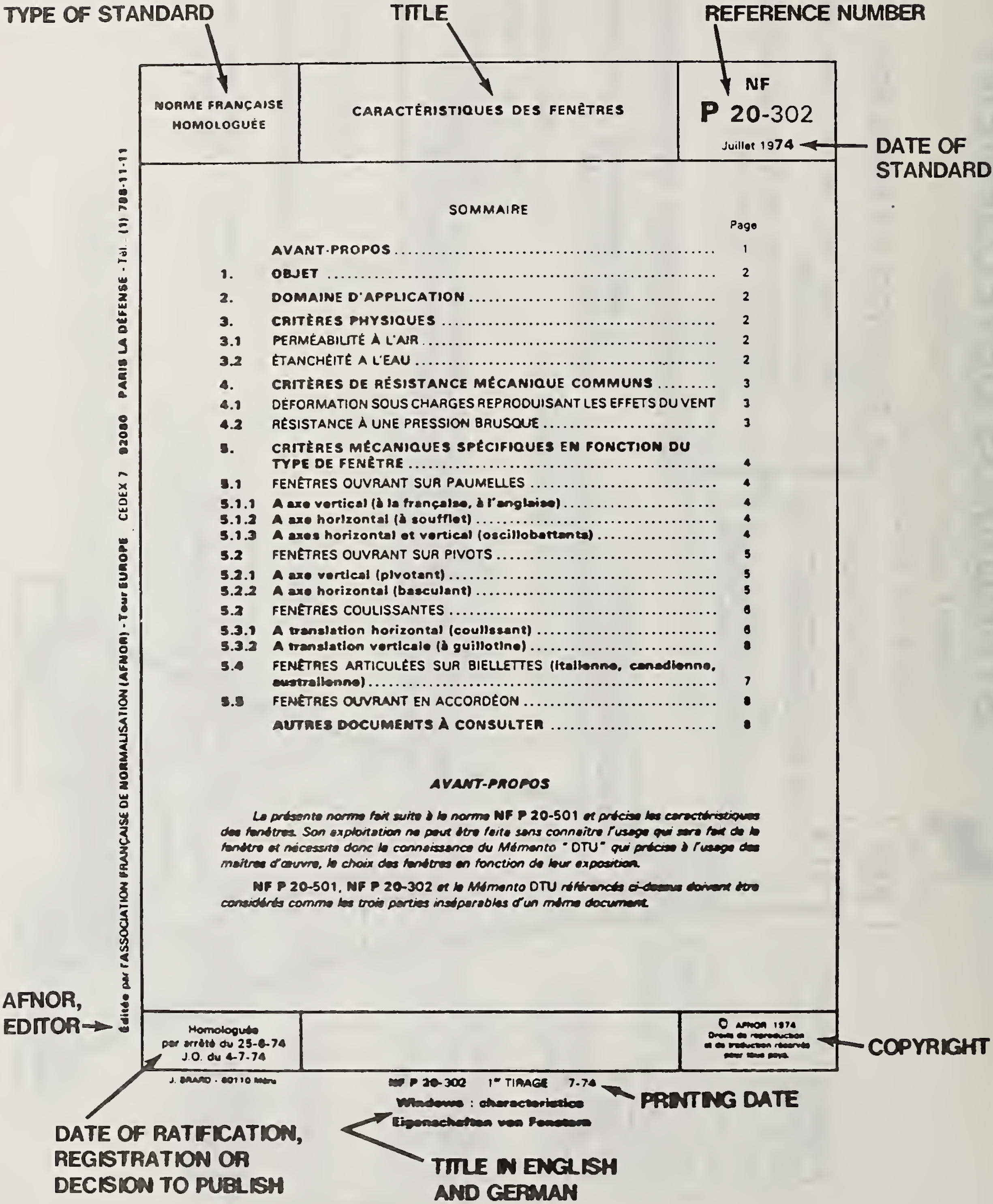

STANDARDS DEVELOPMENT
NF
STEP 4
RATIFIED STANDARD OR REGISTERED STANDARD
STEP 3
PUBLIC INQUIRY
STEP 2
COMMITTEE'S WORK
STEP 1
FIRST DRAFT
TESTS
GOV'T
PRODUCERS
USERS
RATIFIED STANDARDS:
-ALL PUBLIC CONTRACTING MUST CONFORM
-SUBMITTED TO SPECIAL INQUIRY IN GOV'T AGENCIES
REGISTERED STANDARDS:
-IT IS RECOMMEDED THAT PUBLIC CONTRACTS COMPLY
EXPERIMENTAL STANDARDS
INFORMATION LEAFLETS

FIGURE 3

TYPICAL COVER PAGE OF A FRENCH STANDARD



NORME FRANÇAISE HOMOLOGUÉE

CARACTÉRISTIQUES DES FENÊTRES

NF P 20-302

Juillet 1974

SOMMAIRE

AVANT-PROPOS

La présente norme fait suite à la norme **NF P 20-501** *et précise les caractéristiques des fenêtres. Son exploitation ne peut être faite sans connaître l'usage qui sera fait de la fenêtre et nécessite donc la connaissance du Mémento* " DTU " *qui précise à l'usage des maîtres d'œuvre, le choix des fenêtres en fonction de leur exposition.*

NF P 20-501, NF P 20-302 *et le Mémento* DTU *référencés ci-dessus doivent être considérés comme les trois parties inséparables d'un même document.*

Éditée par l'ASSOCIATION FRANÇAISE DE NORMALISATION (AFNOR) - Tour EUROPE CEDEX 7 92080 PARIS LA DÉFENSE - Tél. (1) 788-11-11

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NF P 20-302 1er TIRAGE 7-74

Windows : characteristics

Eigenschaften von Fenstern

A CASE HISTORY OF THE INTEGRITY OF THE NATIONAL ELECTRICAL CODE

by

David J. MacFadyen, President
Technology + Economics, Inc.
Cambridge, MA 02140

ABSTRACT

A new system for surface-mounted branch-circuit building wiring is being commercialized that holds substantial promise for flexibility and cost-effectiveness. This system is based on the flat conductor cable technology developed by the National Aeronautics and Space Administration for aerospace use. NASA sponsored a project to commercialize flat cable-based building wiring systems, which included a NASA contractor and a consortium of twelve major Amercian corporations.

One of the most critical aspects of making advanced wiring systems available to the public is the development of code provisions to allow their use. The process of establishing a new National Electrical Code Article 328 permitting flat conductor cable wiring systems involved use of every procedural step available in the Code-making regulations of the National Fire Protection Association. Unfounded technical objections and procedural irregularities on the part of opponents to the new technology necessitated the use of every protest and appeals process available under those regulations. It was only at the highest level of the Code-making organization--the NFPA Board of Directors--that the final favorable action was taken on the basis of proper technical justification.

The adoption of Article 328 as an amendment to the 1978 National Electrical Code was a victory, not only for the public and the proponents of the Code change, but also for the NFPA and the whole consensus approach to Code making. The checks, balances, and recourses in the system were shown to be adequate to assure that the Code change was ultimately resolved on technical merit.

Key Words: Appeals process; consensus standards; electrical distribution systems; flat conductor cable; National Electrical Code; technological innovation.

INTRODUCTION

This paper concerns flat conductor cable building wiring systems and the achievement of a new National Electrical Code (NEC) article permitting such systems. The use of flat conductor cable in surface-mounted systems for building electrification has important potential. Such systems hold promise of reducing the cost of branch circuit wiring for office and commercial buildings by as much as 70%. A new Code article (Article 328) now permits these systems. Due to technical irregularities and procedural delays, the Article is not in the 1978 Codebook, but a Tentative Interim Amendment (#1-70-1978) has been promulgated to make Article 328 part of the 1978 Code.

The history of this Code change is of interest for two reasons. First, the proponent of the Code change was an outsider to the electrical industry with no vested interest to promote or protect. Second, the Code change was accomplished through an established appeals process that had not previously been used. At the same time, however, the events in this Code change process show that it has important operational weaknesses.

This paper will describe what flat conductor cable wiring systems are, their anticipated uses, the procedural fairness and operational weakness of the NEC, and the lessons learned from a protracted Code change fight.

FLAT CONDUCTOR CABLE WIRING SYSTEMS

Flat conductor cable--or FCC--is a thin-profile cable originally developed for aerospace use. A building wiring system using FCC has now been developed. This system, intended for offices and commercial buildings, uses thin flat cable for surface-mounted branch circuits. The flat cable is mounted on the floor and covered by carpet squares.

The FCC system is intended by its manufacturers to serve as an alternative to under-floor conduit systems: it requires no conduit or ductwork, no holes in the floor, and no risers or nipples. Instead, the electrical distribution cable is surface-mounted and covered by a steel shield.

One importance of the system rests in the cost tradeoffs of using FCC instead of existing systems. The system developers contend that when both flat cable telephone and power systems are installed together, the savings for a new installation come to $350.00 per desk, and for each relocation come to an additional $40.00 per desk. The potential savings in new electrification costs are projected to be on the order of $200 to $400 million per year.

The ease and flexibility of making wiring layout changes is an important part of FCC systems. Office layouts are changed up to twice a year, and conventional electrical systems have difficulty coping with the quickly changing electrification requirements. With FCC, wiring layout is completely flexible, and changes can be made with minimal disruption and at low cost.

The following is a brief description of the components of a FCC under-carpet wiring system and how they are put together. The illustrations show the main features of the system.

The flat conductor cable used in single-phase branch circuit wiring has three flat conductors, each of them equivalent in cross-section to a 12-or 14-gauge round wire. For a 12-gauge system, the conductors are 9 mils thick and 600 mils (or 6/10 inch) wide. A three-conductor cable is 2-1/2 inches wide and about 25 mils in total thickness.

The first step in laying an FCC system is to clean the floor and lay down an anchor strip. The anchor strip has adhesive on both sides. The bottom adhesive adheres to the floor. The upper adhesive holds down the cable and shield. Release paper protects the upper adhesive film until the cable and shield are ready to be laid over it.

T-taps and splices into flat cable runs are made using quick-connect joints. Connections are insulated by means of sealed pouches.

Cable corners are made simply by folding the cable over on itself.

The steel shield is electrically inter-connected and grounded with clinch joints. A steel shield covers and protects the cable. The shield is 8 mils thick. It provides both mechanical and electrical protection. It has the same conducting capacity as an armored cable jacket or a single cable conductor.

Carpet squares cover the completed system. Release-type adhesives are used so that the system remains accessible. At receptable locations the carpet is cut--as around any floor projection--and can be tucked into a separate compartment in the receptacle housing.

The FCC system concept is intended to be versatile and flexible in office applications, and to permit easy system changes.

The system may be fed from a conventional wall box with the wall-mounted portion of the cable located inside a heavy metal protective raceway. It may also be fed from a baseboard location, or from an existing floor duct using a special adapter.

Receptacles can be moved or added: A receptacle can be placed directly on an existing cable run, or a T-tap can be made from an existing run to the new location. In installations where there is an existing ducted system, a flat cable run can be made from an existing duct access. The access location can be covered by a flush-mounted cover and then carpeted over.

To tap into an existing flat cable run the existing shield is cut and peeled back, then the T-tap is connected and sealed in an insulating pouch. The shielding is then reconnected using clinch connectors.

FCC may be used to service baseboard or wall outlets. Flat cable-to-round cable transition assemblies are used to route service into a wall.

The FCC system is designed so that it is easily inspectable both during installation and thereafter. The recommended time to inspect it during installation is after the cable runs have been permanently laid and connected together but before the protective shielding is permanently connected and fastened down. Receptacle bases can be easily inspected at any time before the housing is attached.

Even after the installation is complete, the FCC system remains inspectable. Receptacle housings can be opened at any time, and carpet squares can be removed to inspect a splice, T-tap, or corner.

The FCC power system is designed to be used with a companion flat cable telephone system. Flat cable telephone systems use either woven cable, flat conductor cable, or flat coaxial cable. No metal shielding is required for telephone systems. Flat cable telephone systems are completely compatible and complementary with the power system. Crossings of power and telephone cables are permitted, provided that a layer of shielding always separates the two systems. Flat telephone cabling is already available and state tariffs are being set.

What are the applications for FCC systems? The primary applications of FCC systems will be in commercial space and particularly in office space. In fact, the Code Article as presently written restricts the system from hospitals, residential use, and schools. It is in addition required to be installed under carpet squares. These restrictions result from a desire on the part of the National Electrical Code Committee to gain operating experience in limited applications. Some of these restrictions may be removed in 1981.

FCC systems are seen to have potential markets in both new and existing construction. In new buildings, major cost savings are expected in comparison with ducted systems. Complete freedom of furniture placement is achieved without use of utility poles. In existing building remodeling, FCC systems can economically provide service without utility poles or hung ceilings. Even in buildings with existing ducted systems, it is less costly to add outlets using FCC than to open new holes; and the new outlets will be unconstrained as to location.

THE COMMERCIALIZATION OF A NEW WIRING SYSTEM

In order that buildings can be built utilizing the FCC system and in order that the FCC system can be used to rewire exisitng buildings, it is necessary that the system be recognized by local electrical codes. The National Electrical Code (NEC) is the most widely adopted model code in the United States. Most state and local codes reference the National Electrical Code, although some add to it or delete from it at the time of adoption. Because the NEC is widely adopted it is critical to the success of any wiring system that provisions be introduced into the National Electrcial Code permitting use of that system. In addition, since codes require the use of "approved" hardware, system hardware must have been tested in accordance with established requirements by an independent testing organization such as Underwriters Laboratories.

The National Aeronautics and Space Administration (NASA), as the developer of flat conductor cable technology, operates under a Congressional mandate to assure the maximum utilization of the technology it develops for the public's benefit. As part of its technology utilization program, NASA retained the firm of Technology + Economics, Inc. (T+E) to facilitate the application of NASA technology to building related problems

To commercialize flat conductor cable for building wiring, T+E formed a consortium of manufacturers. Collectively, these manufacturers were capable of producing each required FCC system component and of gaining Underwriters Laboratories (UL) approval for these components. The consortium of manufacturers included:

- Amp, Inc.
- Bell Telephone Laboratories
- Brand-Rex Corporation
- Clecon Metals, Inc.
- Collins and Aikman, Inc.
- E.I. DuPont de Nemours & Company, Inc.
- Fasson Division, Avery International, Inc.
- Lamotite Products
- Deering Milliken, Inc.
- Parlex Corporation
- Thomas and Betts Company
- Western Electric Company

In addition to chairing the consortium, T+E introduced a Code-change proposal for FCC to the National Electrical Code. It is important to realize that while T+E chaired the industrial consortium, it was not part of the electrical establishment. And, as you will see, the members of the consortium that were part of the establishment were unable to fully participate in the Code change activity.

In order to accomplish a Code change, T+E assumed the advocacy position and submitted the Code change proposal to the National Electrical Code Committee (NECC). The manufacturers produced prototypical hardware for demonstration of the concept and for testing to establish the safety inherent in FCC systems. After prototype development was finished, a complete fact-finding study was conducted by Underwriters Laboratories (UL).

The stage was then set -- in late 1975 -- for a unique series of actions that ultimately resulted in the granting of a new Code article for FCC, but not without a fight.

THE NATIONAL ELECTRICAL CODE CHANGE PROCESS

In order to fully understand all of the events that took place in the battle for a Code article covering Flat Conductor Cable, it is necessary to understand the relationship of the National Electrical Code Committee to the National Fire Protection Association, its Board of Directors, and its Standards Council. The organization chart on the following page shows the relationship of the National Electrical Code to not only the NFPA, but also to the American National Standards Institute.

To obtain a National Electrical Code change, it is necessary to submit a proposal to the National Electrical Code Committee, which determines which code-making panel should consider the technical merit of the proposal. In the case of FCC it was assigned to Code Making Panel 7 of the National Electrical Code Committee.

When the Code-Making Panel has considered and acted upon a proposal, a report is prepared and forwarded to the Correlating Committee. The Panel reports its action on each proposal, and if that action was negative, states why it was negative. Any panel member whose vote is against the majority vote on a proposal must give the technical justification for his negative vote. The Correlating Committee then examines the Code-Making Panel reports to assure that there are no conflicts among panels and also examines the reasons for the negative votes, to be sure that due consideration has been given to the dissenting votes. Once the Correlating Committee's actions have been incorporated, the panel reports become the report of the National Electrical Code Committee. The report of the National Electrical Code Committee is then submitted to the entire NFPA for approval at its annual meeting. Unfortunately, Article 328, "Flat Conductor Cable," did not progress through the steps of approval in a smooth or consistent manner.

The initial draft of what was to become Article 328 was submitted to the National Electrical Code Committee and acted upon when the Committee met in the spring of 1976. Code-Making Panel 7 voted to reject the proposed 1978 National Electrical Code Article 328 for two stated reasons. First, it was pointed out that the Article was not in the

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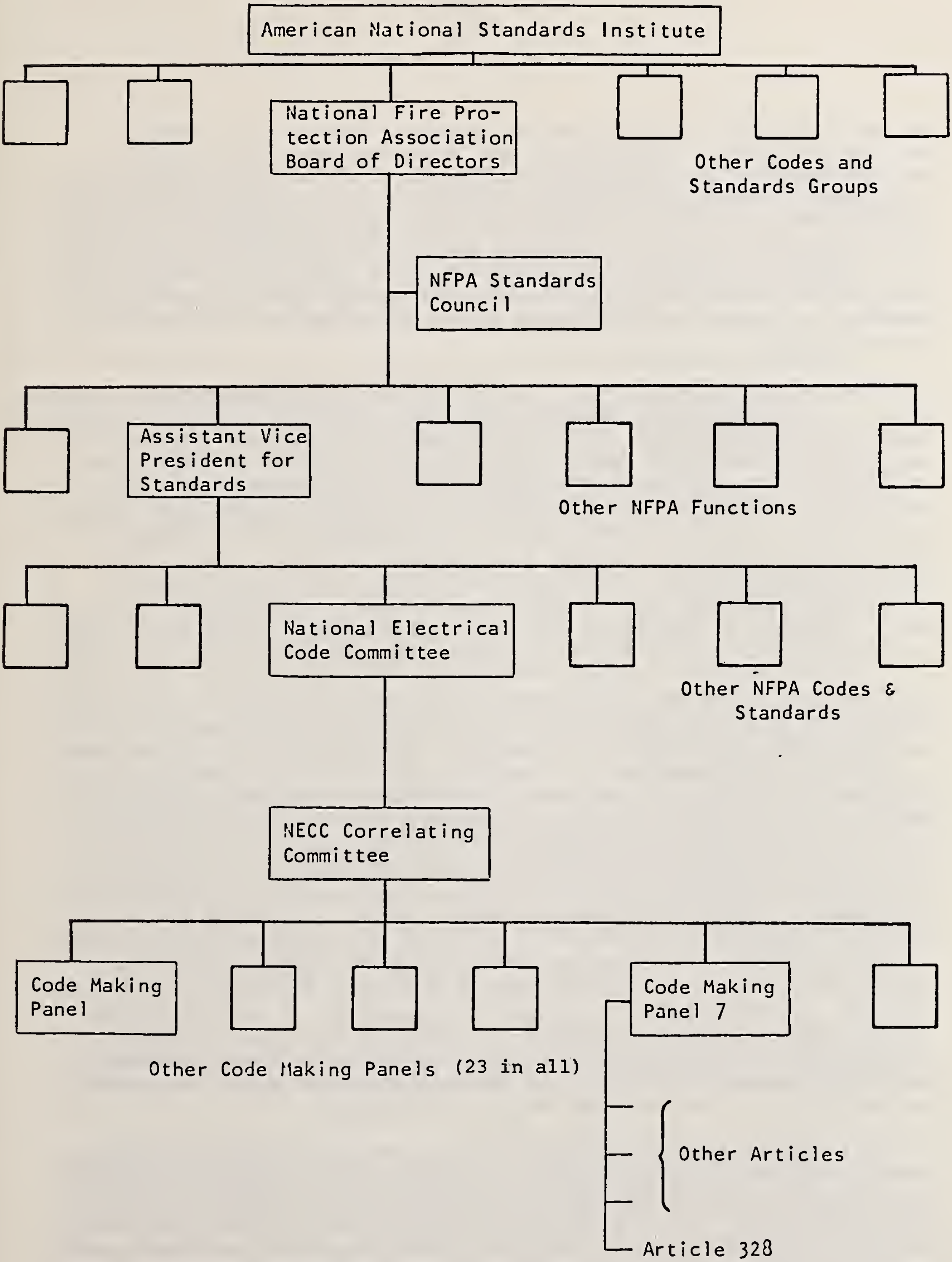
ORGANIZATIONS & LINES OF AUTHORITY
RELATING TO THE NATIONAL ELECTRICAL CODE



appropriate format. Second, certain long-term tests of the system at UL were not at the time complete. The first concern, that of format, was the result of a miscalculation on the part of the industry consortium. The consortium had assumed that the Code Panel would either rewrite the proposed article to suit is needs, or else direct the submitter to rewrite it, without rejecting it. The second concern, that UL was continuing to test, was technically true but was nevertheless a weak point, because the test results already available exceeded any testing that had ever been supplied in substantiation of other articles, and had not detected any adverse results.

Technology + Economics and the industry group overcame these objections in the course of the next year, and the Code Making Panel agreed to reconsider the proposed article at its December 1976 meeting. At that meeting, the Code Making Panel took a voice vote on the new Article 328 which was by then reformatted and supported by the complete and final version of the Underwriters Laboratories Fact Finding Report. The voice vote at that meeting was 10 in favor and 2 abstentions. The formal, written ballot 30 days later was 8 affirmative, 2 negative, with 2 who had voted affirmatively in December determined to be not qualified to vote on this article. The results, then, were an apparent victory for Article 328 and it appeared that it would pass through the final approval processes and be part of the 1978 National Electrical Code.

The next action was by the NEC Correlating Committee. The Correlating Committee's main role with regard to Article 328 was to determine whether the Panel vote represented a "consensus". The determination of consensus is inherently problematical. It should be noted that the Correlating Committee must examine on the order of 2000 proposed actions, large and small, every three years. It is assumed that the Correlating Committee cannot be technically knowledgeable on these proposals; it is instead assumed that the Code Making Panels have carried out a full and proper technical deliberation, so that the Correlating Committee's ruling on "consensus" is essentially non-technical. At the minimum, it is assumed that the Correlating Committee will not raise any technical questions not explicitly brought out in the Code Making Panel's report. The problem is that the Correlating Committee must be highly disciplined in order to restrict its consideration to issues of "consensus". A further problem is that even if it does so restrict its consideration, the determination of "consensus" is almost never divorced from technical considerations. Technical judgement is involved in determining whether a particular dissenting opinion is of technical merit, for example.

Unfortunately, when it took up Article 328, the Correlating Committee did not consider the 8 affirmative, 2 negative votes a consensus among the panel members. The new article was rejected for inclusion in the 1978 National Electrical Code by the Correlating Committee. Upon examination of the Correlating Committee's deliberations it was found that information far beyond the reasons put forth by the 2 negative voters was incorrectly introduced into the Correlating Committee's deliberations. That information not only was inappropriately introduced, but was also completely without basis.

An appeal was written to the Correlating Committee stating the procedural irregularities that surrounded the Correlating Committee's consideration of Code-Making Panel 7's activity. The Correlating Committee's reconsideration resulted in a simple majority of the Correlating Committee voting in favor of the new article. Unfortunately, a three-quarters majority was required to reverse the Correlating Committee's previous action, and this majority was not achieved.

At that point, in the spring of 1977, T+E initiated the appeals process available to anyone proposing a change in the National Electrical Code. The first step was to present an amendment to the NFPA's Electrical Section at the NFPA's annual meeting. The presentation to the Electrical Section resulted in its endorsement of the Amendment by a 71 to 67 vote. Again, the Correlating Committee met, and dictated that the Article should not be incorporated in the 1978 NEC, but should be reconsidered for the 1981 version of the Code.

The following day at the annual meeting of the NFPA, T+E introduced the article on the floor of that annual meeting for action by the entire NFPA. Unfortunately, because of the earlier procedural irregularity, the revised Code article was not contained in the National Electrical Code report, and copies of the subsequently approved Article 328 had also not been made available for the membership of the NFPA. According to the rules established by the Chairman of the NFPA annual meeting, T+E's representative tried to exercise the right to read the proposed article into the record. The chair intervened in the reading of the proposal onto the record and suggested that the assemblage did not wish to spend its time listening to the entire article being read into the record, even though the rules were that each speaker would have 10 minutes to present his position, and even though the proponent of Article 328 had been speaking for less than 3 minutes. The T+E representative made clear his disagreement with the procedures being followed at the annual meeting. The annual meeting was forced to vote on the early 1975 version of Article 328 that had appeared in the NEC Preprint, and rejected it since it bore no relationship to the completely revised scope and language of the article.

A protest was then lodged with the Board of Directors of the NFPA as is appropriate under the procedures governing the National Electrical Code. The Board instructed the Standards Council to investigate the protest and act on behalf of the Board of Directors to resolve it.

T+E presented the relevant information to the Standards Council and one Standards Council member asked if a Tentative Interim Amendment issued within 30 days would be acceptable if the Standards Council chose to recommend such an action to the NFPA Board of Directors. The answer was that a Tentative Interim Amendment was acceptable as a processing convenience for correcting the procedural and technical irregularities that had accompanied the process to date. It was also clearly stated at the time that it was <u>not</u> acceptable to the proponenets of Article 328 to be allowed to submit a Tentative Interim Amendment to the same Code-making process that had to date inappropriately frustrated all efforts to obtain a technically-based resolution of the controversy. Subsequently, the Board of Directors did ask T+E to request a Tentative Interim Amendment that would be issued without being subject to review by the normal Code-making process.

The proposed Tentative Interim Amendment was submitted to the Standards Council. The Standards Council contacted key members of Code-Making Panel 7 to establish their position on the issue. By that time, political pressures had been brought on members of Code-Making Panel 7 to change their vote to oppose the article. Even though the Panel 7 vote was short of that required to adopt a Tentative Interim Amendment under usual NFPA procedures, the Standards Council found unanimously that the technical facts justified the adoption of Article 328. Hence, Article 328 was incorporated into the 1978 National Electrical Code by amendment on October 13, 1977, two months before the 1978 Code took effect.

Based upon the success of Article 328, the manufacturers involved initiated major product development activities and began planning the submission of flat conductor cable system hardware for Underwriters Laboratories approval and listing.

Unfortunately, through lack of foresight, the NFPA's Standards Council, Board of Directors, and T+E all failed to address the specific requirements for subsequent processing of Tentative Interim Amendments that are contained in the NFPA rules governing committees. Because the Board of Directors failed to explicitly state that Code-Making Panel 7 and the Correlating Committee did not have to review the Board's action regarding the 1978 Code at the time of the 1981 Code, it was possible for the staff and officers of the NECC to interpret certain procedures as applicable to Article 328. At this time, Article 328 might not be included in the 1981 National Electrical Code. This peculiar circumstance can occur because the Board of Director's decision may be overridden by the same subcommittee and committee that the Board chose to override in granting the release of Article 328. A request that the Standards Council and Board of Directors of the NFPA review the status of Article 328 and take action to assure that it be considered on a technical basis is currently pending. The results are of utmost importance, not only to the public, but perhaps to the entire consensus code structure. There is little question that the Board and the Standards Council will find the appropriate path to assure that the issues are resolved on the technical merits. They have, to this point, acted completely on the basis of procedural fairness and technical justification.

SEQUENCE OF EVENTS LEADING UP TO
THE ACCEPTANCE OF NEC ARTICLE 328

Spring '76	CMP7 Rejects Article 328
	T+E Objects to Rejection
December '76	CMP7 Accepts Article 328 8+ 2-
February '77	Correlating Committee Rejects Article 328 3+ 6-
March '77	T+E Objects to Correlating Committee Action
April '77	Correlating Committee Reconsiders but Article 328 Fails to get 3/4 Vote Required 5+ 4-
May '77	Motion to Accept Article 328 Passes NEC Section of NFPA Annual Meeting 71+ 67-
May '77	Correlating Committee Intervenes to Reject Article
May '77	Procedural Irregularities on the Part of the NFPA Keep Motion to Accept Article 328 From Coming to a Vote at NFPA Annual Meeting
June '77	NFPA Board of Directors Hears T+E Protests and Designates Standards Council to Act on Behalf of Board to Resolve the Protest
June '77	Standards Council Hears Protest
	Standards Council Investigates Issues
October '77	Standards Council Invites all Interested Parties to Meeting: Proponents of 328 & UL Representatives Attend. Opponents to 328 Fail to Attend. Standards Council Votes Unanimously to Accept Article 328

STRENGTHS AND WEAKNESSES OF THE NEC PROCESS

Last year the Code Article was accepted for its technical merit, and it is assumed that it will remain in the National Electrical Code unless a technical defect is found in FCC systems. To date such systems have outperformed competing systems in both economy and safety. The activity that put the article in the 1978 National Electrical Code displayed a number of interesting features about the consensus code process as evidenced by the NFPA and the National Electrical Code. Strengths of the consensus approach as well as weaknesses were evident. In the discussion that follows, some of the most important strengths and weaknesses are discussed.

The obvious weaknesses in the NEC are the degree to which the entire process rests upon vested interests for financial support, technical validity, and manpower. In general, the participants in the Code-making process are employed by organizations that have substantial financial stakes in the outcome of the Code-making process. The existence of a vested interest has two interesting features: The first is that there is substantial resistance to change that adversely affects the financial interests of the organizations represented by the individuals that serve on the Code-making bodies. The second interesting feature of vested interests that became apparent in this project is the vulnerability of firms attempting to innovate in electrical distribution systems. Those firms that were members of our consortium were unable to support the project when protests were lodged, because the protests were lodged against other vested interests that could influence areas of existing business for the companies involved. None of the companies were willing to risk the adverse impact on their current product line that might be generated by the protest activities required to achieve a just resolution. Those organizations opposing Article 328 had the ability to seriously affect the use of other projects unrelated to Flat Conductor Cable marketed by members of the consortium.

No user representation is apparent in the Code-making bodies. This is true and unavoidably so when each Code-making panel member is sponsored by his own interest group, whether it is an association or an individual corporation. No sponsorship appears to be available to finance the travel and manpower needed to represent the public interest. In addition, as is frequently pointed out, the relevant knowledge for Code-making rests with those individuals who are involved in the electrical industry, and it is difficult to find a knowledgeable representative capable of presenting the user's viewpoint. In this unusual proceeding, the involvement of T+E could objectively include the impact on users in a way that would not have been possible if T+E had had a vested interest in the electrical industry.

It would be possible to include representatives for each panel from private or public groups representing user or public interests. For example, HUD or GSA representatives could serve on appropriate panels. But it is unclear that a few isolated votes could fundamentally affect an entrenched vested interest system.

A very difficult issue to deal with in the consensus code process is the concept of social benefit versus social cost in the establishment of codes and standards. No cost-benefit argument can suffice to foster the adoption of a Code article if there are any weaknesses in the proposed hardware when compared with conventional or existing hardware. That is to say that a wiring system that decreased the cost of wiring buildings by an order of magnitude would not be adopted if there was any area in which it did not meet the performance standards met by existing systems with which it would compete. This would be legitimate were it the case that existing performance standards are systematically related to actual minimum safety requirements for a system in real-world use. In fact, there is no such relationship in many cases. Safety standards, rather, are based on precedent: If conventional components have the capability of performing up to a certain level, then that level becomes the performance or safety criterion even though this level of performance may represent an extreme condition that would never be encountered by a system in actual use. If an innovative system cannot comply with this criterion, then it is deemed "unsafe" even though it may exceed any criterion demanded by real-world operating conditions. Conversely, if conventional components cannot meet a real performance standard, the safety criterion that is established reflects the limitations of these components, making conventional systems slightly unsafe in objective terms, for want of a satisfactory technical solution. If an innovation comes along that can overcome these limitations, its strong advantage may be unappreciated by the existing precedent-based system of safety criteria.

The problem relates to types of performance as well as levels of performance. The technical criteria by which a system is initially judged are based on tests that are applied to existing products which accomplish the same function as the proposed system, even though those tests may be unrelated to the proposed system. Similarly, and unfortunately, it is possible to fail to realize tests that should be conducted on a new system and incorporated into the approval process for that system when those same tests have not been appropriate nor required for the products with which the system competes.

These problems of social benefit versus social cost are difficult to deal with and may be no less inherent in any alternative code system than they are in the present consensus system. The present system could benefit, though, from a rethinking of this area. The problem involves Underwriters Laboratories and other independent testing laboratories, and their complex relationship to the code structure, at least as much as it involves the formal code bodies themselves.

A further problem is that it is difficult to carry out field test installations under the current system. There is a potential Catch-22 situation. The Code-making body may require field documentation of a new system as a condition for accepting it; but the only practical way of getting this field experience may be through having Code acceptance in the first place. A special or limited field test program might work to everyone's benefit.

In the case of the National Electrical Code, the unique role of the Correlating Committee is of importance. The Correlating Committee role is ost nsibly procedural rather than technical: It determines consensus and consistency in the Code-making process, and does not explicitly address technical issues, issues that are considered to be handled by the Technical Panels. In reality, however, the Correlating Committee must understand the substance of those technical issues in which a Panel does not reach consensus. There is a basic question as to whether the Correlating Committee <u>can</u> understand these technical issues, given its workload and the fact that it is normally not provided with the technical documentation for controversial proposals. If the actions on Article 328 are any indication, the primary basis of consideration by the Correlating Committee has been the range of vested interests it represents. It seems to have been an historical fact that the concentration of vested interest influences has been greater in the Correlating Committee than in the Technical Panels.

A related problem of the Correlating Committee is the secretiveness of its deliberations. No complete transcript of its proceedings is made available, with the result that there is no assurance that extraneous or unsubstantiated information is not introduced into the proceedings.

The NFPA has been considering stripping the Correlating Committee of the ability to determine "consensus" -- so that its only role will be to determine the consistency and compatibility of actions by the various different Code Panels. This change greatly reduces the potential for abuse of the Code-making process by vested interest pressure.

These weaknesses are substantial and may be of sufficient concern that the consensus code organizations should consider their impact. However, there are many strengths in the consensus code process that must not be compromised in any effort to improve the process to overcome the identified weaknesses.

The first strength of the consensus code process is the obvious indepth knowledge brought to the code-making process at minimum cost to the public. The organizations that are involved in the electrical industry furnish their manpower and pay travel and living expenses for participants in the code-making process. The knowledge represented by these individuals is unattainable elsewhere at any cost.

To the degree that the code-making organizations achieved a balanced representation of the many interest groups that are impacted by any code change activity, it is possible to establish checks and balances against individual vested interests. Unfortunately, when a revolutionary wiring system is proposed, the new system may impact too many of these vested interests at once to achieve a fair consideration on technical grounds. While representation continues to be balanced, it is balanced among a number of organizations, all of which perceive themselves as negatively impacted by the new Code article.

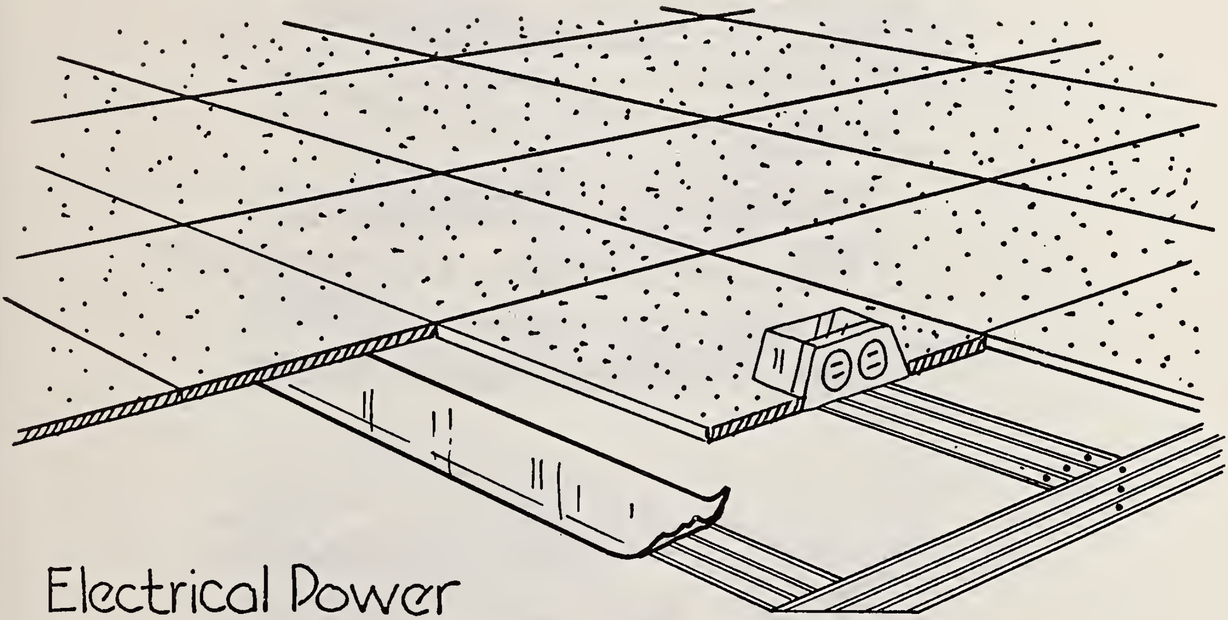
The procedures of the National Fire Protection Assocation provide recourse to assure that each issue can ultimately be resolved on its technical merit and through a system of appeals. Unfortunately, the appeals process is protracted, and the time schedule in the normal code process reduces the effectiveness of the appeals process in achieving resolution of technical injustices. It is almost built in to the system that resolution such as was achieved for Article 328 must come after, not before, the "final" adoption and promulgation of the new Code.

But the appeals mechanism does exist and is viable for a public-interest advocacy, such as T+E's, that does not stand to lose by alienating the NEC Committee membership. While the NFPA Board of Directors and Standards Council do represent their own set of vested interests, these interests are very broadly based throughout NFPA's purview; and the members of these bodies are very aware of the visibility of their actions and of their ultimate accountability to the public.

One final strength of the code process is the vulnerability of the entire consensus code process to alternatives. Congressional committees have been constantly examining the code-making process to determine whether or not it can better be accomplished by a government agency or by an independent organization established specifically for that purpose and funded with public monies. While it is unlikely that there is a better procedure available than the consensus code process, the potential of alternative approaches to the development of codes serves as a powerful check to assure that the consensus code process is responsive to the interests of the public and fair in all respects. Should abuse of the process become widespread, or should even a single instance of blatant disregard for the public interest be clearly documented, then the consensus code process might indeed be jeopardized.

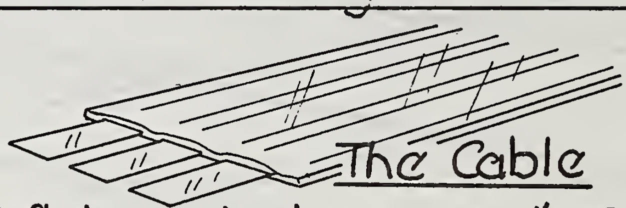
CONCLUSION

The ongoing case history of Article 328, at least as it has unfolded up to the present time, indicates that the consensus code process is viable and is probably better than any alternative that has so far been articulated. The strength of the present system lies in the technical competance of its working participants, and in the insight and integrity of its leadership. At the same time, there are significant operational barriers to realizing the fully equitable process that is intended. The main problem is the scope that is currently allowed to vested interests. Also, the appeals process, while existent and viable, is so difficult to use that the case history of Article 328 is almost unique as an exercise of that process. If the accountability of the consensus code system can be established in fact as well as in theory, then it can be of major service in the enlightened advancement of public needs.



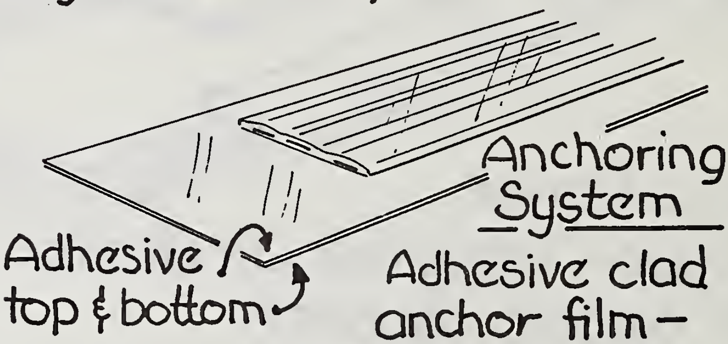
Electrical Power
Distribution using Flat Conductor Cables under carpet squares.

What are the ingredients ?



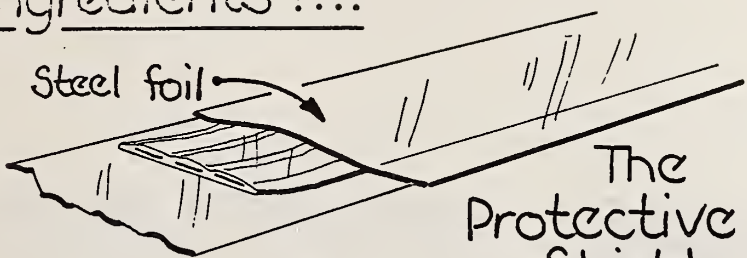
The Cable

3 flat conductors .009" x .600" -each-
12 or 14 gauge equiv.
Mylar insulated, .025" thick



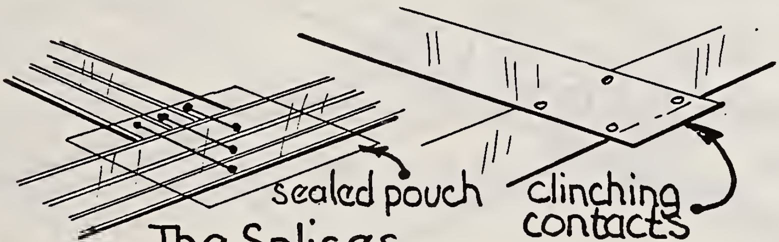
Adhesive clad anchor film - adhered to the floor - then the release paper is removed as required.

Ingredients ?...



The Protective Shield

8 mil. steel foil for physical protection, grounding, and safety.
(Same conductivity as BX jacket)

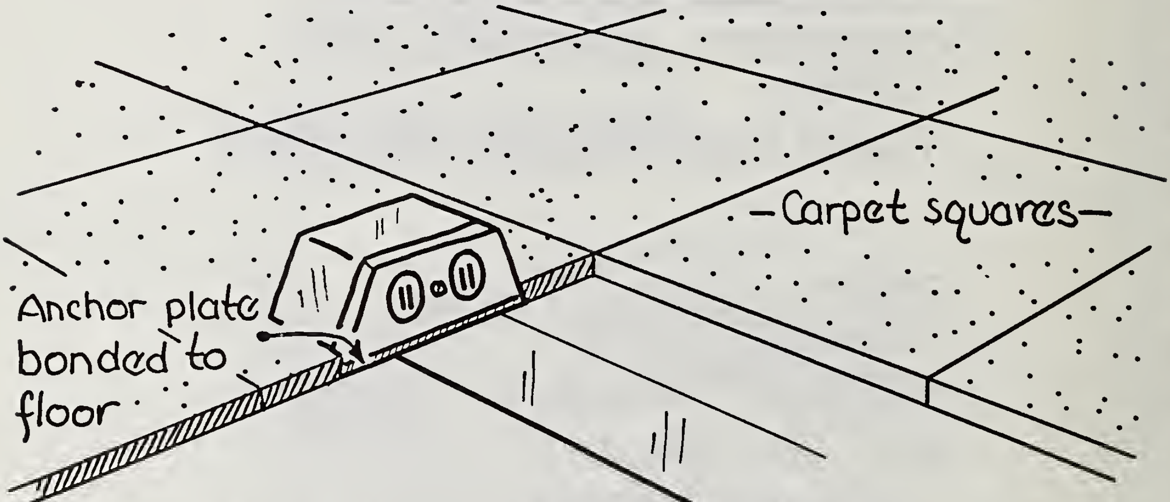


The Splices and T-Taps

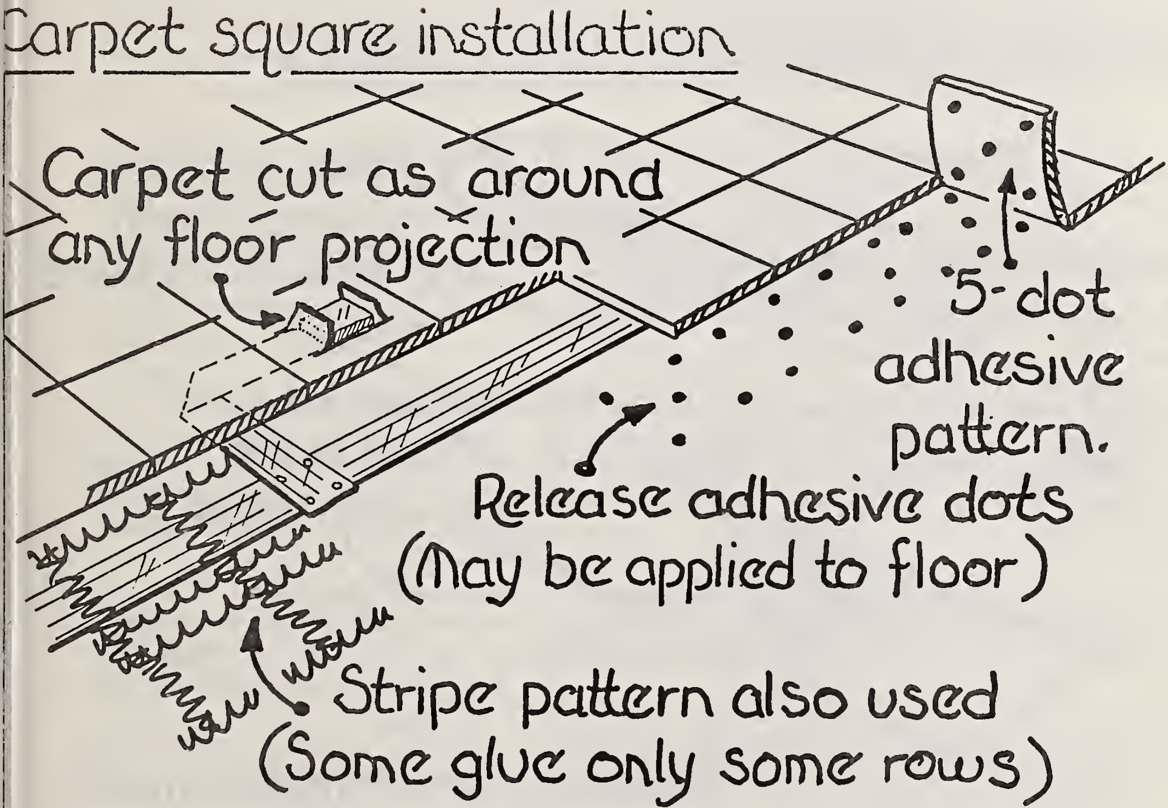
Quick connect joints used to tap outlets into a flat cable run.

Ingredients?...

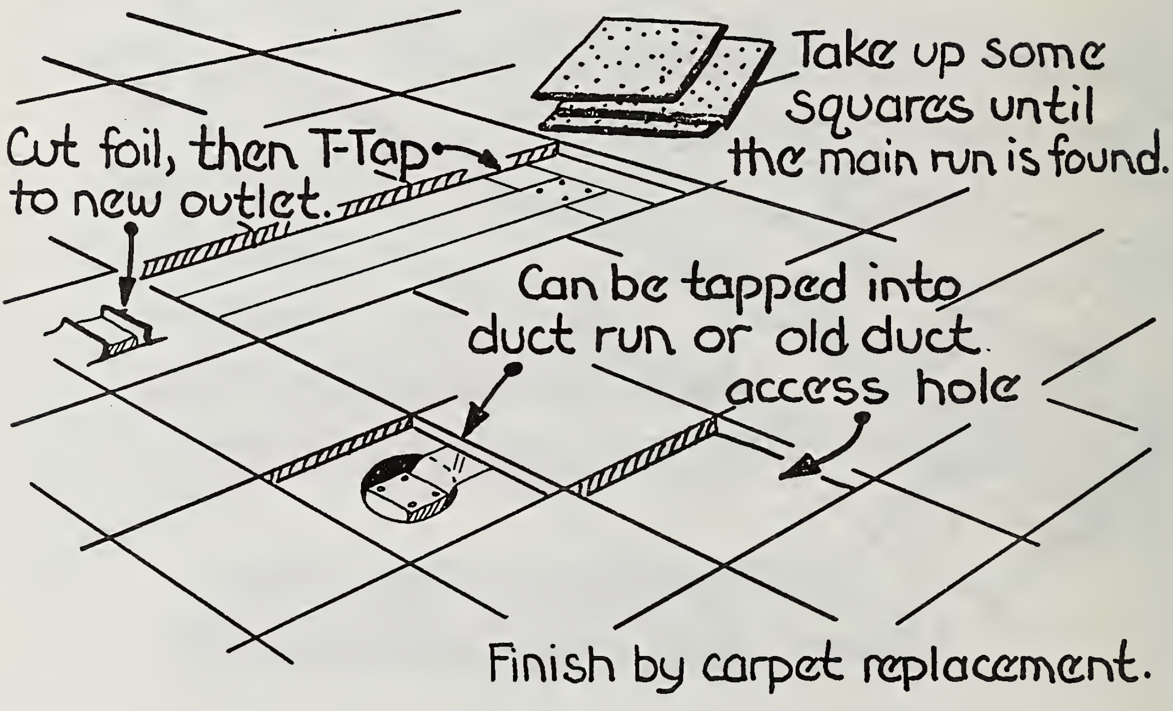
The floor receptacle housing



Base plate bonded to floor.
Top shell installed after carpet.


Carpet square installation
Carpet cut as around any floor projection
5-dot adhesive pattern.
Release adhesive dots (May be applied to floor)
Stripe pattern also used (Some glue only some rows)

Easy to change and add outlets



FEDERAL GOVERNMENT ACTIVITIES RELATIVE TO THE

DEVELOPMENT OF VOLUNTARY CONSENSUS STANDARDS

by

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Federal government agencies have been involved in voluntary standards activities for many years and have made significant contributions to the development of consensus standards covering many product areas. This involvement of Federal agencies has strengthened the voluntary standards system and has tended to reduce the need for government regulations.

The policy established by one Federal regulatory agency - the Consumer Product Safety Commission - regarding the involvement of its staff in the development of voluntary standards is discussed in this paper along with the criteria that have been imposed on the staff in an attempt to reduce the appearance of any conflict of interest between these activities and the agency's regulatory responsibilities.

The philosophy and requirements of the proposed circular published by the Office of Management and Budget is also described in this paper. The restrictions on Federal agency involvement in voluntary standards activities and the objectives of this proposed uniform Federal agency policy are discussed.

The paper also presents a summary of the voluntary standards activities of several Federal regulatory agencies and compares the similarities as well as the differences of some Federal agency policies and programs.

Key Words: Federal policies, voluntary standards, consensus standards, voluntary standards system, Federal voluntary standards policy.

Federal Government Activities Relative to the Development of Voluntary Consensus Standards*

HISTORICAL BACKGROUND

The Federal government has been both interested in and involved in voluntary standards activities for many years. The National Bureau of Standards has been represented on committees of the oldest consensus standards organization in America - The American Society for Testing and Materials, - since shortly after its establishment in 1902. The National Bureau of Standards was also associated with the American Engineering Standards Committee from its establishment in 1909. In 1919, the Department of Commerce along with the War Department and the Navy Department became founding organizations with five engineering societies of the reorganized American Engineering Standards Committee. This Committee became the national clearinghouse for engineering and industrial standardization activities throughout the United States. In 1928, the committee was again reorganized, this time as the American Standards Association, the predesessor to the American National Standards Institute.

Representatives of Federal agencies have contributed significantly to the development and growth of the voluntary consensus standards system throughout the years by providing guidance and assistance in establishing procedures and requirements for the consensus process and by suggesting voluntary standards projects as well as by providing technical assistance in developing such standards. This involvement by Federal agency personnel has not only strengthened the voluntary standard system generally, but has tended to reduce the need for mandatory government regulations by encouraging the development and use of appropriate voluntary standards.

CPSC POLICY

One of the first Federal agencies to establish a formal policy concerning the participation of its staff in the activities of voluntary standards organizations was the Consumer Product Safety Commission (CPSC). The Commission, established in May of 1973, is a relatively new

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*This article was written by Donald R. Mackay, Director, Voluntary Standards, Office of Program Management, of the Consumer Product Safety Commission. Inasmuch as it was written by Mr. Mackay in his official capacity, it is in the public domain and may be freely copied or reprinted. The opinions expressed in this article are those of the author. They do not necessarily represent an official position of the Consumer Product Safety Commission.

independent Federal regulatory agency with responsibilities for the safety of consumer products. In its first year of existence, the Commission discussed the need for a formal policy concerning the membership and participation of its staff in voluntary standards organizations. The need for such a policy was identified by the Office of the General Counsel which was particularly concerned about a real or an apparent conflict-of-interest situation. The lawyers were concerned that any involvement by Commission senior staff persons in voluntary standards activities might conflict with their assigned responsibilities for selecting offerors under Section 7 of the Consumer Product Safety Act (CPSA) to develop mandatory consumer product safety standards or for selecting voluntary standards to be mandated by the Commission under Sections 7 and 9 of the CPSA.

In an effort to avoid any such potential conflict of interest situations, and in an attempt to reduce the appearance of any possible conflict of interests between the voluntary standards activities in which the Commission staff were involved and any regulatory development proceedings, the Commission developed and implemented a policy to prohibit certain senior staff persons from being involved in voluntary standards activities and established specific criteria for those who were allowed to participate in such activities. The policy identifies those individuals who, because of their positions, are responsible for recommending or selecting potential offerors under Section 7 of the CPSA and for recommending or selecting existing voluntary standards as possible mandatory standards. These individuals, as well as the Commissioners, their special assistants, and members of the Office of the General Counsel, are prohibited from any involvement in voluntary standards activities.

The Commission policy requires that any individuals who are not prohibited from involvement in voluntary standards activities can participate as "advisory non-voting" members of standards development committees or organizations, but only after such participation had been approved in advance by the Executive Director. This particular requirement provides control over the selection of personnel to represent the Commission in these activities and provides coordination over the involvement of personnel from various organizational units within the Commission in the standards development process.

The Commission policy requires that the meetings of standards development committees be open to the public, at least for those portions which the Commission staff attends. This requirement is in line with the Commission's openness policy which requires that all outside meetings attended by Commission staff be announced in advance and be open to the public. The "announcement" requirement is facilitated by a weekly "public calendar" published by the Commission listing all outside meetings to be attended by Commission personnel. This policy requirement did cause some standards groups to open previously closed standards development sessions. It also prevented Commission staff from being involved in several groups that could not function in an open forum.

The Commission policy requiring participation as "advisory, non-voting" members of standards committees was established to preclude any possible indication of approval by the Commission representative of a voluntary standard. The Commission believed that it would be inappropriate for the staff to indicate acceptance or approval of a voluntary safety standard that might subsequently be the subject of a review and critique during a regulatory proceeding. The policy requires that any listing of the committee include an explanation that the Commission representative is an "advisory, non-voting" member of the group. This Commission policy, which was recently revised to include the changes resulting from the reorganization of the Commission, has been codified in the Code of Federal Regulations, Title 16, Part 1031.

In 1976, the Commission became concerned about the need for establishing specific criteria concerning the type of involvement of the Commission staff in specific voluntary standards activities and the approval process for such involvement. In November of 1977, the Commission published in the Federal Register a policy governing its involvement in specific activities. This policy was subsequently modified as a result of comments and the revised policy was published on May 4, 1978, in the Federal Register. It has been codified in the Code of Federal Regulations as Title 16, Part 1032.

The Commission's second policy statement describes the importance of voluntary standards to the overall mission of the Commission, discusses the types of support the Commission might provide in the development and implementation of voluntary safety standards, and defines three levels of involvement in the development of such standards. These levels are "liaison", "monitoring" and "participation" and are defined as follows:

"Liaison" includes responding to requests for information concerning the frequency and severity of injuries involving a specific type of consumer product, providing summaries of in-depth investigation reports, and describing the Commission's policies or programs regarding voluntary standards.

"Monitoring" includes attendance at meetings of voluntary standards committees and active involvement in the development of the standards either in person or through correspondence.

"Participation" includes "monitoring" activities and a commitment of Commission resources to actively support the development and implementation of a voluntary standard.

The policy allows the Executive Director to approve liaison and monitoring projects, but requires that participation projects be approved by a majority of the Commissioners. These activities must be approved because Congressionally appropriated funds are to be used to support specific voluntary standards projects. Such funds could be used to provide engineering research and assistance in the development of performance criteria and test methods, to support the development of labeling criteria, or to provide information and educational materials to support the use of a safety standard.

At the present time, the Consumer Product Safety Commission is involved in some 33 voluntary standards projects including 5 liaison projects, 25 monitoring projects, and 3 participation projects. Included in the voluntary standards program are monitoring projects for smoke detectors, energy conservation devices, television sets, solar collectors, and ranges and ovens, to name some that might be of interest or concern to building code officials. One of the participation projects concerns voluntary standards for bathtubs and shower enclosures. These standards, which have just been approved by ASTM, provide performance requirements for slip-resistant bathing surfaces, thermal shock prevention devices, and temperature limiting scald burn prevention devices. These standards will become the topic of discussion among building code officials in the near future because they will not become effective unless they are referenced in state and regional codes.

The voluntary standards project for bathtub and shower enclosures provides a good example of why and how the Commission interacts with the voluntary standards system. In 1973, bathtubs and shower enclosures were ranked 14th in a list of 369 consumer products on the Commission's product hazard index. In an attempt to identify the hazard patterns associated with bathtubs and shower stalls and to develop possible corrective actions, the Commission contracted with Abt Associates in Cambridge to analyze the Commission's injury data and to develop ways to reduce these hazards. While this contract study was being conducted, a task force was set up in ASTM's newly established Committee F-15 on Consumer Product Safety to develop voluntary safety standards which would effectively address the hazards associated with the use of bathtubs and shower stalls.

One major complication to the initiation of a voluntary standards effort was a Department of Justice consent decree which restricted joint industry activities and appeared to preclude the involvement of the producers in the development of voluntary standards. A request was made by ASTM to the Department of Justice to provide an opinion as to whether or not participation by the industry in the development of ASTM consensus standards would represent a violation of the consent decree. After several months, the Justice Department suggested specific procedures, including the involvement of consumers and general interests in the standards development process, that would tend to avoid anti-trust concerns and restraint of trade problems.

Once this assurance was received, the ASTM Task Force F15.03 was established and held its initial meeting in April of 1975. One of the first actions the task force took was to write to the Commission to ask that it withhold the development of any mandatory standards for bathtubs and shower stalls while ASTM was actively engaged in developing voluntary safety standards that would adequately and reasonably address the identified risks of injury. This request to the Commission was based on information that the Commission was considering the initiation of mandatory standards, and a recommendation in the report from the Abt contract study. The Commission indicated that while it could not guarantee that it would not initiate a mandatory standards proceeding at some time in the future, the Commission had no immediate plans to do so.

The ASTM Task Group F15.03, using the Abt report and the Commission's injury data, decided to address not only the slipperiness of bathing surface but also, the need for requirements for grab-bars, and the hazards of hot water burns and thermal shocks. Representatives of companies producing each of these products were invited to join the task force along with consumers and general interest representatives. The membership of the task group totaled over 100 persons and was appropriately balanced so that no one group dominated the discussions and decisions of the task group or its subgroups.

In June of 1976, just 14 months after the task group was formally established, proposed standards had been developed for

1) slip resistant bathing facilities,
2) grab-bars and accessories installed in the bathing area,
3) scald-preventing devices, and,
4) thermal-shock preventing devices.

These standards were subsequently subjected to letter ballots within the Task Group and the F-15 Committee where they encountered some opposition The resulting negative ballots took time to resolve and required some additional research and testing. Finally, after a Society ballot, and the resolving of additional negative ballots, the four standards were approved for publication on August 12, 1978.

During the standards development process, the Commission was appropriately represented on the task force and its subgroups. Representatives from the Commission's Voluntary Standards Division, its Bureau of Engineering Sciences, and its Bureau of Information and Education attended many of the meetings and participated in the discussions relating to the development of the requirements and test methods. The Commission also supported key research work at the National Bureau of Standards in the development of a test method and testing equipment to measure the slipperiness of bathing surfaces.

It appears at the present time that the effectiveness of the four standards approved by ASTM for improving the safe use of bathtubs and shower enclosures will be dependent upon the adoption of these voluntary standards by state and local code authorities and by the nationally recognized building codes. The increased costs of products meeting the ASTM standards will not induce individual builders or homeowners to install this equipment in new homes, townhouses and apartments. Builders will have to be encouraged to procure and install this equipment.

The problem of encouraging the use of those products meeting the ASTM safety standards might be reduced if the Commission promoted the use of these products, and if the FHA and VA specifications required the installation of these products, but the greatest support would come from the incorporation of requirements for improved safety in the nationally recognized building codes. This approach will be considered by the Commission within the next year as the bathtub and shower safety project is reviewed and reevaluated. Obviously, the safety standards will not benefit anybody if they just sit on ASTM shelves. And with hazards associated with products such as these, which last a life-time or more, it is very difficult to mount effective retrofit programs. To my mind, the way to solving problems such as those associated with bathtubs and shower stalls is through the model building codes and through building code officials.

OMB CIRCULAR

In December of 1977, the Office of Management and Budget (OMB) published a proposed circular which established a policy for Federal agency involvement in voluntary standards activities. This circular was the administration's response to several bills that had been debated in the U.S. Congress concerning the voluntary standards system in the United States and the need for Federal intervention into the system. The OMB proposed circular provided for:

1) Federal agency reliance upon, and use of, voluntary consensus standards, whenever feasible and appropriate, as a means of reducing and eliminating redundant Federal efforts to develop and maintain in-house Government standards;

2) Federal agency participation in, and support of, standards-development activities of voluntary organizations having approved procedures so that the current confusion and lack of uniformity among Federal agencies in this regard can be eliminated, and

3) Coordination of Federal agency participation in voluntary standards-developing bodies so that the most effective use is made of Federal agency representatives and the views expressed by such representatives do not conflict with the views and interests of Federal agencies.

The draft Circular provided guidelines with regard to each of these policy principles - primary among which is the requirement that, as a precondition to Federal participation, voluntary consensus standards-developing bodies must abide by appropriate procedures for ensuring due process. The proposed Circular also assigned to the Secretary of Commerce the responsibility for directing and overseeing the implementation of the proposed policy.

Specifically the policy proposed in the OMB Circular provided that:

1) Voluntary consensus standards will be adopted, in whole or in part, and will be used by Federal agencies in lieu of developing and using in-house standards when voluntary consensus standards will serve the agencies purposes and are consistent with applicable laws and regulatio

2) Voluntary consensus standards will be assigned preference in procurement actions in the absence of mandatory Federal standards unless use of such voluntary consensus standards would result in impaired functional performance, unnecessary overall cost to the Government or the Nation, anticompetitive effects, or other significant disadvantages;

3) Voluntary consensus standards will be utilized in Federal regulatory applications after a careful evaluation of such standards assures their adoption and use to be in full accordance with the agencies statutory missions and responsibilities, and other applicable laws and regulations;

4) Voluntary consensus standards which are adopted by Federal agencies will be cited, along with the dates of their issuance and source of availability, in appropriate publications, regulatory orders, and related in-house documents;

5) Notwithstanding the foregoing, agencies will not be inhibited, if within their statutory authorities from developing and using in-house standards in the event that voluntary standards-developing organizations cannot or do not develop a standard needed by, and acceptable to, these agencies or do not do so in a timely fashion. Nor shall the policies contained in this Circular be construed to commit any agency to the use of a voluntary standard which, in its opinion, is inadequate, does not meet statutory criteria, or is otherwise inappropriate for the agency concerned.

Further, the OMB proposed circular recommended that specific criteria be met prior to participation in voluntary standardization activities. These criteria included the following provisions:

1) Participation by Federal agency representatives shall be authorize by apropriate agency officials but such participation, of itself, shall not connote agency agreement with, or endorsement of, decisions reached by voluntary standards-developing committees or of standards approved

and published by voluntary consensus standards-developing bodies.

2) For regulatory applications, participation by Federal agency representatives should be aimed at contributing to the development of voluntary standards which will minimize the need for development of mandatory Federal standards or, as a minimum, collecting technical and other information which will provide a basis for well-considered Federal regulatory actions.

3) Federal agency participants in voluntary consensus standards-developing committees will avoid dominating or exerting undue influence in such committees. The number of individual Federal agency participants on a given voluntary standards-developing committee shall be kept to the minimum required for effective presentation of the various program, technical, and other concerns of Federal agencies.

4) The granting of Federal support to a voluntary consensus standards-developing committee shall be limited to that which is clearly in furtherance of an agency's missions and responsibilities. The amount of Federal support given shall be no greater than that of all non-Federal participants in that committee.

5) Participation by agencies should not extend to decision making involvement in the policy making process of voluntary standards-developing bodies (e.g., election of officers, setting of membership fees), except in accordance with the policies and precedures established by the Secretary of Commerce.

Finally, the proposed OMB Circular established certain preconditions for Federal involvement in the activities of voluntary consensus standards-developing bodies. These preconditions included the following:

1) That adequate public notification of meetings and other standards-development activities is provided;

2) That standards-development meetings are open to interested persons and that unreasonable restrictions on membership on standards-development committees by means of professional or technical qualifications, trade requirements, unreasonable fees, or other such restrictions are avoided;

3) That standards-developing bodies make a good faith effort to achieve appropriately balanced representation of all affected interests on their standards-developing committees. Such representation may include, for example consumers; small business concerns; manufacturers; labor; suppliers distributors; industrial, institutional and other users; environmental and conservation groups; and state and local procurement and code officials;

4) That prompt and full consideration is given to the expressed views and interests of all interested persons;

5) That adequate and impartial appeals mechanisms are in force for use by interested parties;

6) That appropriate and complete records are maintained of formal discussions, decisions, standards drafts, technical or other rationale for critical requirements of standards, meeting minutes and balloting results; and that such records are readily accessible to all interested persons on a timely basis;

7) That literature published by standards-developing bodies specifica state that participation by Government officials in that organization does not constitute Government endorsement of that organization or the standards which it develops;

8) That standards-developing bodies agree to utilize the Department c Commerce mediation and conciliation service, as described in paragraph 7a(6), in the resolution of procedural complaints by private sector parties, and to be bound by the results of that process, provided that appeals procedures of the voluntary consensus standards-developing bodies have been exhausted.

10) That existing standards are periodically reviewed and revised, as necessary, and that access to the review process is granted to all interested persons;

11) That preference is given to the use of performance criteria in standards development when such criteria may be used in lieu of design, materials, or construction criteria.

Clearly, the proposed OMB circular attempts to establish reasonable requirements for involvement of Federal personnel in the voluntary standards system and in the development of voluntary consensus standards, while proposing certain procedural requirements in the organizations developing such standards. The restrictions proposed in the OMB circular are intended to improve the consensus standards development process, the standards themselves and the organizations responsible for them. Although the Federal government cannot dictate requirements and improvements to the voluntary system, it can establish some conditions for Federal involvement and participation in the system. The results of the final OMB Circular, whenever it is issued, should have a significant impact in the voluntary system.

SUMMARY OF FEDERAL ACTIVITIES

The National Bureau of Standards probably has the longest history of involvement in the development of voluntary consensus standards and undoubtedly has the greatest number of employees participating in the voluntary standards system. However, it is interesting to note that eleven cabinet level Federal departments and seven other Federal agencies are involved in the activities related to the development of voluntary standards. Each of the eighteen Federal agencies are identified in the Appendix with the major voluntary standards organizations to which they provide representatives.

Only a few Federal agencies have as yet established formal policy statements governing the participation of staff personnel in the development of voluntary standards and membership in voluntary standards organizations. Some agencies have no official policies but rely on the judgement of the official responsible for authorizing travel to meetings of voluntary standards committees and organizations. Other agencies, such as the National Bureau of Standards, the Food and Drug Administration, and the Consumer Product Safety Commission have an established policy and require approval in advance to represent the agency on particular standards committees.

The major difference in the various established policies concern the issue of voting on the approval of standards. The National Bureau of Standards, for instance, allows its staff representatives to ballot on the approval of voluntary standards. The Consumer Product Safety Commission, on the other hand, prohibits its staff from voting or otherwise indicating approval of voluntary standards. One other significant difference between standards policies of different agencies concerns the openness of the meeting convened by standards development organizations. The Commission specifically prohibits the attendance of its staff at meetings which are closed to the public while other agencies are silent on this matter. The last difference which should be mentioned concerns the encourgement of standards development under full consensus procedures. The Commission policy specifically encourages the involvement of its staff members in the development of consensus standards through committees that are appropriately balanced with representatives of all valid interests. Other agencies allow their staff to be involved in the development of industry standards through committees that are not appropriately balanced.

CONCLUSION

The Federal government and its several agencies have a definite interest in the development of voluntary consensus standards and in the success of the voluntary standards system in the United States. Over the years, Federal agencies have made significant contributions, both technical and administrative, to the development consensus standards covering many product areas. This involvement of Federal agencies has strengthened the voluntary standards system in the past and it is anticipated, particularly with the finalization of the OMB Circular, that such Federal involvement will continue to strengthen and improve the system in the future.

The role of building code officials and nationally recognized building code organizations is very important to the successful implementation and use of voluntary consensus standards for it is only through the adoption by regulatory agencies with compliance and enforcement powers that the many voluntary standards become very effective in improving health and safety and in reducing hazards and other problems which these standards were designed to address.

Therein lies a challenge both to building code officials and voluntary standards organizations - to involve the building code officials and representatives of national building code groups in the initiation and development of voluntary consensus standards that may subsequently be referenced in nationally recognized building codes and subsequently enforced by state and local building code officials. For, if these persons are involved in the development process as well as the approval process, the resulting standards will obviously be more acceptable to those who will be able to reference them in building codes and enforce them at the local level.

The challenge is to encourage the standards development committees to invite the building code officials to the standards development table and to stimulate the building code officials to willingly participate in voluntary standards activities. It will only be through this type of a voluntary process that we will be able to make progress in improving our living standard as well as our building requirements.

APPENDIX I

LISTING OF FEDERAL AGENCY INVOLVEMENT IN VOLUNTARY STANDARDS ACTIVITIES

(A partial listing of organizations)

Department of Agriculture

- American Society for Testing and Materials
- American Society of Mechanical Engineers
- Association of Official Analytical Chemists
- National Sanitation Foundation

Department of Commerce

- Aerospace Industries Association
- American Association of Textile Chemists and Colorists
- American Gas Association
- American Nuclear Society
- American Public Health Association
- American Society for Testing and Materials
- American Society of Mechanical Engineers
- Electronic Industries Association
- Instrument Society of America
- National Electrical Manufacturers Association
- National Fire Protection Association
- Outdoor Power Equipment Institute
- Society of Automotive Engineers
- Underwriters' Laboratories

Department of Defense

- Aerospace Industry Association
- American National Standards Institute
- American Society for Testing and Materials
- American Society of Mechanical Engineers
- Electronics Industry Association
- Society of Automotive Engineers

Department of Energy

- American National Standards Institute
- American Nuclear Society
- American Public Health Association
- American Society for Testing and Materials
- American Society of Mechanical Engineers
- National Council on Radiation Protection and Measurements

Department of Health, Education, and Welfare

- American National Standards Institute
- American Society for Testing and Materials
- Association for the Advancement of Medical Instrumentation
- Institute of Electrical and Electronics Engineers
- National Council on Radiation Protection and Measurements
- National Fire Protection Association
- Society of Automotive Engineers

Department of Housing and Urban Development

American Lumber Standards Committee
American National Standards Institute
American Society for Testing and Materials
National Fire Protection Association

Department of the Interior

American National Standards Institute
American Nuclear Society
American Society for Testing and Materials
American Society of Mechanical Engineers
National Fire Protection Association

Department of Justice

American National Standards Institute
American Society for Testing and Materials

Deapartment of Labor

American Industrial Hygiene Association
American National Standards Institute
American Society for Testing and Materials
National Fire Protection Association

Department of Transportation

American National Standards Institute
American Society for Testing and Materials
National Committee on Uniform Traffic Laws and Ordinances
Society of Automotive Engineers

Department of the Treasury

American Petroleum Institute
American Society for Testing and Materials
Association of Official Analytical Chemists

Consumer Product Safety Commission

American National Standards Institute
American Society for Testing and Materials
National Swimming Pool Institute
Society of Automotive Engineers
Underwriters' Laboratory

Environmental Protection Agency

American Health Physicists Association
American National Standards Institute
American Public Health Association
American Society for Testing and Materials
American Society of Mechanical Engineers

Federal Communications Commission

American National Standards Institute

General Services Administration

American National Standards Institute
American Society for Testing and Materials

National Aeronautics and Space Administration

American Institute of Aeronautics and Astronautics
American Institute of Electrical Engineers
Society of Automotive Engineers

Nuclear Regulatory Commission

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American Public Health Association
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American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
National Council on Radiation Protection and Measurement
National Fire Protection Association

Veterans Administration

American Association of Medical Instrumentation
American National Standards Institute
American Society for Testing and Materials
National Fire Protecton Association
Underwriters' Laboratories

THE FORMULATION OF SENSIBLE REGULATIONS FOR ACCESSIBLE REHABILITATION HOUSING

by

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In order to achieve better housing alternatives for America's elderly and disabled populations, sensible regulations covering accessibility are necessary. A more accessible housing market could help reverse the present rise in the number of dependent care settings. The regulation of new construction in terms of accessibility will soon be easier with the publication of the American National Standards Institute, Inc. (ANSI) standard on accessibility for the physically disabled. While the document is expected to be comprehensive in terms of new construction, the same standards may not be appropriate in regards to the adaptation of existing housing. Additional research on adaptation is necessary in order to formulate guidelines for making existing housing units accessible for wheelchair bound individuals.

The new research should include a study of a variety of existing housing units which have been adapted and modified by disabled users to become more accessible. Methods for programming designs of housing projects with future adaptations in mind need to be explored. Until these new research findings become available, regulatory officials will have little to guide them in regulating housing adaptations.

Key Words: accessible; disabled; regulations; housing.

INTRODUCTION

There is a growing movement in this country to create better housing opportunities for the elderly and disabled populations. Americans can expect to see an expanding trend towards the rehabilitation of existing housing stock in the next few years due to the sharp rise in the cost of new housing.

Relocating elderly and disabled individuals to new housing is becoming costly in other respects also. Elderly residents living alone, for example, often experience physical setbacks which result in forced, and often premature moves to nursing care settings. In the case of an elderly widow who breaks a hip, for example, a long hospital stay followed by an extended period in a wheelchair can be expected. If her home is not barrier free she may be forced into a nursing home, may then become more dependent than she was previous to her injury, and may never return to her own home again. The alarming rise in the number of dependent care settings for elderly Americans can be slowed to some extent if existing housing can be adapted to be more supportive for those individuals.

THE IOWA EXAMPLE

In order to explore the regulatory implications for accessible rehabilitation housing it is useful to review what has happened in the State of Iowa.

In 1975 the State of Iowa passed a law which was to provide better housing opportunities for the physically disabled. The law, which has since been revised, required that all new apartment buildings with five or more living units must have 10% of those units completely "barrier free" or "accessible." As a result Iowa now has over 400 new barrier free apartments. However, as few as 53 disabled people are actually living in the 400 new barrier free apartments. One reason for this is that the rents (usually ranging from $200 to $300 per month) are too high for most disabled people. Additionally, most of the new housing projects are located far away from public transportation and services. Another problem is that when disabled people do not rent the special apartments, the units are difficult to rent to able bodied people. There seems to be a stigma attached to the "specially" designed units, making them less desirable for the population at large. Many builders and developers are currently complaining that even after advertising apartments as "specially designed for the handicapped" they are not renting them. And the cost of these vacant apartments is being borne by the rest of the tenants.

These problems have recently resulted in a relaxation of the 1975 state law. Under the revised law, accessibility requirements apply only to apartment structures having more than 12 units instead of five.

The Iowa example raises a question relating to the idea of regulating the number or percentage of units to be accessible. While the intention behind the idea is well founded, the regulation did not seem to work very well. The new accessible housing has been inappropriately located, inappropriately designed, and inappropriately marketed to the public and thus has not met the needs of the disabled population.

LOCATIONAL ISSUES

In terms of locational issues the answer may lie not in regulations but rather in studying the various locational factors as they affect each project. A checklist of important locational issues can serve as a guide to regulatory officials.

The following example may be included in such a checklist.

Is the site of the proposed project................

1) convenient to "accessible" public transportation?
2) within a few blocks of grocery shopping?
3) surrounded by a neighborhood with well lighted sidewalks, curb cuts, ramps, and accessible parking areas?
4) surrounded by a relatively flat terrain?

Assuming that locational factors such as these can be effectively monitored by local officials rather than regulated by law, how can we insure that the living units themselves are appropriately designed for disabled residents? The answer here is not a simple one. In order to examine this question further, let us first look at the regulatory process in regard to new construction.

REGULATING NEW CONSTRUCTION

A new revised ANSI standard document on accessibility will be available in the coming months. The original document, ANSI Standard 117.1, published in 1961 by the American National Standards Institute, Inc., was entitled "Specifications for Making Buildings and Facilities Accessible to, and Usable by, the Physically Handicapped". The outdated 1961 document will now be replaced by a totally revised and much more comprehensive document.

While there are bound to be problems with the new standard, it does appear to be a step in the right direction. It is anticipated that the new standard, once it is made public, will achieve rapid acceptance at the federal, state, and local levels.

The challenge to make much of the existing housing stock accessible is a great one indeed. As was mentioned in the Iowa example earlier, the cost of new accessible housing is prohibitive for much of the disabled population. Therefore, more often than not, disabled individuals are forced to try and make do with old, obsolete, but less expensive living facilities. In examing how a variety of individuals have managed to adapt their homes or apartments to become accessible the author has noted that doors are frequently removed to provide easier access between rooms. The current recommended clear opening width of 32 inches often cannot be achieved without the complete removal of a door. This may be because the door itself is too narrow or because the door does not swing to a fully opened position. Even when doors are wide enough they may continually get in the way for wheelchair users. This does not imply that we should do away with all interior doors. It does imply that we must employ sensible design procedures to insure that doors function as well for wheelchair bound individuals as they do for fully ambulatory individuals. A thorough study of the multitude of existing interior doorway arrangements should be initiated in order that guidelines for adaptive design can be written. A variety of existing living settings should be examined and studied carefully to cover the spectrum of possible doorway conditions which now exist.

In addition to doors and doorways, kitchen and bathrooms have traditionally presented problems for disabled users. These areas of the home also need to be extensively studied before sensible guidelines for adaptation housing can be drafted. Many disabled individuals have been extremely innovative in adapting their behavior in order to use an unsuitable kitchen or bathroom. The author recalls a guadriplegic individual in a motorized wheelchair who braced her wheelchair against a kitchen base cabinet in order to gain leverage to open a refrigerator door. If the cabinet had not been there, the opening of the refrigerator door would have been impossible for her. Other disabled residents have been observed using sticks to knock things off shelves, elbows or shoulders to flip switches, and teeth to turn knobs. In many cases this sort of behavior adaptation or gymnastics is what gives individuals their independence.

In addition to modifying their behavior disabled users often modify their physical environment as well. An example already cited was the removal of doors between rooms. Another example is the lowering of shelves and clothes rods in closets to gain access from a wheelchair. Adaptation to floor surfaces, mirror heights, faucet controls, toilet seats, etc. have also been observed.

In order to fully research the subject of adaptation, two general approaches should be followed. The first approach should be to investigate the existing housing units which have been modified and document the adaptation in those settings. Creative user adaptation techniques should be fully documented in order to aid other disabled users and to aid designers in modifying existing environments. The results of this research approach would be used to help solve the immediate problem of allowing disabled residents to stay in their own homes rather than having to move into more costly housing or more dependent care settings.

A second recommended research approach to studying adaptation should be the exploration of procedures for the programming and design of new construction with future adaptation in mind. It is anticipated that other states may soon follow Iowa in requiring a percentage of housing units be designed to be "barrier free" or completely accessible to wheelchair bound individuals. As these laws take effect the managers of housing projects can be expected to complain about the barrier free units being unacceptable for able bodied residents, more expensive to build, and difficult to rent. The findings from this second research approach may lead to a long term solution to this problem by providing planners, designers and builders with better design methods and low cost adaptation procedures that allow for future adaptations to be made as necessary.

CONCLUSION

The author maintains that regulations resulting from the revised ANSI standard on accessibility will receive rapid and wide acceptance at the federal, state and local levels. These regulations, however, will mostly affect new construction and will not solve the problem of regulating adaptations to existing housing. Since residents are often forced, because of economic reasons, to stay in their present living units, or to relocate to older buildings following a disabling injury or illness, the new ANSI standard on accessibility will only affect a portion of America's disabled population as far as housing is concerned.

Discovering appropriate design methods for adaptation thus becomes an important area of concern for the country's disabled population. In order to develop sensible guidelines for the adaptation of existing housing new research efforts are called for. The results will not only benefit existing facilities but can be expected to lead the way towards more intelligent design strategies in the planning of new housing construction as well.

Until these new research findings become available the question which regulatory agencies and officials must face is, should accessibility adaptations in housing be regulated? It is the author's opinion that guidelines are now a better alternative than regulations because in spite of the recent surge of activity relating to barrier free design, planners, designers and architects are only beginning to understand the full range of design implications of a barrier free America.

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DESIGNING FOR ACCESS TO, MOVEMENT WITHIN, AND EGRESS FROM BUILDING AND SITES: EFFECTIVE RESEARCH FOR MORE REASONABLE REGULATION

by

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ABSTRACT

This paper discusses needs for a more complete and effective technical basis for design standards impacting occupants' access to, movement within, and egress from buildings and building sites. It is suggested that a major cause of injury and death from fire, and of inconvenience and psychological stigmatization to physically handicapped persons, results (even in code-complying buildings and sites) from adherence to design regulations narrowly founded upon physical and engineering principles alone. This paper recommends that psychological aspects of dangerous and stressful situations guide the development of standards for emergency egress facility design, and that such therapeutic objectives as "normalization" guide development of barrier-free design regulations. Finally, this paper outlines particular programmatic themes and research tasks, and discusses the role of the National Bureau of Standards in improving the technical basis for egress and accessibility design regulations.

Key Words: Architectural barriers; building design; building site planning; environmental psychology; evaluation; fire escape; human research; measurement; pedestrian movement; regulation; safety; standards.

INTRODUCTION

The Environmental Design Research Division of the Center for Building Technology, in collaboration with the centers for Fire Research and Consumer Product Technology, National Bureau of Standards (NBS), is working to develop a more complete understanding of pedestrian behavior within buildings. Two important aspects of this overall effort include designing to facilitate the mobility of physically handicapped persons, and providing effective means of emergency egress for all building users. In this paper, the problem of developing an effective technical basis for access/egress standards-writing is explored.

Current design standards for access and egress derive primarily from engineering or other physical procedures and constants (e.g., computations of flow rates through doors, down stairs, etc.; minimum corridor width required for wheelchair passage). An important shortcoming, however, is that such standards take almost no account of the psycho-social aspects of either fire emergencies or physical disabilities. We are learning, though, that such non-physical aspects cannot be ignored. Persons in fires may not always be counted upon to utilize means of egress in ways anticipated (and hence accommodated) by the designer. A wheelchair-bound individual may not always utilize a particular facility (though specially designed and constructed to be accessible) if doing so increases the "obviousness" of his handicap.

Developing building design standards for accessibility by the handicapped, and for emergency egress, is a complex and difficult task. Important complications arise from the fact that pedestrian behavior involves a number of interacting and psychological factors. These are frequently lost, or at least oversimplified, in most engineering specifications and prescriptions. Moreover: (1) even within a single code-defined occupancy, functional characteristics and levels of potential risk ofen vary widely; (2) within any building, occupants often vary widely in terms of their perceptual, cognitive, and motor capabilities; and (3) although the standards-writer will never have an unequivocal data base from which to draw when dealing in the interface between the physical features of buildings and the behavioral responses of human beings, the existing technical base forces him to make gross (and often untested) assumptions.

Unfortunately, empirical data describing the effects of psychological and social factors upon emergency egress, and on mobility, are virtually nonexistent. Morever, Stahl [9] and Stahl and Archea [10] recently suggested that data which has been reported may not be entirely valid. Even such widely-used physical quantities as flow rates on stairs, ramps, and along level surfaces are seriously questioned by Pauls [6] and Turner [11]. Our objectives, then, are to identify gaps in technical bases supporting access/egress design standards, to suggest appropriate avenues for future research, and to discuss the role of NBS in this area.

MODEL CODES AND REGULATORY LEGISLATION: PROBLEMS RESULTING FROM THE APPLICATION OF INCOMPLETE TECHNICAL BASES

Regulatory legislation and the model building codes recommend design standards for improving accessibility to buildings and sites, and for increasing the effectiveness of means of emergency egress from buildings. Often, such standards are supported by incomplete knowledge. Consider the emergency egress problem, for example.

In the United States, design guidelines for emergency egress first appeared during the 1920's. These were developed from analyses of major building fires, such as the Iroquois Theater fire, the Collinwood School fire, and the Triangle Shirtwaste Company fire. The Building Exits Code, first published by the National Fire Protection Association (NFPA) in 1927, contained the first model standards for emergency egress. After the disastrous fire in 1942 at Boston's Coconut Grove night club, the Building Exits Code (now known as the Life Safety Code) was increasingly used as a basis for design regulation and legal action. Chapter 5 of this code deals specifically with the design and provision of means of egress.

In general, emergency egress provisions recommended by the principal model code-writing organizations are adaptations from NFPA's Life Safety Code. These provisions fall into the following major categories: (a) arrangement of exits; (b) minimum number of exits; (c) occupant loading; (d) exit width; (e) exit capacity; and (f) exit protection.

Empirical data applied to the calibration of such design standards derive primarily from the observation of pedestrian movement during non-emergency - and from non "drill" - situations. For example, the Appendix notes to Chapter 5 of the Life Safety Code inform us that the standard 22-inch (.55 m) unit width is derived from the average space needed for the free flow of a single file of pedestrians. Similarly, the specified flow rates of 45 persons per minute per exit unit down stairs, and 60 persons per minute per exit unit on level surfaces are based on the movement of single files of able-bodied occupants. The questions of whether pedestrians really do move in linear files, or whether all persons may be categorized as able-bodied, are not systematically accommodated within these standards. Moreover, one may question whether the kinds of behavior used as a basis for emergency egress design standards are indicative of egress behavior during real emergencies.

Examples which illustrate such shortcomings are nursing homes, in which a sufficient number of staff members trained to quickly evacuate residents from the danger zone is frequently unavailable. Many anecdotal accounts of specific incidents are available (e.g., newspaper stories and eye-witness descriptions), and these may be interpreted to suggest that code complying emergency egress facilities (including horizontal egress to refuge areas) are often not utilized as anticipated by building designers.

For instance, residents of nursing homes have been reported to return to the danger zone, even after having attained refugee in a fire stair enclosure, for various idiosyncratic reasons (e.g., to retrieve a bottle of medication, or to collect family photos). In addition, residents have been reported to equivocate when responding to a fire alarm, exhibiting slow and uncertain movement toward emergency exits, movement along indirect routes, or even no movement toward the exits at all. Finally, many residents of nursing homes must be evacuated with the assistance of at least one staff member, and some emergency plans even require patients to be rolled out on their beds. Such anecdotes plainly question the hypotheses which appear to be built into current standards for the design of emergency egress facilities. There is no way to determine whether deaths in nursing home fires resulted from specific failures in the design of exitways. We are constantly reminded, however, that: 31 people died in the Harmer House (Marietta, Ohio) fire in 1970; 10 people perished in the Baptist Towers Nursing Home (Atlanta, Georgia) fire in 1972; 7 died in the Sac-Osage Hospital (Osceola, Missouri) fire in 1974; and 26 died in the Windcrest Nursing Home (Chicago, Illinois) fire in 1976.

In spite of many unanswered questions, emergency egress provisions of the model building codes are currently enforced by most regulatory jurisdictions in the nation. Moreover, provisions of NFPA's Life Safety Code are incorporated into Federal legislation and regulations concerning building construction. For example, NFPA's emergency egress design standards are promulgated by the Occupational Safety and Health Administration (OSHA). In addition, Title XVIII of the Social Security Act requires that owners of nursing homes receiving Federal funds assure that their buildings conform to provisions of the Life Safety Code. The extension of such design requirements to other Federally assisted facilities is presumed to be under consid eration.

We see then, that design standards stemming from a potentially incomplete data base have pervaded all levels of building regulation, and that they have been with us a good many years. Designers rarely feel compelled to question the value of standards and regulations. They frequently have their hands full simply trying to comply.

Similar circumstances surround the issue of designing facilities which are fully accessible to the physically handicapped. Here again, design standards and regulations are impacting larger and larger segments of the built environment; and again, important questions arise concerning the adequacy and completeness of underlying technical data.

Just who is potentially affected by environmental accessibility standards? Recent estimates by such groups as the National Center for a Barrier Free Environment, the President's Committee on Employment of the Handicapped, and the Architectural and Transportation Barriers Compliance Board all seem to agree that about 10% of the population of the United States suffers from some form of mobility limitations resulting from either temporary or permanent physical disabilities. In addition, the Department of Health, Education and Welfare's 1971 Health Interview Survey found that some 3/6000

Americans are paraplegics, while another 2/6000 persons are quadriplegics. Moreover, another 10% of this nation's population can be added to the list of those potentially affected, if we consider elderly persons over age 65.

Initial steps in this country toward the development of design standards for accessibility to the physically handicapped were taken as a result of efforts by the President's Council on Employment of the Handicapped (first convened in 1959), and by the National Easter Seal Society. Support by these bodies led to the publication, in 1961, of "Specifications for Making Buildings and Facilities Accessible to, and Usable by, the Physically Handicapped" (ANSI A117. 1-1961), by the American National Standards Institute. In general, this standard prescribed design specifications for site development (e.g., grading, ramps and walkways, and parking lots) and building design (specifically entrances and doorways, toilet fixtures, drinking fountains, public telephones, and elevators). At present, virtually every state has enacted some form of barrier-free design legislation promulgating ANSI A117.1-1961. At the Federal level, ANSI A117.1 was first promulgated (on a voluntary basis) through Public Law 90-480, the Architectural Barriers Act of 1968, and then on a mandatory basis by P.L. 93-112, the Rehabilitation Act of 1973.

Later in 1978, publication of a revised edition of ANSI A117.1 is expected. Major improvements over the earlier document will include greater attention to specific design details, more systematic analyses of user's needs and mobility capabilities, and the provision of graphic descriptions of design requirements.

Unfortunately, however, no standards or guidelines seem forthcoming which will guide building designers in the consideration of psychosocial aspects of physical disabilities. Addressing this problem, Wolfensberger [12] has written on the principle of "normalization". This concept suggests that human service facilities (e.g., buildings) should be structured in such a way as not to stigmatize users any more than might be absolutely necessary. Normalization (i.e., the return of disabled persons to the mainstream of society) is currently viewed as a major objective of theraputic programs not only for the physically handicapped, but for the developmentally disabled, drug addicted, and other groups.

Ideally, the ultimate goals of "normalization" are to provide disabled or handicapped groups opportunities that are substantially equal to those available to the mainstream population, and further, to do so in a manner which attaches no perceived or implied stigma to the disability. From the viewpoint of normalization, design standards based solely upon physical mobility seem incomplete. The ramp adjacent to a stairway, or a specifically designated parking space situated as closely as possible to a building entrance, provide useful physical functions, and may indeed provide access for persons who otherwise might have none. They are also subtle reminders to the wheelchair-bound that they are "handicapped," that they require special care, treatment, and service, and that they are not like "ordinary" people. Equitable alternatives include providing ramps only for use by all occupants, or eliminating all changes in elevation to thus obviate the need for ramps.

Thus, two important regulatory focal points (emergency egress facility design, and accessibility provisions for the physically handicapped) seem to be based upon partially complete technical bases. Namely, while physical features have been emphasized by standards-writing bodies, psychological and social factors have largely been overlooked. Moreover, in the case of designing for the physically disabled, an over-emphasis on physical attributes of the problem appears to have conflicted with certain major therapeutic objectives. Let us now turn to a discussion of means for filling these technical gaps, and to the role of NBS.

TECHNICAL TASKS AND RESEARCH PRIORITIES

Emergency Egress

Within the last few years, the potential shortcomings of a purely physical approach to designing means of emergency egress have become more widely appreciated. First, a variety of research activities were conducted at government agencies and at university departments of engineering, architecture, and psychology. Many of these were oriented toward understanding the role of human response patterns in life safety planning. Examples include the work of Rubin and Cohen [7], Glass and Rubin [3], Archea [1], and Stahl [8] at the National Bureau of Standards; Wood [13] at Loughborough University in the United Kingdom; Loftus and Keating [5] at the University of Washington; Lerup, et al., [4] at the University of California, Berkeley; Bryan [2] at the University of Maryland; and Pauls [6] at the National Research Council of Canada. Most recently, the Committee on Safety to Life of the NFPA has taken a keen interest in data gathered by J. L. Pauls that challenge certain key elements in the traditional computation of exit capacity.

As a result of many of these efforts, it is now possible to identify a number of important issues, and to discuss them in terms of concrete research tasks. Accomplishment of these tasks, many researchers believe, is basic to developing egress design standards which reflect the human behavioral "realities" of fire emergencies in buildings. Five general research tasks are considered below, in descending order of priority. In addition to listing the tasks, we shall briefly consider a number of technical research approaches which we expect to find fruitful.

The NFPA's interest in Pauls' data obviously makes validating them rank high on any priority list. Of even greater importance, however, are more basic questions: What is the role of exit design in reducing fire injuries and deaths? How effective are current design standards for improving means of emergency egress? Researchers at NBS have identified the following tasks:

TASK 1: Determine the actual effectiveness of present code provisions for means of egress. This will require large-scale surveys of historical fire incidents, leading to an epidemiological analysis of fire injuries and deaths for various occupancies. The emphasis of such analyses will be upon the degree to which injuries and deaths occurred in code-complying (versus non-complying) buildings.

TASK 2: Determine the extent to which injuries and deaths due to fires in buildings are directly traceable to some exit design deficiency. This task will necessitate survey and epidemiological analyses of the kind described for TASK 1. Here, however, the emphasis shall be on tracing the specific role of means of egress in particular fires, and on establishing whether injuries and deaths were actually caused by some failure in an exit configuration.

TASK 3(A): Verify flow-rate, evacuation time, and other relevant data recorded by J. L. Pauls during his studies of crowd movement in tall buildings and in stadia. This task will require the replication of specific research designs and data-gathering techniques utilized by Pauls, by a number of independent investigators, and across a number of examples of the occupancies in question.

TASK 3(B): Resolve discrepancies between the interpretation of flow-rate, evacuation time, and other data, rendered by Pauls and other investigators. Without any well-established and universally accepted model of occupants' emergency egress responses, there will necessarily exist multiple explanations of numerically similar findings. Each of these explanations, however, embodies the implicit "theory", or model held by a particular researcher. Consequently, this task requires that such models be tested empirically, and that their overall validity be judged.

TASK 4: Describe initial responses by occupants to alarms and other emergency signals, and develop descriptions of particular emergency response scenarios. This task will require the conduct of field and laboratory experiments aimed at measuring occupants' response times, egress route recognition and utilization, and other behavioral patterns emerging during a fire emergency. The effects of several independent variables shall be sought, including those due to: type and quality of the alarm signal, presence of other persons, personality traits, level of emergency training, previous emergency experiences, egress route configuration, and occupants' familiarity with the building.

TASK 5: Assess the "behavioral validity" of current code provisions for means of egress (i.e., determine occupants' predispositions to act in ways anticipated by code writers). First, it will be necessary to analyze design standards, and the standards development process, for the purpose of identifying those underlying human behavioral assumptions and expectations held by the regulatory and design communities. Through an integrated series of survey studies and experimental procedures, it will then be necessary to validate these assumptions.

Researchers at NBS expect accomplishment of these research tasks to fulfill three immediate needs for a more complete emergency egress knowledge base. These are: (1) Determination of the role of egress facilities in causing fire-related deaths and injuries; (2) Assessment of the adequacy of current codes and standards for the design of means of egress; and (3) Verification of recent findings by J. L. Pauls, which are being considered by NFPA as a basis for modifying current egress design standards.

Accessibility

In general, the problem of environmental accessibility by handicapped persons is similar to that of emergency egress. Here, however, there seems to have been little systematic effort to determine the impact of psychological and social factors upon the effectiveness of design standards. The most significant contributions have been in connection with the therapeutic objective of "normalization," and with the implicit effects of design upon realization of this important goal [12]. It is nevertheless possible (and necessary) to identify a number of critical issues relating to environmental accessibility, and to consider these in terms of specific research tasks. In the absence of research into these issues, standards-writers and regulatory officials may continue to rely upon incomplete technical data which are of limited utility. Architectural and behavioral researchers have identified the following tasks:

TASK 1: Determine the role of architectural elements as barriers to spatial mobility by physically disabled persons. This task will primarily require: (1) Building surveys, in which potential or previously identified architectural barriers are inventoried; (2) User surveys, in which persons at all mobility levels are queried to determine their mobility needs and barrier-related problems; and (3) Epidemiological surveys to determine the statistical frequencies with which various barrier-related problems actually occur in the environment.

TASK 2: Determine the physical adequacy of currently promulgated barrier-free design standards. This task will require surveys conducted in both barrier-free and non-barrier-free buildings. The principal emphasis shall be on whether compliance with specific specifications has, in and of itself, made a significant contribution to increased spatial mobility.

TASK 3: Determine whether current barrier-free design standards stigmatize handicapped users, and adversely affect their efforts toward normalization. This task will also require surveys of users in both complying and non-complying buildings. Here, however, the emphasis shall be upon understanding users' attitudes toward barrier-free design solutions, the emotional aspects of physical disabilities, and the potential interactions between emotional impact, normalization, and effective utilization of barrier-free architectural elements by disabled persons.

TASK 4: Verify new contributions to the state-of-the-art. New barrier-free design alternatives, and data describing various mobility problems are frequently becoming available. This task will require that these be field-tested, or where appropriate, that they be brought into the laboratory for intensive verification.

We expect accomplishment of these tasks to fulfill several immediate needs for a more complete knowledge base for barrier-free design. These are: (1) Quantification of the role of architectural elements as barriers to mobility by physically handicapped persons; (2) Determination of the adequacy of currently promulgated barrier-free design standards; and (3) Verfication of specific design solutions, which are usually interpretations of codes and standards.

Research Themes

We have expressed needs here in terms appropriate to the special problems of emergency egress and environmental accessibility. When viewed in more general terms, they emerge as major research themes and priorities of access/egress research:

(1) Determination of the role of architectural elements in causing inconvience, injury, or death. (The following questions are implied: What is the specific role of an architectural element? What is the statistical frequency of the alleged problems?)

(2) Determination of the adequacy of current standards for designing architectural elements. (The following questions are implied: Have the current standards accommodated all critical aspects of the potential hazard? Have the current standards been shown to reduce the overall impact of the potential hazard?)

(3) Verification of new contributions (data, models, standards and design schemes), and demonstration of their improvement over current design or regulatory practices.

THE ROLE OF THE NATIONAL BUREAU OF STANDARDS

The analysis of individual failures in the built environment, the assessment of the utility of design solutions and standards, and the verification of new data and design approaches each requires the fundamental ability to quantify and measure the behavior of elements and systems. In many cases, the measurement of phenomena relating to access, movement, and egress involve reference to straightforward quantities. These include both static dimensions of human beings (e.g., height, weight, frame dimensions) and of prosthetic devices, and dynamic dimensions of human movement (e.g., walking speed, length of stride, gait, wheelchair movement characteristics).

In other cases, however, the quantification of less easily measured variables and processes will be necessary. These concern individual's perceptions of the physical environment, the processes by which they select movement routes and modes, their attitudes toward various design solutions, and the extent to which they are stigmatized by the environment.

The measurement of complex systems, the improvement of measurement technology, and the maintenance of reliable and unequivocal data for standards are all missions of NBS. Each of these are essential to the continuing development and improvement of standards for the design of facilities for access to, movement within, and egress from buildings and building sites.

It is therefore expected that NBS will apply its resources and expertise to this timely and significant problem area, and that it will make important contributions. For these reasons, a number of research architects and environmental psychologists at the Environmental Design Research Division, NBS, are already engaged in relevant research efforts. Investigations now in progress include studies of stair use safety, access and egress behavior on ramps, wheelchair usage on carpeted surfaces, and emergency egress responses during building fires. A variety of technical approaches and procedures are being applied through these studies, including: motion picture filming and videotaping of user behaviors in buildings, laboratory simulations, and computer simulations. Moreover, access/egress research at NBS supports important programs of the Occupational Safety and Health Administration, the Department of Health, Education and Welfare, the Consumer Product Safety Commission and the Architecture and Transportation Barriers Compliance Board.

Important new knowledge is already becoming available from these preliminary efforts. In particular, we now have a firmer grasp than ever before on the causes of stairway accidents, and on the role of architectural elements in causing such accidents. In addition, we have begun to verify important equations traditionally used to describe flow rates and walking speeds on ramps and other surfaces. Moreover, we have begun to identify the intricate network of variables which contribute to complex occupant responses during building fires. In the very near future, we hope to apply much of this new knowledge directly to the data needs of access/egress design standards.

SUMMARY

The Environmental Design Research Division of the Center for Building Technology, NBS is working to develop a more complete understanding of pedestrian behavior within buildings. Two important aspects of this overall effort include designing to facilitate the mobility of physically handicapped persons, and providing effective means of emergency egress for all building users. In this paper, the problem of developing an <u>effective technical basis</u> for access/egress standards-writing was explored.

First, difficulties surrounding the development of access/egress design standards were discussed. Chiefly among these was seen to be the heavy reliance by standards-writers upon physical and engineering principles, to the virtual exclusion of psychological, social, and other human factors believed to influence facility performance.

Second, model code provisions and regulatory legislation relating to building egress and accessibility were briefly overviewed. In particular, we surveyed the technical origins of applicable design standards, and described several problems which arise when building regulations are based upon incomplete technical foundations. In the case of emergency egress, for example, we noted that occupants often do not respond to real fires in a manner anticipated by code-writers. Concerning accessibility by the physically disabled, we suggested that design solutions based solely on physical issues often conflict with such therapeutic objectives (and political imperatives) as "normalization".

Third, technical tasks and research priorities which relate to designing for access and egress were enumerated. In general, these tasks clustered into three principal themes: (1) Determining the role of architectural elements in causing inconvenience, injury or death; (2) Determining the adequacy of current access/egress codes and standards; and (3) Verifying new contributions to the state-of-the-art, and demonstrating their improvement over current design or regulatory practices.

Finally, this paper discussed the role of the National Bureau of Standards in conducting research on accessibility and emergency egress. We stressed the notions that measurement and problem analysis are fundamental to each of the themes described above, and that such tasks are important to the overall objectives of NBS. We overviewed current efforts at the National Bureau of Standards, and enumerated various access/egress research projects involving collaboration between NBS' Centers for Building Technology, Fire Research, and Consumer Product Technology.

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COMMUNICATION TECHNIQUES IN
BUILDING CODE IMPLEMENTATION

by

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Communication is essential in any process of change. Occasionally, when a building code is altered, changes are made which substantially influence users of the built environment. This is certainly true of building code specifications regarding accessibility for physically handicapped persons.

North Carolina pioneered the development of code requirements for accessibility. Since implementation of the fundamental provisions in 1973, the State has embarked on a vigorous educational campaign to increase understanding of environmental barriers, needs of disabled people, laws and codes. This project has included the production of illustrated handbooks, brochures, manual and automatic slide presentations, radio and television announcements and newspaper articles.

This report explains the selection and development of appropriate media for presentation to audiences including the building community, owners, consumers and others. The techniques are pertinent to other areas of concern, such as energy efficiency in buildings, which affect a wide spectrum of interests.

Key Words: Accessibility standards; building codes; code administration; communication; physically handicapped; public awareness; public relations.

INTRODUCTION

Alteration of a building code affects building officials, builders, designers and consumers. Considerable responsibility for remaining current is placed on those in the building community. Occassionally, changes are made which substantially influence the users of the built environment. This is certainly true of implementation of building code provisions which require access and use of facilities by disabled people. It is doubtlessly true of other building code provisions. Yet, in North Carolina, consumer pressure has rarely been so apparent as during the development of these elements of the building code. (A previous paper details the process of creation of this section and regulatory aspects of the North Carolina State Building Code.[1])

North Carolina led the nation when the basic, current code requirements for accessibility became effective September 1, 1973. They were published in a pamphlet with the following note in bold face type:

> "The goals of the physically handicapped person are to have access to and throughout all buildings so they can live a more normal life and assume full responsibilities as citizens. This goal is shared by everyone."

EDUCATIONAL MATERIALS AND PROGRAMS

It was soon obvious that the written specifications of this novel section of the code were difficult to interpret for both building designers and inspectors. Ronald Mace, architect confined to a wheelchair, was commissioned to prepare <u>An Illustrated Handbook of the Handicapped Section of the North Carolina State Building Code.</u> Through diagrams, explanations and paraphrasing, this book makes intelligible the complex requirements for accessible components of buildings and sites. Free distribution of first copies was made to building officials, government agencies and design professionals throughout the state to speed understanding and implementation. A copy was also mailed to each representative of the National Conference of States on Building Codes and Standards. (This manual has been used internationally as a text and basis for most current accessibility standards. Nearly all such standards are now originally published as illustrated guides.)

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[1]Raper, Theresa J. Rosenberg, "Regulations and Communication in the Implementation of a Building Code for Accessibility to the Physically Handicapped", <u>Research and Innovation in the Building Regulatory Process</u>, Patrick W. Cooke, Ed., NBS Special Publication 473, National Bureau of Standards, Washington, D. C., June 1977.

The Engineering and Building Codes Division of the North Carolina Department of Insurance is the center for general administration of the statewide building code. Initially, under contract with this Department, Mace personally provided slide presentations for educational programs and consultation in interpretations of the code. A slide presentation was designed to convey technical aspects of the code to the building community, which is the primary clientele of the Engineering Division. Pages from An Illustrated Handbook were projected alongside illustrations of handicapped persons confronting particular obstacles and, then, ably utilizing the architectural elements provided under the building code, such as wide doors and parking spaces. The objective of the presentation was to provide both appreciation of the problems and knowledge of parameters for solution. The reproduction of actual pages from An Illustrated Handbook contributed to the participant's familiarity with this frequently referenced text.

In 1976, the Special Office for the Handicapped was established in the Engineering Division as a focal point for support of this section of the code. The Office is staffed by a full time architect, charged with providing technical assistance and consumer information. Routine activities include providing educational programs, review of building plans, telephone consultation and response to written inquiries. Together, the Special Office and architect Mace have been able to respond to almost every request for seminars and slide presentations.

Particular attention has been given to the technical slide presentation at meetings of design professionals and regular code enforcement seminars. A building which is initially designed to be accessible has very little additional cost associated with provisions for persons with disabilities. However, relatively few buildings (by percentage) are designed by architects or other licensed professionals. Thus, the building official is especially important as the person responsible for achieving compliance with these (and all other) requirements of the code at the building site. Workshops have now been held for audiences including educational and hospital facility planners and vocational rehabilitation professionals.

The Commissioner of Insurance recognized a need to provide civic clubs and other interested organizations a program which would increase awareness of the abilities of handicapped people. In response to this, Mace designed a brief slide/tape presentation, "Are You Aware?"; the building code, legislation and the activities of the Special Office are also summarized. The "Are You Aware" brochure is a suitable companion, giving specific information on rights, such as housing, as well as history and supporting personnel. More than 25,000 brochures have been distributed through university extension, rehabilitation, health and social services and organizations of municipal governments, design professionals, code administrators, churches and handicapped citizens - including North Carolina's seven regional White House Conferences on Handicapped Individuals.

The White House Conferences, held around the state in 1976 and nationally in 1977, emphasized the need for increased understanding of the capabilities of handicapped people. Workshops on "Social Concerns: Attitudes of the General Public Toward Handicapped Individuals" and "Architectural Accessibility" stressed greater visibility and positive, realistic portrayal of handicapped individuals in mass media. A typical comment by a person confined to a wheelchair was, "I am a disabled person, physically inconvenienced. I am handicapped by barriers. When you get rid of the environmental obstacles, then I can get in and work on the attitudinal barriers." The Special Office recognized that brochures and slide presentations must be augmented with other kinds of messages designed for the public.

Public service announcements for television were one such medium. Immediately, it was possible to adapt "spots" which had been produced by Washington (State). They piloted the slogan, "Make Life Accessible". Particular announcements illustrated typical environmental barriers and called for "a little consideration" in design as a wheelchair user confronted a door which was too narrow and a curb which prevented independent access to a sidewalk.

A more comprehensive public awareness campaign had to be developed. It would include television, radio and print media. A request for proposals was offered for design and production of new television and radio announcements. A professional media consultant, who had previously collaborated with architect Mace, was selected.

The two new television spots employ familiar subjects, incorporating aspects of disability in a poignant and sophisticated manner. One demonstrates the capable, disabled person in athletic and business activities; another develops the similarity between wheeled transportation for commerce, convenience and pleasure and the wheelchair. Television graphics, slides over which stations can place their own symbols and call letters, were designed to focus the viewer's momentary attention on a particular element of living with disability. Packages of these materials, along with explanatory information and program suggestions, are mailed to television stations; each station duplicates tapes and slides for its own use.

Companion radio announcements, both prerecorded on cassettes and prepared scripts for local announcers, have been distributed statewide. The radio spots are "catchy" but serious; for instance, one uses a game show format. Additional scripts are provided for radio announcers to read for specific audiences, such as one appropriate for a young rock clientele. All radio and television spots conclude with "Make Life Accessible" and "For more information, contact the North Carolina Department of Insurance". Prior collaboration between the media consultant and Mace was critical in devising these innovative and sensitive television and radio productions.

The television and radio announcements were previewed at a press conference introduced by the Commissioner of Insurance. Representatives of broadcast and print media were present and actively questioned the participants. Television, radio and newspaper features have followed; the public service announcements are being used.

Two automated slide/tape presentations are constantly available; these do not require the preparation or scheduling of a staff member. A presentation on the technical provisions of the building code has been used more frequently out of North Carolina than in state. The "Are You Aware?" production is used in introducing many pertinent programs. The companion brochure is being brought up to date.

Development and implementation of provisions for access and use of new facilities increased consciousness of the inadequacies of existing ones. Therefore, Mace was asked to prepare Accessibility Modifications: Guidelines for Modifications to Existing Buildings for Accessibility to the Handicappped. A companion slide presentation has been organized. Once again, reproductions from the book accompany illustrations of typical barrier problems and alternative solutions. An effective workshop can be organized utilizing this presentation and allowing participants to study plans of an existing building and propose alterations. Participants contribute freely and complement each other's proposals; this results in an understanding that barriers can be removed, often without significant architectural renovations. Successful workshops have been held for design professionals, building officials and professionals in areas such as aging, housing, rehabilitation and other related services. Professional diversity within a workshop sometimes produces especially innovative responses to sample problems.

The Special Office works in collaboration with other agencies, such as the Division of Aging, Governor's Council on Employment of the Handicapped, School Planning, Facility Services and Natural Resources and Community Development. Activities include participation on an interagency task force on housing, surveying existing buildings, and co-sponsorship of a student poster contest. The Library for the Blind and Physically Handicapped has produced Braille text and cassette recordings of An Illustrated Handbook, Accessibility Modifications, and the "Are You Aware" brochure. The "Make Life Accessible" slogan will be used by other advocacy groups emphasizing the concept of optimum life opportunities for all people. Plans are underway for a bumper sticker to increase the visibility of this message.

The demand is increasing for more people who are trained in the requirements for accessibility and understand how to accomplish modifications to existing buildings. In the past year, publication of federal regulations prohibiting discrimination on the basis of handicapping condition (Section 504 of the Rehabilitation Act of 1973) has increased demand for information about access by organizations with federal funding and contracts exceeding $2500.00.

Numerous requests to survey existing buildings and propose alterations are made of the Special Office, design professionals and building officials. Additionally, recently enacted legislation in North Carolina will require, throughout the state, building inspection by qualified individuals. Accordingly, a new series of regional workshops is being planned.

CONCLUSION

Each year, the Special Office has developed a contract for the production of specific educational materials to increase awareness and enable effective enforcement of accessibility requirements. The products address increasingly broader issues and audiences. Appropriate, varied media must be readily utilized in building code implementation, especially in those aspects which spur such consumer interest.

It is difficult to assess objectively the impact of this communication effort in providing increased accessibility or regulatory effectiveness. In order to achieve the original goal, both environmental and attitudinal barriers must still be removed. There is continued demand for information and educational programs.

"Make Life Accessible" is a commitment which has effective implementation of building code provisions as a benchmark. Disabled citizens are taking advantage of accessible facilities and protesting inaccessibility. The building official can accept pleasure in gaining compliance and responsibility for resolving consumer complaints. Equal access is the law in North Carolina; it is also good business. Through increased knowledge and understanding, all audiences and participants are better able to foster an hospitable, accessible environment.

A SUMMARY OF KENTUCKY'S EXPERIENCE IN IMPLEMENTING A STATEWIDE ENERGY CODE

by

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In the near future, every state will have to adopt some form of an energy code. Compatability with existing codes and code enforcement procedures will be a major consideration in the adoption and implementation process. Public Law 94-163 made funds available to states for the adoption of a five part energy conservation program. Of primary significance where codes and standards are concerned are the lighting and thermal provisions of that plan. To implement those provisions has called for the adoption of an energy code.

For many states, the energy code represents one of if not the most all inclusive code application and enforcement effort in the area of code enforcement. Especially in those primarily rural states where building code applications has been limited to the more urban areas, the adoption of a uniform energy code which applies to all new buildings including single family residences has posed special problems.

Key Words: Energy codes; lighting and thermal efficiency standards; new construction plans review; Kentucky Fire Marshal's office; training and education; design professionals; local governments; energy audits.

INTRODUCTION

For several years, many writers have been suggesting procedures for implementing energy enforcement programs. All of these efforts had some validity especially where discussions of the training and education for both enforcement personnel and design professionals were concerned. Als the fact that public education on energy issues has involved a good deal of just plain marketing efforts was often mentioned.

The nationwide energy conservation program stands to be as broad an all pervasive as any in which the federal government has participated. However, it has been difficult for the American people to attach any direct significance to energy conservation aside from several instances of gasoline shortage and somewhat higher heating costs based primarily on the severity of the two winters just past. There has been little of a crisis nature to motivate the general public. True, much has been said and will continue to be said about the necessity for energy conservation and management. The fact seems to be, however, that even Congress, as of this date, is having a difficult time translating into legislation the energy needs and requirements of the near future. Whether this has resulted from the enormous complexity of the effort or indifference or both is not clear. The result has been, however, that the energy program has been slow to get moving, although from all indications, the pace is about to quicken.

BACKGROUND

In 1975, Congress enacted Public Law 94-163 which made available to the states funds for the implementation of statewide energy programs. The program was voluntary but the inducement was two-fold. First, substantial sums of money were available to support the efforts in those states who chose to adopt the program. Second, by enforcing statewide energy codes, the states were in the process of preparing for mandatory federal legislation which would apply energy standards to all buildings which in any way utilized federal funds, including individual home mortgages where federally insured monies were used. All states are participating in the program to some degree and many are well into the process of not only adopting but enforcing a statewide energy code along with the other codes applicable to the built environment. Inasmuch as all states will attempt to achieve the general goal of energy conservation, and given the fact that the states are more or less starting at the same time in that effort, there exists a golden opportunity for the states to learn from one another what works and what does not insofar as energy code enforcement is concerned.

ACTIVITY IN KENTUCKY

As a committed participant, Kentucky has forged ahead with a broad energy conservation program and has learned many valuable lessons in the process, those lessons being the subject to which this paper is addressed.

Rather than writing its own code or adopting the ASHRAE Standard 90-75 as a basis for the code, Kentucky has chosen to adopt the National Conference of States on Building Codes and Standards (NCSBCS) Code for Energy Conservation in New Building Construction. The Kentucky Department of Energy has been assigned the overall task of coordinating energy conservation. In addition to the thermal efficiency standards, which is one of five parts covered by the Kentucky Energy Conservation Plan, and based on the Energy Policy and Conservation Act of 1975 (Public Law 94-163), there are four other parts. They are lighting efficiency standards, car pool/van pool/public transportation, energy conservation, state procurement practices to conserve energy and right turn on red legislation.

Maintaining its position as a nucleous rather than an all encompassing state agency, the Kentucky Department of Energy has delegated several of the tasks inherent in the above effort. The adoption of codes and their enforcement as relates to lighting and thermal efficiency standards have been delegated by contract to the State Fire Marshal's Office within the Kentucky Department of Housing, Buildings and Construction. Right turn on red, car pool/van pool/ and public transportation matters have been similarly delegated to the Kentucky Department of Transportation. Likewise, procurement practices for state and local governmental units have been assigned to the Kentucky Department for Finance and Administration, Division of Purchasing.

ENERGY SAVINGS IN THE BUILT ENVIRONMENT

The major task emerging from this overall program, and the one which is the focus of this paper, is that of enforcing lighting and thermal efficiency standards.

Historically, the Kentucky State Fire Marshal's Office has performed a new construction plan review function. The applicable statutes and administrative regulations give to the State Fire Marshal the authority and responsibility to review plans for all buildings consisting of three or more living units. All schools, places of assembly, or medically-related facilities are also included regardless of size. Any other building greater than 10,000 square feet, generally speaking, also must be subjected to the Fire Marshal's Office for review. This responsibility for plan review and on-site inspection has been delegated by the Fire Marshal to several of the major metropolitan areas within the state and are thus conducted at the local level. Concurrent jurisdiction is retained, however.

This scheme of regulation and review leaves very few buildings outside of the scope of the Fire Marshal's review. While the Fire Marshal does not have the authority to compel plans for, or inspect, one and two family dwellings, that authority does exists at the option of local governments. The New Construction Plan Review Section of the Fire Marshal's Office reviews drawings for compliance with both the National Fire Protection Association Fire Code and, in particular, the Life Safety Code, NFPA 101, and also applies the provisions of the National Building Code, using the more stringent standard where there are similar provisions in both codes.

This procedure has been developed over a number of years and extensively expanded in recent months making the Fire Marshal's Office the logical entity in state government to administer thermal and lighting efficiency standards. A half dozen plan review personnel in the New Construction Plan Review Section are consulted by and advise architects and engineers on a day to day basis. Typically, architects will either submit by mail or personally bring their plans for review by a member of this section. Upon review, discrepancies, if any, are noted in a letter which is transmitted to the architect or owner and which then becomes the basis for further plan review or field inspection during construction. The New Construction Plan Review Section consists of a field inspection division of some fifteen inspectors statewide as well as the plan review staff.

While strategies will vary, it is the position of the Department of Housing and the State Fire Marshal, that each plan reviewer in the New Construction Plan Review Section should be capable and competent to review drawings for compliance with the energy code. The method of operation in the New Construction Plan Review Section is such that each plan reviewer has responsibility for a category of buildings, such as schools, mercantile, medically-related, industrial or other places of assembly. While this represents a certain degree of specialization, it is felt that each individual plan reviewer should be able to determine the energy efficiency of each building reviewed. The training involved in this superimposition process has been and will continue to be ongoing. Normal personnel turnover and expansion combined with the constant need for training and educational efforts in other areas for which the plan reviewers are responsible has made the tasks formidable.

Generating additional concern is the fact that in most instances the plans reviewed have been prepared by architects or engineers. The tasks of training plan reviewers such that their review process approaches the level of technical understanding necessary for dealing convincingly with design professionals required much effort.

While refinements have yet to be made, one of the keys to the plan review aspect of energy conservation will rest in the development of a simple, concise, yet all inclusive, standard format for data which will be adaptable to all buildings.

It is perceived that the end product will take the form of a table or chart to be submitted as part of the contract documents preferably to be included as part of the set of drawings. As with other "schedules" typically included in the set of drawings for such matters as hardware, door placement and room finishes, the energy efficiency schedule would reflect the designer calculated energy conservation characteristics of the various rooms and/or components of the building.

While certainly calculations must be made for each building, the use of a standard format for recording those calculations should appreciably expedite the entire process.

Once implemented and refined, this process should represent minimal additional work for the design professional as well as minimal review time required by the plan reviewer.

CONCURRENT DEVELOPMENTS IN OTHER STATE CODES

While efficient and effective plan review have been foremost among the goals related to energy conservation in Kentucky, there have been other significant factors having an impact. Early this year, the Kentucky Legislature created a new Department of Housing, Buildings and Construction. That Department was charged with bringing together into a single efficient "one stop" organization those agencies in state government having the primary responsibility for regulating the built environment. Primarily concerned are the Fire Marshal's Office, the Division of Plumbing, the Kentucky Housing Corporation and the administration of the electrical inspection program. Bringing these agencies together under one roof was the first step in a plan which also included creation of an eighteen-member policymaking board to oversee and generate policy for the new department. An additional task assigned to the Board was that of adopting a uniform statewide building code within one year of its first meeting. The first meeting took place in August of this year.

While a statewide uniform building code is a positive step in almost everyone's mind, there are at least two major considerations which bear on the success of the overall effort. The first has to do with the predominantly rural nature of the State of Kentucky and the difficulties involved with the enforcement of the building code at all local government levels. The second is that while the legislature may reverse itself, the uniform statewide building code, when adopted, will not apply to single family homes except those marketed under a trade or brand name. Local governments may themselves elect to apply the statewide code to single family homes but it is not required.

One result from the above is that a major effort will have to be and in fact has been undertaken by the Department of Housing, Buildings and Construction to train and educate both building officials and laymen statewide in an effort to ensure that the objectives of the new Department and the statewide building code are realized. Local governments will have up to two years after the adoption of the code to put the code into effect. The two year period will allow for the preparation and training necessary to effectively implement the code. It is also a period during which the Department will examine ways of dealing with single family homes throughout the state with the objective of convincing each local government that application of the code to single family homes is the best interests of the public. Simultaneously will be an effort to convince the Legislature that application of the Code to single family residences statewide is a necessary step.

In many ways, the promulgation of a code for energy conservation by the State Fire Marshal's Office concurrent with the overall process of adopting a statewide building code is highly compatible. It is a coincidence of good fortune to Kentuckians. There is at least one matter which remains unresolved, however, and that concerns the method by which the energy conservation code will be applied to single family homes in the state. If, in the foreseeable future at least, the majority of the state does not apply the uniform statewide building code to single family residences, it obviously presents a problem when the necessity for comprehensive coverage by the energy code is considered. Clearly the energy code will apply to single family residences. The perplexing result is that the State Fire Marshal's Office along with local government building code officials and inspectors will for the most part not be applying the fire or building codes to single family residences. However, some method to ascertain that the energy code is being complied with in the construction of single family homes must be found. This is made even more delicate in the fact that the Legislature has inasmuch said that governmental regulation-making should not extend to single family homes especially those in the rural areas and those in any way associated with farming operations. Ironically, it is often times those people in rural areas who are paying the highest utility costs and who could benefit most from energy saving, not to mention the fact that a HUD sponsored study has shown that the additional costs to meet the energy code in typical single family homes is negligible.

The situation at hand seems to be one of a backlash more against regulation making and bureaucratic intervention than energy conservation. In an effort to deal with the problem proposals are being studied which may utilize plumbing inspectors, electrical inspectors or rural co-ops in monitoring compliance with the energy code requirements where single family residences are concerned. Another alternative, but one thought to be somewhat less satisfactory, is that of putting the regulation into effect and, insofar as single family homes are concerned, confine the enforcement activities to a complaint response basis only. That is to say that any enforcement of the code provisions and subsequent legal action to ensure compliance initiated by the Department or the homeowner would result only from complaints based on proven instances of noncompliance with the code. In some ways, this puts the cart before the horse, but it is an expedient method which may have to be utilized given the predominantly non-urban character of the state and the time and promotion necessary to train local government building inspection officials and to encourage local governments to extend the application of the statewide building code to single family residences. Where the local government option is exercised, plan review and on-site inspection at the local level for single family homes could easily incorporate provisions for enforcing the energy conservation code.

One encouraging factor in the matter of single family homes is that for the most part, new homes constructed today are meeting the requirements of ASHRAE 90-75 or could be brought to those standards with comparatively little additional cost or effort. The addition of more ceiling or floor installation, storm windows and doors, and other minor modifications, if required, should not constitute a major or costly modification.

CONCURRENT DEVELOPMENTS IN OTHER STATE AGENCIES

In addition to the overall program of the Kentucky Department of Energy, and the efforts undertaken by the State Fire Marshal's Office as part of that scheme, there is at least one other state agency which had independently undertaken a substantial energy conservation campaign.

While the Governor has mandated an ongoing energy conservation program for all of state government, the Kentucky Department of Education has gone one step beyond. Recognizing the great opportunity for energy conservation in school facilities throughout the state, the Kentucky Department of Education has created an Energy Audit Section. That section is charged with conducting and carefully documenting energy audits in school facilities such that not only that existing levels of energy consumption can be determined, but corrective measures can be planned and costs implications weighed.

Mention is made of this effort by the Kentucky Department of Education in that it represents the first major area of state government involvement in retrofitting buildings for energy conservation.

The University of Kentucky College of Engineering has designed a program to certify energy auditors on a statewide basis. Individuals so certified will be recognized by the State Department of Energy as qualified to perform energy audits on buildings in both the public and private sector with the end result being a determination of initial costs and payback periods required in the retrofitting process.

The process of certifying energy auditors is one component of a much broader program which relates back to the efforts of the Fire Marshal's Office. One of those efforts is the planning required for the inevitable task of applying the energy code to existing buildings, the content of which has yet to be finalized. The difficulties and complexities associated with this endeavor are immense, not the least of which is the basic consideration of whether any building related code should be retroactive, a legal question which in itself has received much attention.

RETROFITTING BUILDINGS

The subject of renovation and retrofitting is growing in significance as more buildings are subjected to recycling rather than demolition. While few commentators would be willing to go so far at this point as to say that an energy code for existing buildings would in their application go much beyond those instances where almost total renovation is involved, it may be that if a true crisis condition exists at some future date, the requirements of an all-encompassing and totally retroactive energy code could take precedent over building and fire codes in some parts of the country. This portends a rather grim scenario, but then this country has not yet been subjected to even a moderate energy crisis much less anything approaching depletion of energy resources or imports.

A discussion of the above brings into play the many examples of alternative sources of energy which are under investigation including solar, wind, nuclear and geothermal. As each or all of these become active components in the energy picture, codes and regulations affecting their usage can also be expected to develop.

Kentucky, through its universities, is developing a very active cadre of solar research and development individuals. Interestingly, some serious questions have already arisen concerning the legal aspects of access to sunlight and, in another vein, the rights of plumbers to have exclusive jurisdiction in the installation of plumbing related solar hardware. Both of these questions and innumerable others will be addressed in a policy for alternative energy source utilization which the Kentucky Department of Housing, Buildings and Construction is beginning to formulate.

Returning to the subject of energy audits, while there are federal funds available to communities for purposes of conducting pilot energy audits of buildings, the selection of which is often left to the local government, there, as yet, is little inducement for a small or moderate size business or industrial concern to initiate an energy audit even if the payback period for the required improvements amounts to only a few years. As energy costs increase, however, and as laws are developed allowing tax relief to offset energy improvement costs, the use of energy auditors will greatly expand.

CONCLUSION

Kentucky is a rapidly growing state. Lexington, for instance, is among the fifteen fastest growing communities in the nation. Even the historical migration from Eastern Kentucky to more urban areas in the state and the industrial North has been reversed in the last several years. As a supplier of energy, because of its coal resources, Kentucky will provide a good part of the country's energy needs in the future. As a result, Kentucky faces the dual challenge of utilizing her energy needs so as to stand as an example for other states utilizing her coal resources. It is intended that this paper give some indication of those leadership efforts and provide a glimpse as to what lies ahead in the national energy conservation effort.

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ENERGY CONSERVATION IN BUILDING CODES AND STANDARDS

by

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Many states have recently adopted energy model codes and standards or are considering the adoption of such regulations.

This paper explains what has happened in New Mexico since the adoption of an energy model code two years ago. (September 10, 1976). The implementation of the code in the real world of on-site construction projects has revealed several special problems with enforcement and/or interpretation of the code. The effective U values being developed and implemented in New Mexico are adding a new perspective to the traditional understanding of the thermal conductance characteristics of building envelopes. It may be more cost-effective to paint a south facing wall a dark color than to add insulation.

Key Words: energy code, building official, on-site construction, enforcement, energy efficient, implementation and effective U value.

INTRODUCTION

As one of the first states to adopt a model energy code, New Mexico has a great deal to share concerning not only the adoption but the implementation of a state-wide energy building code.

The traditional enforcement of most building codes has been on the basis of health and safety rather than the performance of building components. Having a building condemned because it is not safe is one thing, and having a building condemned because it is wasteful of depletable energy sources is quite another.

The building official will have to develop an entirely new manner of enforcement leverage to deal with buildings that are in violation of the energy code. Once a set of plans is reviewed by the plans checker and a building permit issued, the building must be built exactly according to the plans. The whole subject of last minute on-the-job material substitutions takes on an entirely new aspect. Bear in mind that the building official will still be charged with the responsibility of protecting the health, safety, and welfare of the people; and what better way to protect the welfare of the citizens of your state or political subdivision than by providing them with cost effective dwelling and buildings they can afford to heat and/or cool in future years. Complicating these objectives is a national construction industry that generally builds as profit intensive as possible for the short run original investment and gives little consideration to the long-term energy costs to the consumer, especially in todays upward spiral of increasing labor, materials, and land costs.

As building officials and code administrators, we want to make sure we are doing the right thing. We need to examine old principles and traditional concepts to make sure that the actions we take in the immediate future will indeed save energy. I would like to share a few of the things we have learned in New Mexico as well as problems of the real world of on-site construction, and hopefully one will ask themselves, "does the or will the model energy code adopted by my state or political subdivision really save energy?"

CODE ADOPTION

The I.C.B.O. model energy conservation code (Chapter 53) was added to the state building code in New Mexico on September 10, 1976. Since the State Construction Industries Commission was already using the Uniform Building Code, the adoption did not require action by the state legislature which simplified matters. A year was spent on the review and screening of the document at which time we commissioned the Energy Institute at the University of New Mexico to develop an applications manual and to conduct workshop training sessions for building officials contractors and the design community. These workshops had to be condensed to no more than one (1) day length with the understanding there would be many short sessions rather than one (1) week long program that would shut down construction for a week. Some of the workshops were presented on Saturday. We are looking to keep the workshop program as an on-going state-wide method of gathering information. As problems develop, the workshops will receive the input and the building officials can react to keep the implementation of the code up to date.

Each political subdivision must make a concerted effort to upgrade the working knowledge of local and municipal plan checkers, field inspectors and code administrators.

Presently, the workshops are being up-graded to include electrical and mechanical portions of the model code. The initial approach was strictly devoted to understanding the methodology of calculating the thermal conductance of building envelopes U_o. Once this basic concept is expressed to the target audience, we plan to break up into small groups for special consideration of areas of mutual concern. Those primarily interested in the H.V.A.C. and mechanical sections of the code will comprise one group with electrical and general construction comprising their own respective study groups. This provides a forum for the discussion of the technical aspects of different types of construction. We feel the input gained at these sessions will be valuable to the growth and adaptability of the energy code to the unique aspects of the State of New Mexico.

We are presently looking at a state-wide program to promote energy conservation at the point of combustion or where it is consumed. We feel that this type of program will have a measurable effect on fuel conservation and the attitudes of those that actually install, repair, and maintain lighting and H.V.A.C. systems.

One important thing that we have learned regarding the enforcement of the model code is to stress a joint effort by all regulatory personnel. For the first time, many field inspectors will have to be cognizant of the entire construction picture, rather than only the framing, electrical, or other independent areas of concern. We have found that the energy code requires an overlapping effort by all building officials.

Hypothetical Example:

A house is approved for construction in conformance with the energy code requirements. The plans are approved, the building permit is issued and the contractor commences construction. However, due to a lack of communication the dwelling is constructed with a number of deficiencies in the building envelope. The perimeter of the slab is not insulated, the sole plate is not caulked, due to last minute cost considerations single glazed windows were substituted for double glazed and R-11 insulation was installed rather than R-19 as originally approved. Meanwhile, the H.V.A.C. contractor has installed the heating system as specified. The mechanical building officials have encouraged the furnace to be sized so that the least amount of energy is consumed to meet the required steady-state heat loss to encourage energy efficiency and minimize fuel consumption.

The problem of a breakdown in the inspection process for the building envelope will be reflected in the consumer complaints against the H.V.A.C. contractor since the inhabitance of the dwelling are convinced that the heating equipment is inadequate. The heating contractor is upset because when he used to size heating equipment 100% over the steady-state heat loss, he didn't have a single complaint. The point of this example being that the problem could have been caught in a very early stage if the electrical and mechanical field inspectors were overlapping the inspection of the general construction inspectors.

SPECIAL PROBLEMS

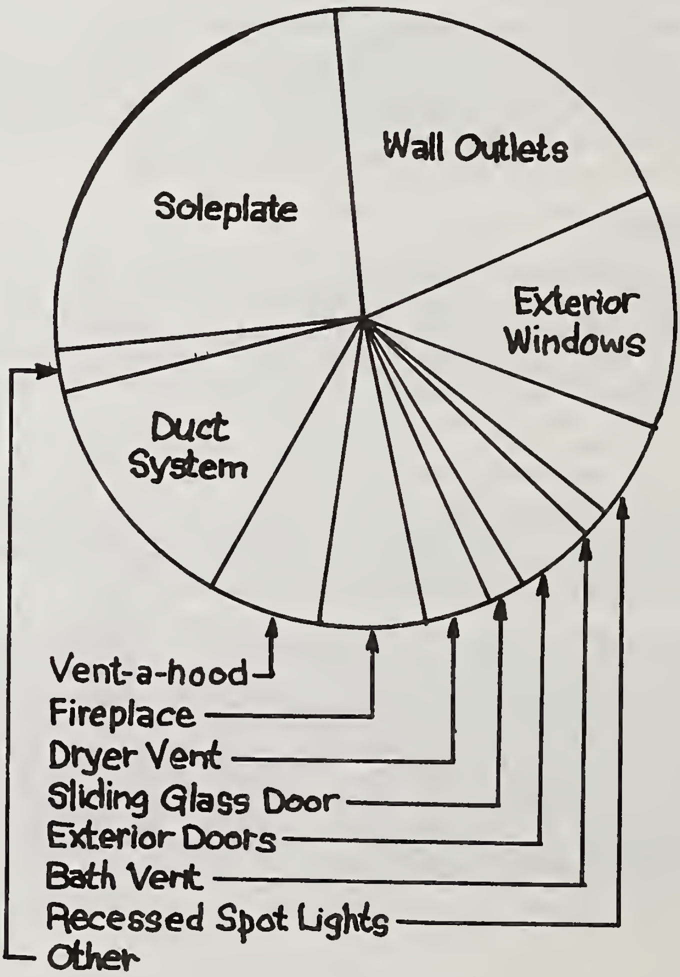
The energy code has been "on-line" in New Mexico for over a year and we have made a special effort to monitor field and enforcement problems which have surfaced during this period. I want to address these developments so that many of the states may learn from our experiences.

1 - Caulking of the sole plate

The model code requires caulking between the sole plate and the concrete foundation on wood frame construction. Figure 1-A indicates that 25% of all infiltration is due to air leakage at the sole plate.

Figure 1-A

AIR LEAKAGE TEST RESULTS
FOR AVERAGE HOME OF 1728 SQ. FT.



All types of materials have been used for this purpose including black roofing mastic that can, during warm weather, soften and bleed out onto the finish floor or carpeting. Fiberglass batts cut into strips, expanded polystyrene, expanded polyurethane, and various types of caulking compounds have been experimented with. There are some products on the market that come in large aerosol cans that seem to work the best although expensive. This product goes on the concrete surface like shaving cream and fills all of the surface irregulations for an air tight seal.

2 - Cracking of Stucco

In the last year we have experienced an unusual increase in the number of homeowner complaints regarding cracked stucco in new construction. Upon closer inspection we found the one thing these houses all had in common was the new concept of 2" x 6" studs on 2' - 0" centers. One may feel that this is not a problem of the energy code but something concerning strictly the general building code. However, the "Arkansas house" type of construction was precipitated by the impact of energy conservation in new construction and the increased interest in providing R-19 insulation for the 2" x 6" wall construction.

The cracking seems to be accelerated near the doors and windows of the structures which gives rise to the feeling that vibrations generated by the use of the doors, windows, etc., may affect the stucco which is supported over this wider span. The stucco must support itself at 33 1/3% wider span than the traditional 16 inch stud spacing and this seems to be the main problem area. At this writing, there are two (2) schools of thought on how to deal with this problem.

a - the requirement of a heavier gauge of wire lath to help support the stucco.

b - require a longer drying time between the various coats of plaster so that the material will be cured before the building is occupied.

3 - Temperature Control

The model energy code based on A.S.H.R.A.E. require a maximum temperature setting of 75° F. for heating only thermostats. The problem encountered here is one of uniform enforcement. Many contractors claim they cannot get the proper control, others are still installing the thermostats with a range of up to 90° F. Enforcement becomes very difficult with so many sources of supply coming into the state. Presently, the state mechanical bureau has set an enforcement deadline of January 1, 1979 with pressure being applied to the manufacturers and suppliers to produce control equipment that complies with the model code by that time.

4 - Energy Efficient Water Heaters

The State of New Mexico has made good progress on the enforcement of the energy efficient water heater requirements of the energy code. The water heater manufacturers claim they cannot meet the A.S.H.R.A.E. requirements for commercial heaters, but all five (5) of the major manufacturers of water heaters have at least one (1) residential model that meets the stand by loss requirements of the code.

Our approach to enforcement was to contact the supply industry and let them know what was happening and to get them involved from the beginning.

We sent out letters to every contractor and supplier of water heaters in the state in June of 1977, notifying them of the pending code requirement. They were also informed of the fact that they had until January 1, 1978 to move out all of their standard water heater inventory and replace it with energy efficient models. In September of 1977, we met with the Rio Grande Supply Association which represents 90% of all plumbing wholesale supply businesses in New Mexico. They expressed concern that the manufacturers did not make commercial water heating equipment that would meet the pending requirements. The instantaneous, at the source, and high recovery heaters would not be available for some time and expressed concern that we were going to require something that was unavailable. Upon learning this, we involved the association in helping to gather information and advise us on the best course of action within the established time-frame.

As it turned out, we announced to the industry in November that there would be a moratorium on the enforcement of the commercial portion of the regulation, but that all new installations of group R occupancy (residential) would require an energy efficient water heater. We also informed the contractors that the state and municipal field inspectors would be looking for a statement on the heater as follows:

> "This unit meets or exceeds A.S.H.R.A.E. 90-75 energy efficiency requirements."

When January 1, 1978 rolled around we polled the majority of the suppliers to see how they would be affected. Obviously, many of these companies had not taken us seriously and gave a variety of "sob stories" as to why they had not been able to comply. At this point we had to get tough, so one last memorandum was sent to all concerned (about 1,000 letters) that April 1, 1978 was the final cut off point with no exceptions. We then issued press releases to newspapers throughout the state and had the field inspectors inform the contractor that we meant business and if they installed a standard water heater after April 1, it would have to be removed and they would bear the financial loss. Lastly, we notified the home builders associations that gas and or electric service would be denied to new residential houses unless the approved water heaters were installed.

Most of the hollering was over by the middle of March with about 90% compliance and surprisingly enough April 1, 1978 came without a fraction of the fire works expected. We have subsequently followed this up with a media campaign explaining to the consumers the fact that an energy efficient water heater can save up to $1000 in energy costs during the next ten years and to make sure that they got what was legally required by the state energy code.

We have had one other problem on this subject in the form of a possible law suit concerning the replacement of standard water heaters under warrantee. The proponent contend that a warrantee is in essence a contract and to replace a faulty standard heater with an energy efficient one would require them to break their contract. We didn't feel we had anything to lose so we told them to go ahead and file their suit. To date, there has been little action or correspondence along this line so we do not have the final outcome yet.

5 - Perimeter Insulation for Slab On-Grade Construction

This problem is best illustrated by making a comparison between figures 1-B and 1-C.

Figure 1-B

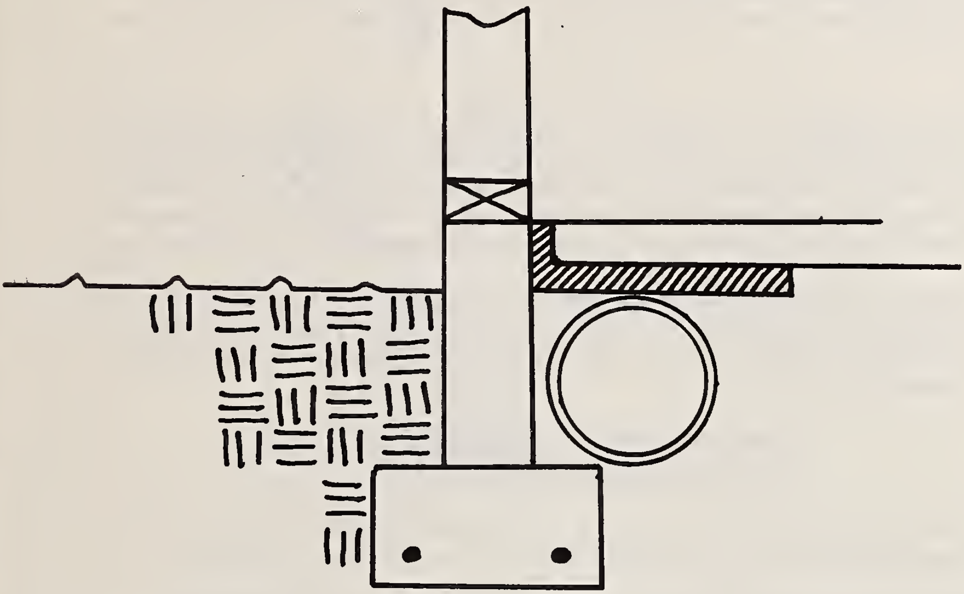
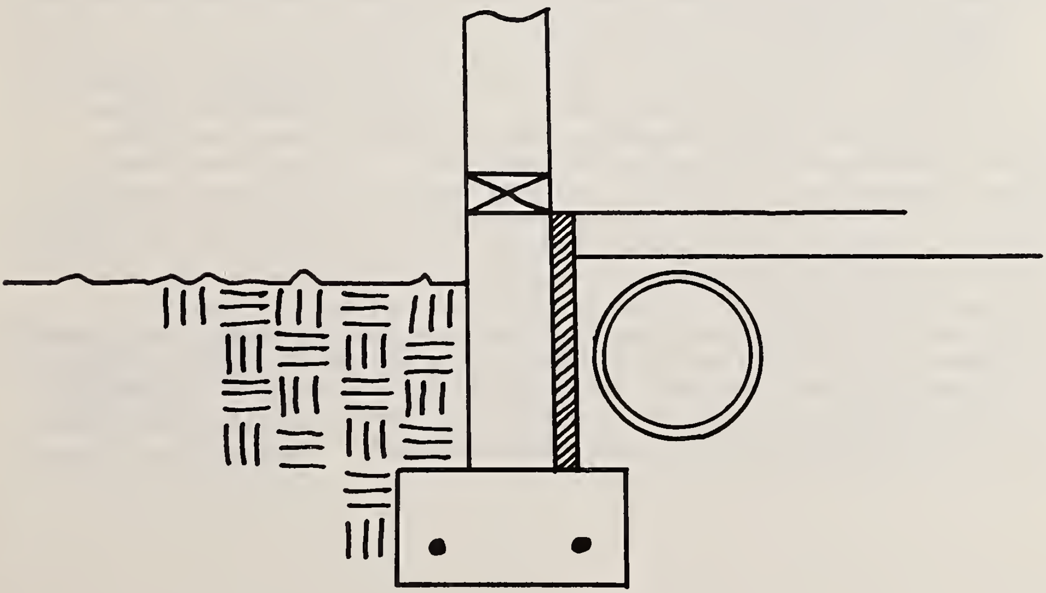


Figure 1-C



In this comparison figure 1-B illustrates an installation that is not in violation of any technical aspect of the energy code. The H.V.A.C. contractor installs the under slab duct system in compliance with the mechanical code and the general contractor places the perimeter slab insulation to conform to the model energy code. The lack of communication in this case will cause duct heat loss to be accelerated through the stem wall and will actually prevent the verticle flow of heat into the floor of the dwelling. It is obvious that no perimeter insulation at all would be better than what we have in figure 1-B. Both contractors are complying with the letter of the code but not the spirit of the code.

Figure 1-C represents an energy efficient way to make this installation. A code change or at least a clarification is needed to require the rigid insulation to be placed in a verticle position when applied in conjunction with a perimeter duct system. The contractors that know about this problem are presently complying on a voluntary basis because it is logical, but of course that is no way to enforce a building code.

The other problems concerning the perimeter slab insulation such as the tack strip for carpeting, shallow footings (less than 24") and insulation placement inside of the stem wall as opposed to outside will all work themselves out.

RE-EVALUATION OF U VALUES AND THE BUILDING ENVELOPE

President Carter has stated that the United States should set an energy conservation goal of insulating 90% of all homes by 1985.

The Arthur D. Little report suggests possible energy savings obtainable by increasing wall insulation and reducing window and glass areas.

In New Mexico we assume that the intent of energy conservation model codes is to reduce energy consumption as much as possible. However, many energy conservation standards reduce "peak" rates of energy consumption and assume that this will also reduce "average" energy consumption through the building envelope over the long haul.

The State of New Mexico has done a great deal of research in the area of effective U factors for heating. We have an intuitive feeling that the long term energy consumption should depend on more variables than the performance of construction components. We know that overall thermal transfer value (O.T.T.V.) calculations for cooling are based on a number of variable heat gain factors including such things as wall color, orientation, climate, and internal heat gains. We realize that this entire subject is controversial in that it represents a challenge to the steady state methodology which is currently used to establish the thermal conductance of building envelopes based on peak heating loads. Our research still needs to be proven out over a reasonable period of time, but if the conclusions turn out to be what we presently feel is accurate, it may be more cost effective to paint an existing south facing wall a dark color than to add insulation as the President has stated.

One word of caution, however, when dealing with the term "average" as shown in figure 2-A.

FIGURE 2-A

A person with one foot in dry ice and the other in boiling water is experiencing temperatures in an "average" comfort range of 75° F.

As previously mentioned the Arthur D. Little report suggests a policy of adding insulation and reducing window area whereas our effective U value research encourages the effective placement of those windows to take full advantage of solar heat gain, and that reducing steady-state U values by adding insulation does not necessarily reduce average fuel consumption.[1]

[1]New Mexico Energy Institute
Report No. 76-161 B (second revision)
February 1978
"Effective U values"
Wybe J. van der Meer
L. W. Bickle, Ph.d.

We are convinced that steady-state methods based on peak conditions are paramount in sizing heating eqiupment and that we cannot ignore the aspects of health, safety and welfare provided by adequate heating equipment which will handle any weather condition which may arise. Effective U values cannot be used to calculate the size of H.V.A.C. equipment.

The main point of this issue is that we need to look at all aspects of energy conservation from a new perspective and to re-evaluate principles which we have always accepted without question.

CONCLUSION

Building officials and code administrators have been thrown to the forefront of energy conservation in the construction industry due to Public Laws 94-163 and 94-385 of which we are all familiar. It is important that the states maintain their code promulgating powers and take full advantage of the ability to make local code changes. We encourage the states to take a careful look at the model energy code which their state has adopted or is intending to adopt and prepare to make whatever changes necessary to take full advantage of the unique aspects of the various states such as solar radiation, local climatic conditions or other factors which no one knows better than the states themselves.

Lastly, it is important that representatives of the various states work together and freely pool their efforts, distribute information, and communicate ideas with each other so that we are not caught up in the re-invention of the wheel on a state-by-state basis. To relate with one another as well as the federal agencies in the development, promulgation and implementation of the model energy conservation building codes and standards thereby producing measurable energy savings through the proper and intelligent enforcement of the code.

IMPLEMENTATION OF ENERGY CONSERVATION STANDARDS

by

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Energy conservation in new buildings is one area where a code will affect virtually all aspects of the building construction. It is an area that can create confusion, misunderstanding and even resentment over a short time span. This can be further heightened when the code is implemented in areas where no code enforcement previously existed.

Chapter XXXII "Efficient Energy Utilization in New Buildings" of the North Carolina State Building Code was by necessity implemented over a short time frame, and enforced without exception across the state. The Engineering and Building Codes Division of the North Carolina Department of Insurance used its previous experience in new code implementation, the research presented by NCSBCS, ERDA, and DOE, and some innovative ideas of its own to bring this code into reality across the state, and it is hoped this experience may be of some benefit to other states as energy conservation codes are implemented by those states.

Key Words: Energy utilization codes; legislation; education; illustrated handbook; thermal envelope criteria; thermal performance criteria.

INTRODUCTION

The implementation of codes will vary from state to state, but there are usually steps and methods that can be common to several states, if not all. One way to examine some methods of implementation is to look at the energy conservation code for new buildings in one state, and the measures taken by that state for implementation.

To understand the codes and methods of implementation it will be necessary to take a brief look at the history of codes within the state, how the codes were developed, how they were enacted, and how they were implemented. Sometimes innovative ideas occur without the realization that the idea is anything but a very logical step. This was true of the illustrated handbook for the Handicapped Section of the North Carolina State Building Code. The interpretations of the code were as varied as the inspectors enforcing it, the designers designing for it, and the building owners using it. Once the code was put into illustrations the interpretations became more uniform and the intent of the code began to become a reality as each party knew what to expect, and what was expected.

The section on energy conservation, "Chapter XXXII, Efficient Energy Utilization in New Buildings" provided the basis for the same varied interpretations. The experience with the Handicapped Code convinced the code officials that not only is an illustrated handbook desirable, it along with short courses for all parties concerned is a necessity. The energy code certainly has a more profound effect on new buildings than most new codes have had in the past, because the energy code affects virtually every sector of the construction system.

The following paper presents an overview of the codes, legislation, and enforcement procedures one state has adopted for energy conservation in new buildings. It is hoped that some parts of this may be beneficial to other states that are still in the developing process of their energy code.

North Carolina had its first building codes in the 1880's when the Commissioner of Insurance was directed to develop standards for building in the State. Then, in 1933, the Legislature of the State set up the Building Code Council to develop, adopt and revise standards for building. The Commissioner of Insurance was given the responsibility to administer the code, and enforcement was given to the local governing body having jurisdiction.

BUILDING CODE COUNCIL

The Building Code Council is empowered to operate as a quasi-legislative body. The makeup of the Council is spelled out in the enabling legislation and includes representatives from the design professions, builders, subcontractors, materials suppliers, government, and the public at large. There are prescribed legal steps that the Council must follow in developing, advertising, and holding public hearings on code adoption, whether it entails new codes, or the revision of existing codes. Once these legal steps are followed, the actions of the Council become applicable and no other legislative action is required.

STATE DEPARTMENT OF INSURANCE

The Engineering and Building Codes Division of the Department of Insurance acts as staff to the Building Code Council, and works in cooperation with local code officials to administer the code. The Division maintains the code up to date and presents training classes, orientations, and opinions in code interpretation primarily to the local code officials. The Division also reviews plans for certain types of buildings for code compliance.

LOCAL ENFORCEMENT

Enforcement of the statewide building code is done totally on a local basis. Prior to 1978, local governing bodies had the option of enforcing or not enforcing the code although the code applied on a statewide basis to most buildings. Methods of enforcing and compensation of enforcement officials was within the local jurisdiction, as was qualifications of all inspectors other than electrical. The local governing body cannot enact codes either more stringent or less stringent than the statewide code without prior approval of the State Building Code Council. This provides a uniformity statewide, but also permits local modifications where they are warranted.

INITIAL ENERGY CONSERVATION REGULATIONS

The oil embargo of 1973 created acute fuel shortages in North Carolina, and prompted the Governor to request the Building Code Council to take appropriate steps to enact energy conserving codes for buildings. The Council reviewed the Southern Building Code Congress recommendations and adopted those recommendations for all new buildings. The reaction was quick and massive.

Designers, builders, owners, and government building departments considered the regulations to be too prescriptive with little or no room for alternate methods. The Council relented, rescinded the regulations and appointed a subcommittee to develop a code tailored to construction in North Carolina.

CODE DEVELOPMENT FOR NEW RESIDENCES

The energy subcommittee developed a prescriptive code for residential buildings, that is, one and two family residences and multifamily residences three stories and under. These recommendations went to the Council in the fall of 1974, were adopted and became effective 1 January 1975. The state bacame one of the first three states to have a statewide energy conservation code for new buildings. The code was on the books but the implementation and execution was not assured.

CODE DEVELOPMENT FOR OTHER NEW BUILDINGS

The State Senate, in its 1975 session, passed a unanimous resolution requesting the Council to enact energy conservation codes for all other new construction. The Council created an energy advisory subcommittee to gather necessary data, and to make recommendations to the Council for such codes.

The energy advisory subcommittee worked for some fourteen months, getting information from as many sources as possible, writing and rewriting before makings its recommendation. The result was a code that would reduce energy consumption, yet could be implemented without serious dislocations in the building process. With the exception of some severe hot water requirements, the code could be accomplished with materials and equipment currently available. This code was adopted in the spring of 1977 to become effective January 1978. The state had energy conservation codes in effect for new buildings, but nothing for existing buildings, and no assurance of complete implementation as many areas of the state were not enforcing the building code. The legislature addressed this issue in several ways.

STATE LEGISLATION RELATED TO ENERGY COMPLIANCE

The Legislature adopted House Bill 1003 that granted tax relief and put some sharper teeth into the building code.

This bill granted certain tax incentives for the installation of insulation, storm windows and doors on existing buildings, plus certain solar applications on both new and existing buildings. These tax incentives were limited to a two year period, thus encouraging immediate installation.

The bill required that any new residence, one or two family and multifamily three stories and under, be certified as being in compliance with the energy conservation code before permanent utility hookup could be made. Where insulation of only electrically heated houses had been economically encouraged by the power companies, now insulation and weather sealing was demanded regardless fossil energy sources.

The third provision of this bill required that all residences be individually metered for electricity and gas. It was determined that each dwelling unit would become more energy conscious as the monthly statement accelerated.

These measures were appropriate and well intended, but were loaded with the possibilities of fraud unless adequaely enforced. The legislature tackled these problems with the enactment of House Bill 1333.

STATE LEGISLATION RELATED TO ENERGY ENFORCEMENT

House Bill 1333 required that every local jurisdiction within the state implement and enforce the energy conservation code regardless of whether it was enforcing any other section of the code. Each jurisdiction was required to appoint an energy inspector by September of 1977 and notify the Department of Insurance of the inspector's name.

This bill further stipulated that the Engineering and Building Codes Division of the Insurance Department "would make available to the energy inspectors courses of instruction covering the insulation and energy utilization requirements."

Enforcement was further enchanced by the bill as it required any person installing energy conservation measures for a fee would be licensed as an energy conservation contractor by the local jurisdiction in which the work was being performed. It also required that an insulation permit be obtained for each individual insulation job. This gave the inspector a handle on the jobs in his jurisdiction, as to what and where they were, and the capability of pulling a license from those persons doing work consistently not up to code standards. The permit requires that the certification on the permit state that the building specifically meets the energy utilization section of the uniform State Building Code. License was not required of any contractor already licensed by the state, nor licensed architect or engineer licensed by the state.

House Bill 1333 further states that the installer shall notify the inspector when various stages of the work are ready for inspection. The inspector, upon completion of the work, issues a certificate of compliance with the energy utilization standards of the code. If a licensed architect or engineer designs and inspects the project, the building inspector may accept a certificate of compliance from either of them.

One last provision of House Bill 1333 requires that all sales contracts for the installation of energy utilization materials or equipment have a provision that the work will meet the requirements of the State Building Code. This provision serves not only to assure compliance with the code, but keeps the inspector free of becoming involved in the middle of contractual disputes.

IMPLEMENTATION PROBLEMS

Now there is in place an Energy Utilization Code that is statewide - legislation requiring that it be enforced - legislation to protect the public from fraudulent operators - so what's the problem? implementation and implementation in a hurry - that is the problem. The towns and counties that have building inspection departments and procedures will suffer the usual pangs of any code change. These pangs will be amplified, however, by the speed with which the code takes effect, and by the additional requirements set forth in the legislation. The real problems of implementation will come about from the smaller towns and counties that do not have any inspection department or procedures.

Approximately 50% of the area of the state lay within jurisdictions that did not enforce the building code. They either enforced none of the code or only the electrical portion. Secondly many of these jurisdictions resented any "meddling from down at the State Capitol" that would tell a man how he had to build his own house. Luckily for the Energy Utilization Code, people were becoming increasingly aware of energy use primarily because of escalating prices. Although many did not truly believe an "energy crisis" was upon us, a crisis of some kind was hurting their pocketbook and they were looking for relief. The local jurisdictions began to comply with the law and appointed their energy inspectors. Unfortunately, many of these inspectors were appointed for reasons other than their knowledge of building and were not absolutely certain of the difference between a four inch wood stud and a four inch fiberglass batt. Clearly education had to be the primary order of the day.

IMPLEMENTATION THROUGH EDUCATION OF INSPECTORS

Legislation by the General Assembly required that the Engineering and Building Codes Division offer courses to the new energy inspectors but it became quickly apparent that some type of courses should be offered to builders, contractors, and the design professionals as well. It was also quickly determined that it would not be feasible to present any indepth courses that could reach everyone prior to the effective date of the code, and that some material explaining the code should be made available to those persons affected who could not attend classes. Manpower became critical as the legislation for implementation of the Energy Utilization Code was enacted without any additional appropriations, either on the state or local basis.

The Engineering and Building Codes Division applied for and received a grant from the Department of Energy through the State Energy Division of the Department of Commerce under the Energy and Conservation Act (P.L. 94-163). Through this grant, the Building Codes Division hired an engineer and an architect, whose responsibilities were to develop and deliver workshops and seminars to building inspectors, building owners, and maintenance personnel, and to develop and distribute an illustrated handbook of the energy code. These professionals began work August 1 1977 working toward a deadline of 1 January 1978, the effective date of the commercial code. Previous experience in new code implementation had indicated short courses and an illustrated handbook greatly facilitated implementation of the code and eliminated some of the confusion that arose by necessity.

The initial work was to develop and deliver short courses. The two new personnel devoted full time to the course material and especially visual aids for the course presentation, and to the actual presentation.

The material presented by NCSBCS and ERDA at the University of Utah in August 1977 was the nucleus of the initial short courses. A trial run of one and one half days was set up for late September and October and scheduled at four locations across the State. Material was lifted from parts of the NCSBCS course and reproduced, Standard 90-75 and other documents were obtained from Washington and a slide presentation of the North Carolina Code and explanatory sketches was assembled, a limitation of thirty persons per class was set, and the show went on the road.

This initial series of courses were as educational for the instructor as it was for the student. It pointed out several factors.

1. Although the residential insulation code had been in effect for over two years, it was neither fully understood nor fully enforced.

2. The inspectors understood that insulation was supposed to reduce heat transfer, but were unaware of the serious problems that could be caused by improper installation.

3. The inspectors initially wanted a "cookbook" approach to what to look for, and a detailed explanation of inspection administration.

4. The inspectors were apprehensive of calculations for "U" values in buildings.

5. It would not be possible to get the limited enrollment course to all the inspectors, much less the public, prior to the effective date of the new code.

It became necessary to drop back and regroup.

The legislation passed required that courses be offered to all inspectors, so larger attendance was mandated. Short courses of one and one half days were set in two locations in the State with class attendance of two hundred and fifty to three hundred persons. These were filled. The courses served the purpose of meeting the legal requirements, but were not as satisfactory as the smaller classes in disiminating information and feedback.

SEMINARS FOR DESIGNERS AND CONTRACTORS

In addition to the required courses for inspectors, the Building Codes Division along with the state chapters of the American Institute of Architects and Professional Engineers, sponsored two one day seminars for architects, engineers, builders, contractors, owners, along with inspectors these seminars were again held in different locations and were attended by three hundred and four hundred and fifty persons respectively. The seminars helped in explaining the intent of the code, especially the procedures involving the administration and certificates of compliance.

DEVELOPMENT OF A HANDBOOK

The presentations of the classes and seminars constitued an excellent base for the materials to be contained in the illustrated handbook. The handbook was laid out basically along the lines of a previous handbook prepared by the Department of Insurance to explain the Handicapped Section of the North Carolina State Building Code. This format in the open book, contained only the actual enacted code on the left hand page, and the explanatory data and drawings on the right. When the person referred to the pertinent section of the handbook, the actual code was there also. This same format was used in the classes and seminars with slide projections using two projectors. The code sections were projected on the left hand, and descriptive matter on the right with several different slides for each different requirement of the code. As the courses developed further, this system was adapted to overhead transparency projections in order to modify or add illustrations, or explain a one of a kind situation.

This format and information discussed in the courses were assembled into the handbook "Energy Conservation in New Buildings - Chapter XXXII Efficient Energy Utilization in New Buildings." The handbook contains a brief introduction, a flow chart to determine if a particular building is required to meet the code, and which provisions apply, the code with its explanatory data, the appendix to the code, several pertinent tables from the ASHRAE Handbook of Fundamentals, and the tables from ASHRAE Standard 62-73. The handbook is not intended to be either a design manual in heat transfer nor a catalogue of the only materials and systems that meet the code. It is a manual to explain the Energy Utilization Section of the North Carolina State Building Code, and presents the designer and inspector methods of determining compliance with the code.

It is realized that codes relating to energy will be dynamic codes reflecting availability of source, and states of the art. The handbook was numbered in such a way that individual portions could be revised without the necessity of renumbering the entire manual. Pagest to the left containing the code material have numbers, and the descriptive materials have numbers with subletters.

The handbook was printed on the same color paper as the Energy Utilization Section in the State Building Code. This is to provide a continuity of reference.

REVISED SHORT COURSES

The handbook is now used as a teaching aid in the revised short courses offered to instructors. The Energy Utilization Code has been divided into three short courses. "Course I, Residential" is a two and one-half day course on the fundamentals and application of insulating materials and systems as related to Section 3201 of the Energy Utilization Code. This course covers 99% of the new residences constructed in the state.

"Course II, Thermal Envelope Criteria" is a three day short course with Course I as a prerequisite. Course II deals with new buildings, other than residential, up to 15,000 gross square feet in area, and goes heavily into the calculations of overall heat loss, and into heating, cooling and lighting systems to a lesser degree. This is within the capability of an inspector who is fairly well trained but not necessarily a professional person.

"Course III, Thermal Performance Criteria" is a longer course, the number of hours yet to be determined, that will encompass energy consumption budgets in new buildings larger than 15,000 gross square feet. This is of course a sophisticated area requiring extensive training and experience. At present there are few inspectors with the background to check the plans, specifications, and calculations for a thermal performance project. It is anticipated that this will not be required often in small inspection jurisdictions and therefore all inspectors may not take the course offered. For the most part, buildings of this magnitude will have a licensed professional involved in the design and analysis, and the inspector may accept their analysis and certification of complaince.

PROFESSIONAL SEMINAR

The state chapter of professional engineers is sponsoring a three day seminar for the energy code with particular emphasis placed on the thermal performance sections. Participants in this seminar will include some of the individuals who served on the energy advisory comittee developing the code. This seminar is privately sponsored and is open to all interested parties, but the high registration fee will eliminate most inspection personnel from this meeting.

It may appear that overemphasis is placed on illustration and education in code implementation, but in reality it can hardly be overemphasized. Education, especially in energy utilization, provides the inspector with an understanding of why the code is necessary, how energy utilization works, how to foresee problems and how to inspect the installation. It provides a basis for uniform interpretation and enforcement across the state. This certainly reduces the confusion among designers, owners, and builders as to what is required. It is not to be implied that inspectors were the sole persons needing education; builders were unaware of the dangers of insulation, and designers had been using the old rules of thumb for so long they had forgotten some of the sophomore basics in thermal design consideration.

FUNCTIONS OF STATE DEPARTMENT

The energy personnel of the Engineering and Building Codes Division have had their hands full with the training programs and answering questions from inspectors. The federal grant does not allow these positions to be used for ongoing operations and administration. The Division requested and obtained three new permanent engineering positions from state personnel. These three new positions will be administrative and plan review. This permits the Division to spot check buildings across the state, and to review thermal performance criteria in cooperation with some of the smaller jurisdictions that will not have inspectors with advanced training. These three new positions will also aid in, and eventually absorb the training aspects of the grant funded positions.

One other aid in the implementation of the code is the standard forms, one for Thermal Envelope Criteria and one for Thermal Performance Criteria that must be submitted upon application for building and/or insulation permit. Uniformity across the state is the goal, and provision of a base for review of the application. The code also gives design temperatures indoors and outdoors as a basis for review of calculations. These temperatures may not be limitations necessarily, but they are the basis for design review.

CONCLUSION

The two and one half year experience with implementation of energy codes in new residential buildings, and the seven months of implementation of energy codes in other new buildings points out that new energy conserving codes cannot be implemented without some confusion and resentment from concerned parties. This confusion and resentment, however, can be reduced by the following:

1. Have a state government aware of energy problems and willing to take the steps necessary to alleviate these problems.

2. Develop a code that is economically practical and apply it uniformly.

3. Provide courses for both the inspector and the user.

4. Provide data and illustrations that explain each aspect of the new code. Aim this material toward comprehension by persons without extensive training.

THE USES OF AN INTEGRATED DATA BASE IN MUNICIPAL COMPUTER ASSISTED REGULATORY SYSTEMS

by

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Computer based systems are becoming more prevalent as the basic means of administrative and financial control of municipal governments. With the availibility of computer hardware or the access to computational facilities well established in most cases, the consideration of the additional uses for the municipality of such facilities becomes important.

Two of the many areas receiving considerable attention at this time relate to building regulatory functions and housing inspection functions. Several cities have already instituted departmental programming for use in normal administrative and control functions. The system in Chicago for the building department has already been reported at the 1976 NBS Conference. The Boston Housing Inspection Department has incorporated the use of the computer extensively for their daily operational functions. Many other cities are in the process or have recently installed systems to computerize one or more aspects of their housing or building regulatory functions.

The City of Worcester, population of about 180,000, has been studying for almost two years the potential for a system that would not only provide computerization of normal building and housing inspection administrative and control function, but could provide a base for many inter-related functions, and process specialized data for many coordinated municipal programs.

The size of the city precludes the availability of separate computer facilities for each department. Therefore, the study developed requirements based on a central computer and interdepartmental accessibility of data and results. By looking at a coordinated system, it became apparent that many benefits could be derived for a choice of proper initial hardware and careful software considerations. Studies by departmental personnel and interns from Clark University indicated the following as some examples of potential use:

1. Correlation between housing inspection abatement notices and building or demolition permit issuances.

2. Evaluation of potential arson sites based on coordination of housing inspections and building inspection records and outstanding tax and water bills.

3. Evaluation of overall neighborhood physical characteristics to determine blight areas, potential blight areas and establish the boundaries of such areas.
4. Coordination of Fire Dept. building data and building and housing data.

In addition, there is the potential for coordination of municipal programs involving many other functions and integrated programs involving the building inventory or its infrastructure.

The results of the studies so far indicate that while the normal control and administration functions of computer programs, such as used in Chicago and Boston, have great potential, the readily available spinoffs from the data base and information have even more important potential for municipal planning and control of all city programs relating to buildings and their infrastructure.

Key Words: Municipal governments; computer facilities; regulatory; integrated data base.

INTRODUCTION

The use and importance of computer facilities and processing in municipal governments is becoming more significant and more prevalent. Most cities rely on some form of computer facility or services for processing many of the administrative and financial functions such as payrolls, school grades, schedules and budgets. Cities which are of adequate size to have their own computer and computer staff have the potential for uses of the computer which may go well beyond the basic needs of everyday functions. The determination of the needs for using the computer will depend on the priorities of the government, the capabilities of its staff, the capacity of the machine, the availability of peripheral hardware, or a combination of all of these considerations.

This paper is going to be identified primarily with the experience in Worcester, Massachusetts. Worcester is a city of approximately 180,000 with a large college population of approximately 25,000 students of which probably 15,000 are from outside Worcester. The City is relatively old, and typical of many of the industrial cities of the Northeast with a large number of three family dwellings - called three deckers - many lodging and boarding houses, and much of the residential construction of wood. The City is the second largest city, after Boston, in New England. The City operates a Data Processing Department for all city departments, and operates a leased Honeywell system which will shortly be renewed with a larger capacity machine with specifications to be determined in the near future. The City is in the process of transferring all of its financial management to computer. There are many other basic uses for the system at present, including equipment inventory, all school grading and scheduling, library film distribution control and processing water and tax bills. The capacity, facilities and opportunity for far more extensive use of the system exists.

The size of the City of Worcester is interesting when considering the topic of this paper. The Data Processing Department employs a total of about 24 persons, with several senior programmers and analysts and has the capability of relatively complex programs and systems development. Because of the size of the City, there appears to be the ability to justify only one computer facility - a central computer and Data Processing Department. There are other larger cities, such as Boston, which have several computer facilities which apparently can be economically justified. It is obvious that a city the size of Chicago or New York must depent on many separate computer facilities. However, it is because of the need to look at all requirements in terms of one general use facility that the need and the benefits of integrating data and vunctions for several departments became more necessary and desirable. At the present time, the capacity of the machine is not fully utilized and the time schedule both for real-time, that is, immediate computer response material, and batch porcess, is not fully utilized. Recognizing the availability of the facility and with an increased awareness of the possible uses of the computer facility, many separate departments in the last two years proposed programs for the use of their departments. Several of these were for the Department of Code Inspection, which incorporates Building Inspection and Housing

Inspection among its functions, the Fire Department an on-going program for the Assessing Department, the Planning Department and the Department of Public Works.

BACKGROUND

Many cities incorporate departmental computer facilities or programming of a central computer for regulatory functions. The system in the Chicago building department was reported at the 1976 NCSBCS/NBS Conference. The City of Springfield, Mass. uses a central computer for several programs which integrate housing, assessing and building permit data. Basically, the program has a data base of the assessor's records identifying all properties, location, owners, details of building character, rooms, residential facility condition on a scale of 1 to 5, and the program updates all owner changes, building permit changes to the physical structure, changes of physical condition, and is able to print out maps based on discrete data showing condition of buildings in any area (different types of residential and their condition can be mapped) based on intensity of print (white to black). The City of Boston housing department computerizes all housing violations notices and prints out standardized descriptions, while establishing a data base of the date, location, violations, status, overall condition, legal action period, and several other items for internal administrative control.

In the cases of Chicago and Boston, the systems are apparently independent of other data bases in separate computers. Springfield uses the central computer and integrates the data base for several functions including housing, building and planning. However, the system is not used for normal daily processing such as Boston and Chicago.

While these examples show some of the programs in existance, the fact is, that the scope and potential for integrating the data base for use across a broad range of municipal responsibilities and objectives is tremendous.

EXAMPLES OF APPLICATION

I ARSON STUDY

The value of an integrated data base was illustrated when the Department of Code Inspection and the Planning Department instituted a study to determine the feasibility of predicting arson in buildings. This was initiated about two years ago when the incidence of arson, especially in residential structures, in many of the cities in Massachusetts became epidemic in proportion. In many cases of suspicious fires there was a history of extensive housing code violations, ultimately in some cases leading to condemnation, and tax and water bill delinquency. It was known in some cases that large insurance settlements occurred and that the property was subsequently abandoned, with the City left to demolish the building and absorb the tax losses and cost of demolition. The question arose as to the feasibility of predicting the probability of arson. The prime indicators for such predictions appeared to be the following 1) Tax delinquency, 2) Condemnation, 3) Absentee ownership, 4) Location in "inner city". In addition, the sequence of events leading to city demolition and loss of tax revenue was analyzed to determine if there was any significance to the pattern. Figure 1 shows relationships which were derived. The important point in reviewing this work, in which all the data was derived manually with a great expenditure of time and effort, is the fact that there are several separate and independent data bases involved. These are 1) Tax Collector's Office 2) Assessor's Office, 3) Housing Inspection Records, 4) Building Inspection Records, 5) Fire Department Records. As Figure 2 shows the data base for the Assessor's is independent of all others as are the data bases for all others except for Housing Inspection and Building Inspection, which have an informal link because they are in the same department. Assessor's records are available to the Tax Collector on a batch basis, but there is not access to the same data by both departments. If the data base was properly integrated, there would be common access, based on address and ownership to all the indicated agencies, and all the information necessary for maintaining a continuously updated correlation for the arson study would be available.

II INSURANCE

Based on the results of this study I prepared legislation which was submitted and passed, becoming effective January 1, 1978, which allowed a local government to establish a first claim on any building in excess of $1,000 if the building and/or housing commissioner versified that the building was likely to subject to demolition under several possible statutes. The law also provided that a claim may be instituted by the Tax Collector if the damage exceeded $5,000 and the City had a record of outstanding taxes against the property. Figure 3A shows a flow chart used to control the acquisition of information and route it for evaluation in determining if a claim on the insurance is warranted. In this case the information involved is the following: 1) Buildings which are condemned, 2) Buildings which are on a priority list for demolition, 3) Buildings which have taxes unpaid, 4) Buildings which had previous extensive violations of housing and/or building codes, 5) Buildings with absentee landlords, 6) Buildings whose owners have other property in distress or who have a questionable record of property mamagement or outstanding liens, or numerous suspicious fires. The possible data sources are shown in Figure 3B as follows: 1) Bureau of Land Use Control, 2) Bureau of Land Use Control, 3) Tax Collector, 4) Housing and Buildings Divisions of Code Inspection Department, 5) Assessors/Tax Collector's, 6) Bureau of Land Use Control, Tax Collector, Fire Department, Housing and Buildings Divisions.

The insurance law allows a period of 10 days to elapse between the date of notification by the insurance company and the date of response by the city to restrict the payment of the claim. Based on practical experience in performing the limited information gathering required by Figure 3A it is clear that only an integrated computer data base could provide all the information needed within the time period available.

III OTHER EXAMPLES

A. Violations of the Housing Code often involve the necessity of a building permit to accomplish abatement. In many cases where a house is condemned by the housing inspector, the owner takes out a building permit for work and is issued a certificate of occupancy without abating the housing code violations. In others, where buildings are subject to demolition, the previous owner has sold the building and the new owner takes out a building permit while the building is being processed for demolition. With an integrated data base, any change of status on the building would show up immediately. A building permit update on a condemned building or one subject to demolition could immediately indicate a discrepancy. Changes of ownerships recorded for buildings on these lists could also signal a review.

B. Census tracts or geographical areas based on other boundaries could be tracked in terms of assessment of housing conditions, incidence or arson, crime statistics, tax delinguency, absentee landlords and an evaluation of blight and potential blight areas or potential rehab areas can be evaluated.

BASIS FOR SYSTEM

The basis for the use of any data is its reference to either an address or an owner. All municipal regulatory concerns can be related to either the address or the owner as the computer address for reference. With these two keys, which are essentially within the date base of the Assessor and Collector of Taxes, all other information can be referred. The following items all relate to an address or owner:

1. Assessor's Records
2. Tax Records
3. Municipal Liens and Bills
4. Fire Record
5. Demolitions
6. Building Permits/Inspections/Violations
7. Housing Inspections/Violations/Conditions
8. Condemnations
9. Lead Paint Inspections/Violations
10. Land Use
11. Electrical Permits/Inspections/Violations
12. Plumbing and Gasfitting Permits/Inspections/Violations
13. Fire Department Building Plans
14. Rodent Infestations
15. Street Maintenance
16. Tree Maintenance
17. Sidewalk Maintenance
18. Water supply/Distribution

In most cases there is a critical need to have a constantly updated listing of ownership of a building or of land. Therefore, the updating of the Assessor's records is essential, since all regulatory functions depend on the ability to interact with a legal entity defined as the owner or the person or other entity responsible. Figure 4 shows the interaction of many of the regulatory functions with the Assessor's Base as the repository of the computer reference keys, the address and the owner. Based on these two keys, it is evident that extensive information can be accumulated relative to regulatory functions, and planning functions for such things as systematic code enforcement, rehabilitation and land use patterns.

INTEGRATION OF DATA

1. HOUSING CODE - BUILDING CODE - ELECTRICAL - PLUMBING

Current activity for either building code violations, housing code, electrical or plumbing could be integrated so that any building could not receive a certificate of occupancy, or a certificate of abatement of housing code violations while activity under any of the cited codes was progressing. Since all are statutorily separate but necessarily integrated activities it provides an important control.

2. CONDEMNATION - TAX BILLS - MUNICIPAL LIENS - BUILDING, PLUMBING ELECTRICAL CODE VIOLATIONS - RODENT INFESTATION

Buildings which have a record, or start accumulating a record, of tax bills, liens, and code violations have shown an overwhelming consistency in leading to condemnation and further problems. The sooner these buildings are identified, the easier it is to expedite action and the greater the likelihood of preserving the building.

3. SINGLE OWNER RECORDS

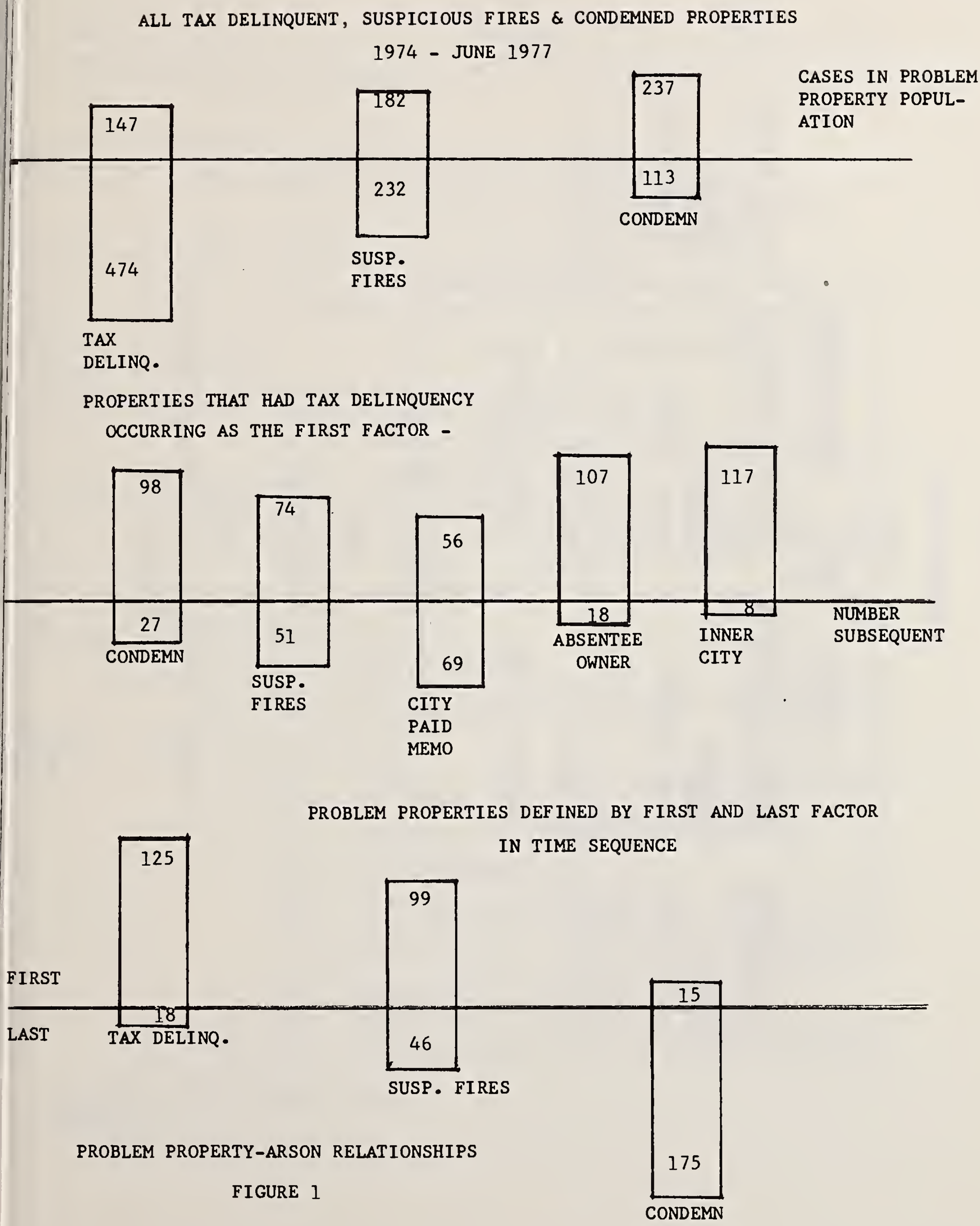
The determination of policy on buildings may depend on accumulating all information on a single owner of many buildings relative to his other properties including information on building condition, tax bills, liens, condemnations, fire history, and demolition history.

4. OTHER USES - NON REGULATORY

The potential for non-regulatory use of information generated within the regulatory process is extensive. Specific details of certain alterations to buildings can be reported directly to fire department data for updating their fire attack strategy. Planning based on evaluation of building conditions can be done by aggregating specific information for all addresses within a neighborhood. This can also be integrated with street, sidewalk, water supply and tree maintenance programs for a neighborhood or section of a city.

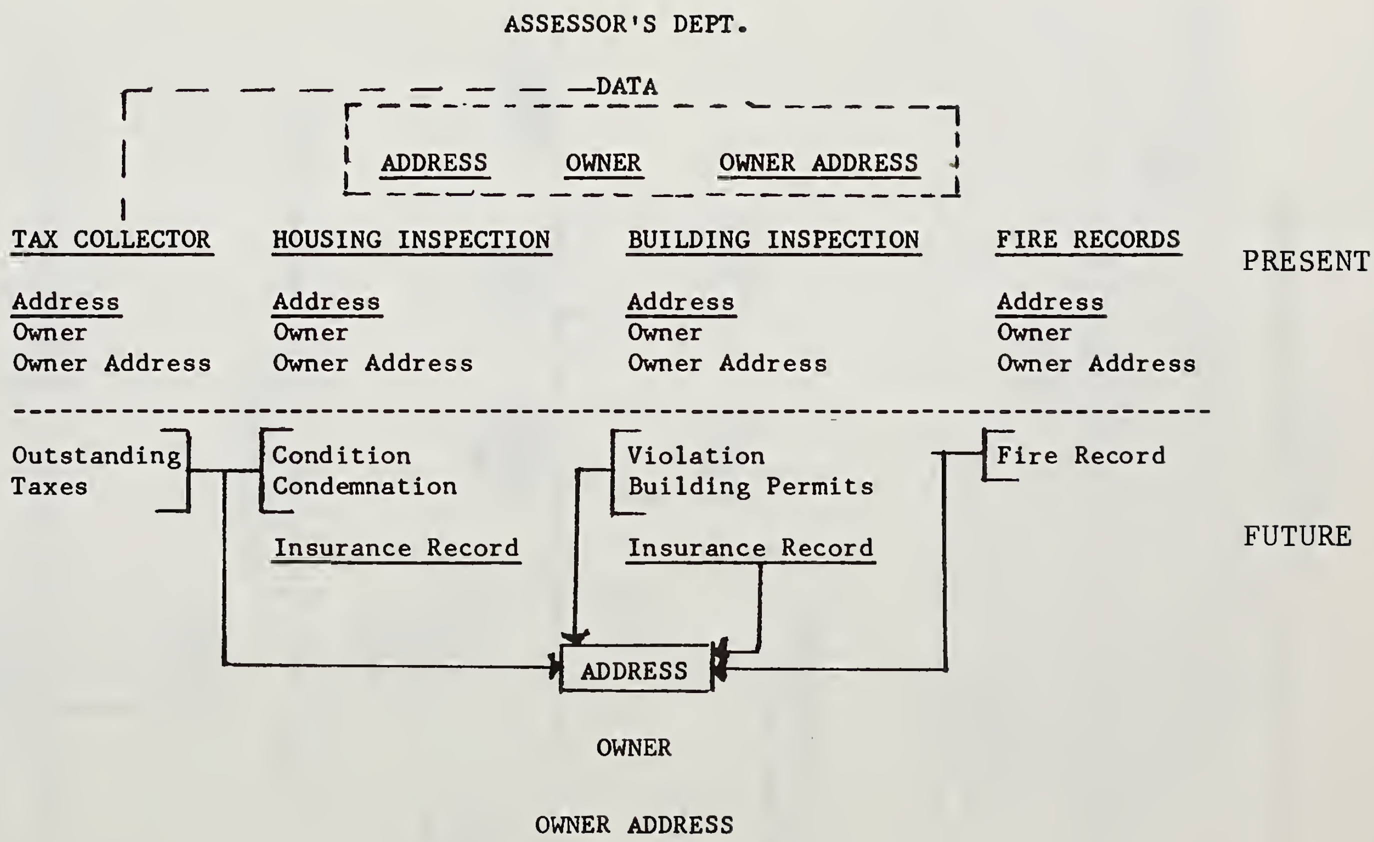
CONCLUSION

Examples and possible applications of the use of an integrated data base in a local government have been demonstrated. The scope is even greater than this brief introduction reveals. Because so much of the regulation, planning and services of a local government are addressed by means of address and owner's name, there is an extensive base of information available for any address, owner or aggregation of addresses. The City of Worcester is now in the process of reviewing the functions and programs which can be addressed through address and/or owner and establishing priorities for program implementation to start accessing information relative to the Assessor's records as the overall key mechanism.



PROBLEM PROPERTY-ARSON RELATIONSHIPS

FIGURE 1



DATA BASES FOR ARSON STUDY - PRESENT AND FUTURE

FIGURE 2

REQUEST FOR INFORMATION FORM (DEMOLITIONS)

Structure Address ______________________________
Owner ____________________ Address ____________________
Insurance Co. ____________________ Address ____________________
Date of Notification Received ______________________________

1. Demolition Secretary:
   A. Property previously demolished
   B. Property previously in demolition
   If A. or B., notify the Commissioner and send notice of intent to the Insurance Company
   C. Property not in demolition
   If C. send copies to Housing Division, Superintendent of Buildings, and Tax Collector

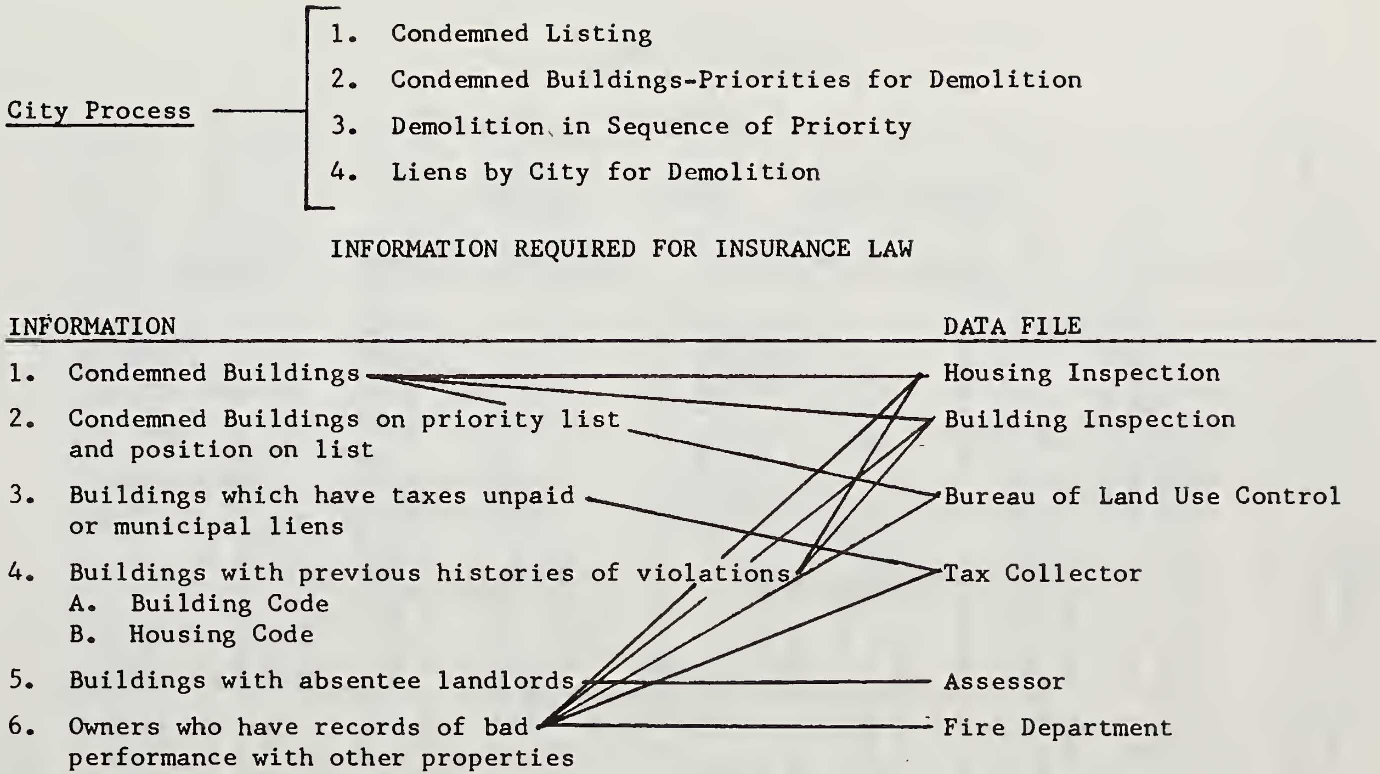
2. Information - to be forwarded to the Commissioner of Code Inspection
   Date __________ A. Housing Division - Chp. 139
   B. Superintendent of Bldgs. - Chp. 143
   C. Tax Collector - Taxes due - $ __________

3. Commissioner of Code Inspection
   A. Chp. 139 Forward to demo. sec.
   B. Chp. 143 Forward to Bldgs. Div. & demo. sec.
   C. No demolition to inactive file

4.A. Demolition Secretary (Chp. 143) - notice of intent -
   Date __________
B. Buildings Division (Chp. 143)
   i. Date order of demolition __________
   ii. Date demolished __________
   Forward to demolition secretary

5. Demolition Secretary
   A. Date - Notice of intent __________
   B. Date - First hearing notice __________
   C. Date - Hearing notice sent to Insurance Co.
   ____
   D. Date - Funds released __________ or
   Date - Dismissed __________ or
   Date - First demolition order: __________
   To Insurance Co. __________ To owner:
   ____
   E. Date - Demolished __________
   F. Date - Of billing __________
   G. Date - Of lien __________

FLOW CHART FOR INSURANCE LAW
FIGURE 3A



DATA SOURCES FOR INSURANCE LAW

FIGURE 3B

	DATA KEYS			DATA RELATIONSHIP	
DATA BASE	ADDRESS	OWNER	OWNER ADDRESS	OWNER BASED	ADDRESS BASED
ASSESSOR	X	X	X		
TAX COLLECTOR	X	X	X		
MUNICIPAL LIENS	X	X	X	X	X
FIRE RECORD	X				X
DEMOLITIONS	X	X	X	X	X
BUILDING RECORDS	X	X	X	X	X
HOUSING RECORDS	X	X	X	X	X
CONDEMNATIONS	X	X	X	X	X
LEAD PAINT	X	X	X	X	X
LAND USE	X	X	X		X
ELECTRICAL	X	X	X	X	X
PLUMBING	X	X	X	X	X
FIRE STRATEGY	X				X
RODENT	X	X	X	X	X
STREET MAINTENANCE	X				X
TREE MAINTENANCE	X				X
SIDEWALK MAINTENANCE	X				X
WATER SUPPLY/DIST.	X				X

DATA KEYS AND RELATIONSHIP

FIGURE 4

Exploiting the Computer to Control the Application of Design Criteria to Construction

by

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The U.S. Army Corps of Engineers is sponsoring the development of a Computer-Aided Engineering and Architectural Design System (CAEADS) to aid the programmer, planner, designer, and constructor of facilities. One of the basic objectives of CAEADS is to provide for systematic application of design and habitability criteria that are the counterpart of building codes and standards adopted by federal, state, and municipal agencies. This paper will describe the overall conceptual design of CAEADS and then go into some detail on the specific system features that deal with criteria.

Key Words: Design criteria, Guide specifications, Habitability criteria, Computer-Aided Engineering and Architectural Design System (CAEADS).

INTRODUCTION

As the largest construction agency in the free world (1500 completed projects per year), the Corps of Engineers is faced with a continuing requirement to improve efficiency and responsiveness in the face of growing complexities caused by new standards and criteria. Examples of these challenges include greater concerns for the environment, the need to reduce energy consumption, and ever increasing expectations in habitability and safety on the part of all people. Furthermore, the ominous inflation that has a long history of going up at a faster rate in the construction industry than in the other segments of the economy places added emphasis on the need to improve the overall process.

CAEADS is being developed toward this end. It is a system of computer aids to be utilized in the construction design process beginning with the definition of a requirement for a facility and continuing through all steps up to and including the preparation of construction plans, specifications, and cost estimates. The primary objectives of CAEADS are to increase the productivity of the design staff, improve the utility of the delivered facility, and to reduce design and construction costs. The users of CAEADS include planners, architects, engineers, specification writers, and cost estimators. The system is intended to relieve architects, engineers, and technicians from repetitive unchallenging computations and processes and to permit consideration of a larger number of design alternatives than is now feasible. These professionals will, however, retain full technical responsibility for the products that are produced. Their opportunity to innovate will be enhanced. Human factors considerations, particularly in relation to interfaces between people and machines, will be given prime consideration in the design of CAEADS.

CONCEPT DESIGN OF CAEADS

CAEADS is oriented to individual projects and to the functions accomplished in the production of contract plans, specifications, and cost estimates. With this as a focus, CAEADS also responds to planning, programming, and budgeting needs. The diagram shown in Figure 1 depicts how the functions of CAEADS have been broken down into activity groups. A number of functions take place in each group. Information flow between functions is indicated.

The heart of CAEADS is a project description data handling subsystem. It is hierarchically designed to facilitate consolidation of structural components into groupings such as wall, roof, and floor sections and above this into assemblies of these groupings. The project will have a three dimensional geometric representation and provision is made for carrying an unlimited number of properties, addresses, and pointers at each level of the hierarchy. The overall data base structure is divided into two components. The first of these, termed "project-independent," contains design criteria, technical instructions, guide specifications, task cost guide, and other information that has overall application to all projects. The second component is the "project-dependent" portion of the data base. It contains all of the information related to individual projects and grows with each project as design progresses. Computer programs operate on project-independent data to produce project-dependent data.

A hierarchical structure is also used to define the concept design of CAEADS. The four levels of the hierarchy are as follows:

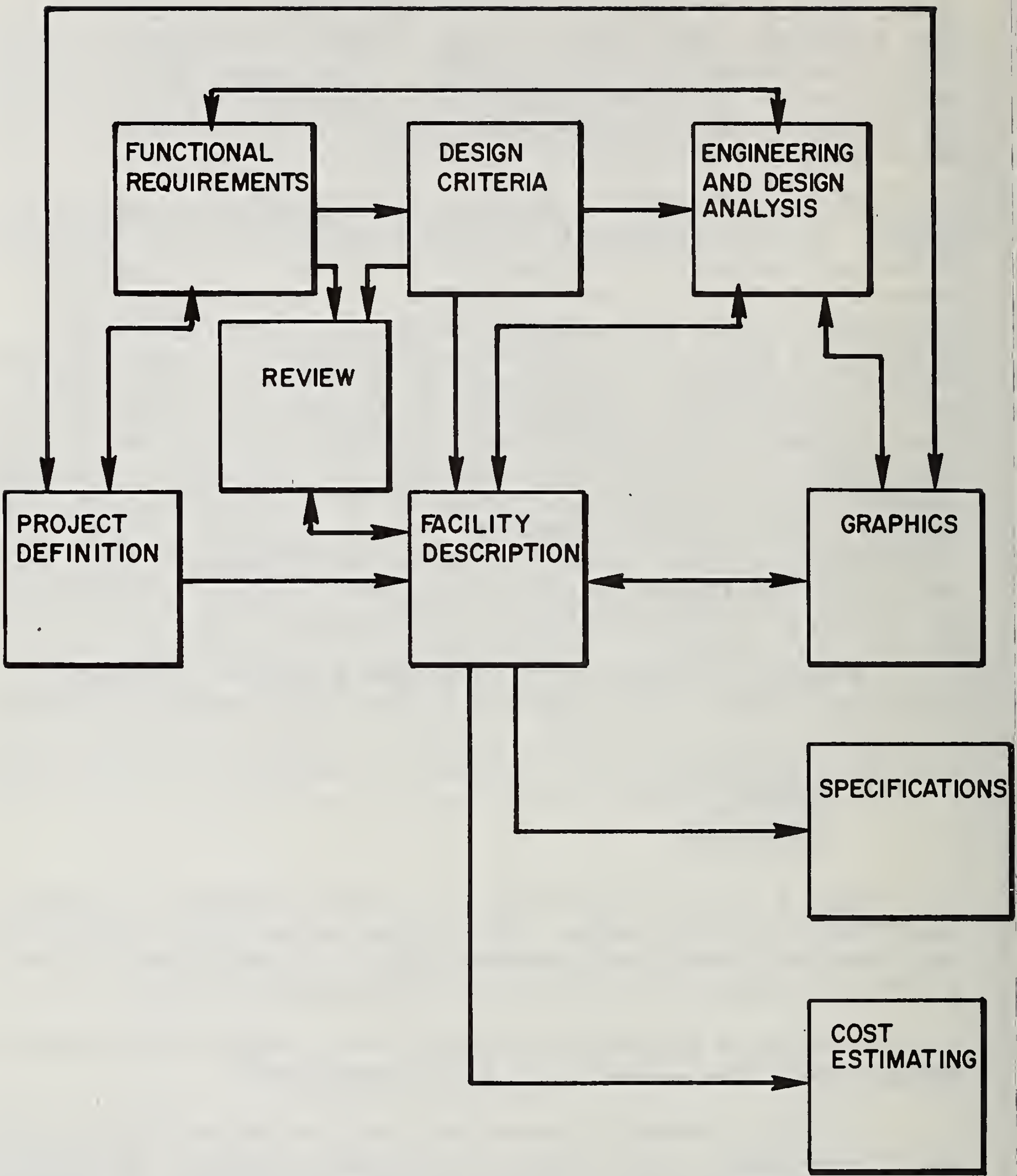
1. Project
2. Design Phases
3. Activities
4. Disciplines

Figure 2 extends this notion to a further breakdown of detail in describing the system design. The project as the first level is at the center of a series of concentric rings. A project may consist of a number of related facilities including utilities systems.

The Corps of Engineers has adopted three phases through which all designs pass. The second level shows these phases.

At level 3, CAEADS is broken into nine design activities, each of which takes place in one or more of the design phases. The individual operating programs support these activities. The number of operating programs to be developed for each activity is open ended.

The outer ring shows the professional disciplines served by CAEADS. Each discipline may function in one or more of the design activities.



CAEADS PRELIMINARY CONCEPT DESIGN ACTIVITY DIAGRAM

Figure 1

CAEADS HIERARCHY

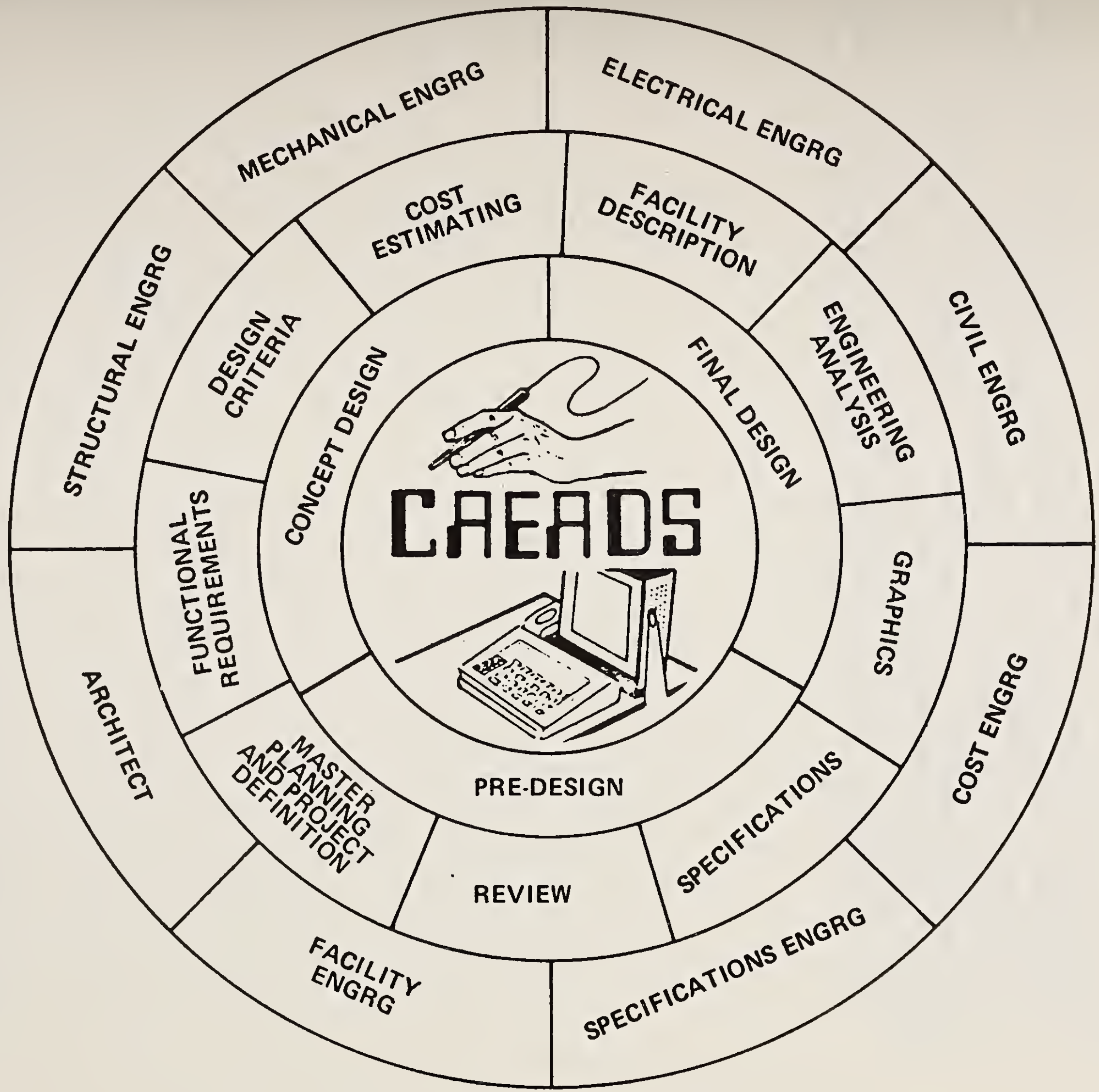


Figure 2

Figures 1 and 2 are from a report prepared by Daniel, Mann, Johnson, and Mendenhall, Los Angeles, CA, on the detailed system design of CAEADS. This work was accomplished under a contract with the US Army Construction Engineering Research Laboratory, Champaign, IL.

METHODOLOGY FOR CONTROLLING DESIGN AND CONSTRUCTION

The Corps of Engineers utilizes three basic mechanisms for controlling design and construction to assure that prescribed standards are met. These are:

Design criteria
Habitability criteria
Guide specifications

Design criteria prescribe the features of construction and values for various coefficients that are included in applicable mathematical equations and algorithms. Habitability criteria apply to human interaction with a specific structure and include dimensions, spacial relationships, environmental conditions, and standards of rapport. Guide specifications provide the verbage to be utilized in describing to the building contractor in specific and performance terms what will go into a structure and, in some cases, methods for performing certain tasks. The drawings supplemented by specifications describe to the contractor what he must furnish the government.

DESIGN CRITERIA

Design criteria are defined in a wide range of documents. Each document covers a specific component of a structure or broad specialty area. Examples of components include walls, roofs, foundations, underground sewage conduit, and electrical pole line construction. Fire prevention and safety are examples of specialty areas. The term, design criteria, as applied by the Corps of Engineers, is synonymous with codes and standards as employed by municipalities and other agencies.

Within CAEADS, design criteria will be stored in a criteria data storage file which is a subset of the project-independent data base described above. Information from the criteria filed will be called for use in both design and review computations. Review is extensive since the majority of the contract plans and specifications for construction accomplished within the Corps of Engineers is accomplished by commercial A/E firms.

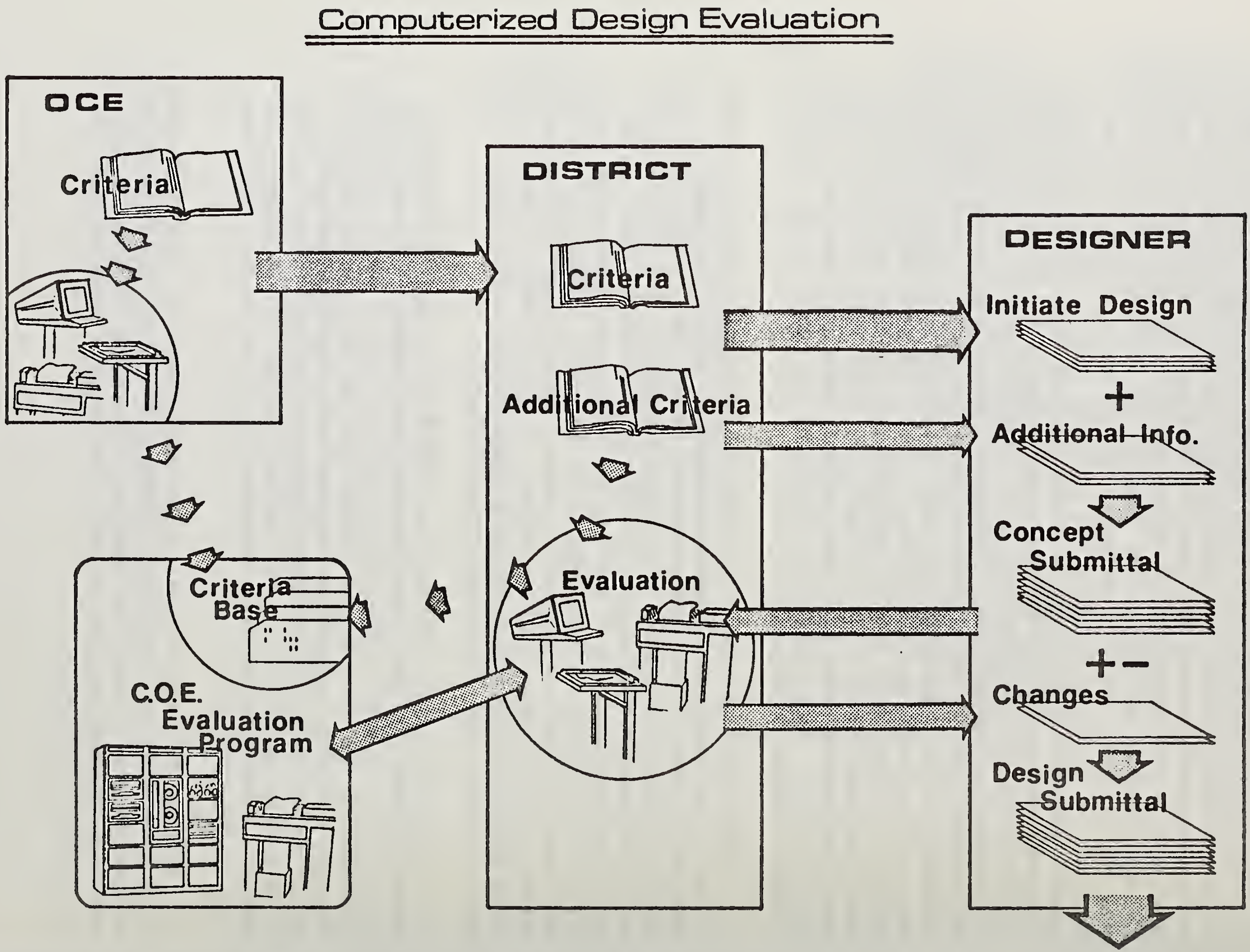
HABITABILITY CRITERIA

The Corps of Engineers is developing a Design Guide series that provides basic planning and design considerations, criteria, and special organization principles for various facility categories. Examples of these categories are Administrative Offices, Recreation Centers, and Service Schools. A computerized system entitled Systematic Evaluation and Review of Criteria for Habitability (SEARCH) is being developed to aid the staffs of the Chief of Engineers and design offices in checking and validating adherence to various criteria categories but primarily those relating to habitability. SEARCH Is also utilized to check and validate the criteria themselves for inconsistencies and conflicts. These criteria include area and space authorizations, walking distances, acoustical separation, visual control, circulation, and handicapped access. SEARCH will also provide material take-offs and inventory listings of furnishings and equipment. The computer can't, however, do all the thinking for us and subjective judgements about aesthetics and overall habitability are, of necessity, left to experienced architects. The SEARCH system performs repetative routine tasks for the designer and reviewer through easily used input-output devices and procedures. This relieves these highly qualified professionals from many mundane tasks and frees them to do creative work. An overall flow diagram of the basic design evaluation process is shown in Figure 3.

SEARCH provides heretofore unavailable design evaluation capabilities. This interactive system encompasses criteria management, building representation, and evaluation procedures. A graphical terminal configuration including a digitizing tablet, a graphic display, and an alphanumeric display or printer is utilized to input layout configurations and related descriptive information from design drawings and to produce output products to the user. SEARCH programs process input information against criteria. Output products show required values, actual values, and deviations. Figure 4 shows a computer produced graphical representation of a segment of a dental clinic that is used to demonstrate the capabilities of SEARCH.

Area criteria are entered into SEARCH and output in the format shown in Figure 5. This shows the area requirements for a group of activities in a dental clinic called Area Group 4. Area criteria for a particular structure may be divided into as many groups as desired. For each activity, maximum and minimum area authorizations may be specified as shown. The maximum applies to the total number of all rooms housing an activity. The minimum applies to each room in the activity. Design guide page references are given on the right hand side of the form.

Walking distance criteria is shown in Figure 6. The quantities shown under REQD are the maximum authorized walking distances in feet between two activities. For example, the maximum walking distance between oral surgery and the recovery room is zero implying that these two should be adjacent.



Computerized Design Evaluation
OCE
Criteria
DISTRICT
Criteria
Additional Criteria
Evaluation
DESIGNER
Initiate Design
+
Additional Info.
Concept Submittal
+−
Changes
Design Submittal
Criteria Base
C.O.E. Evaluation Program

Figure 3

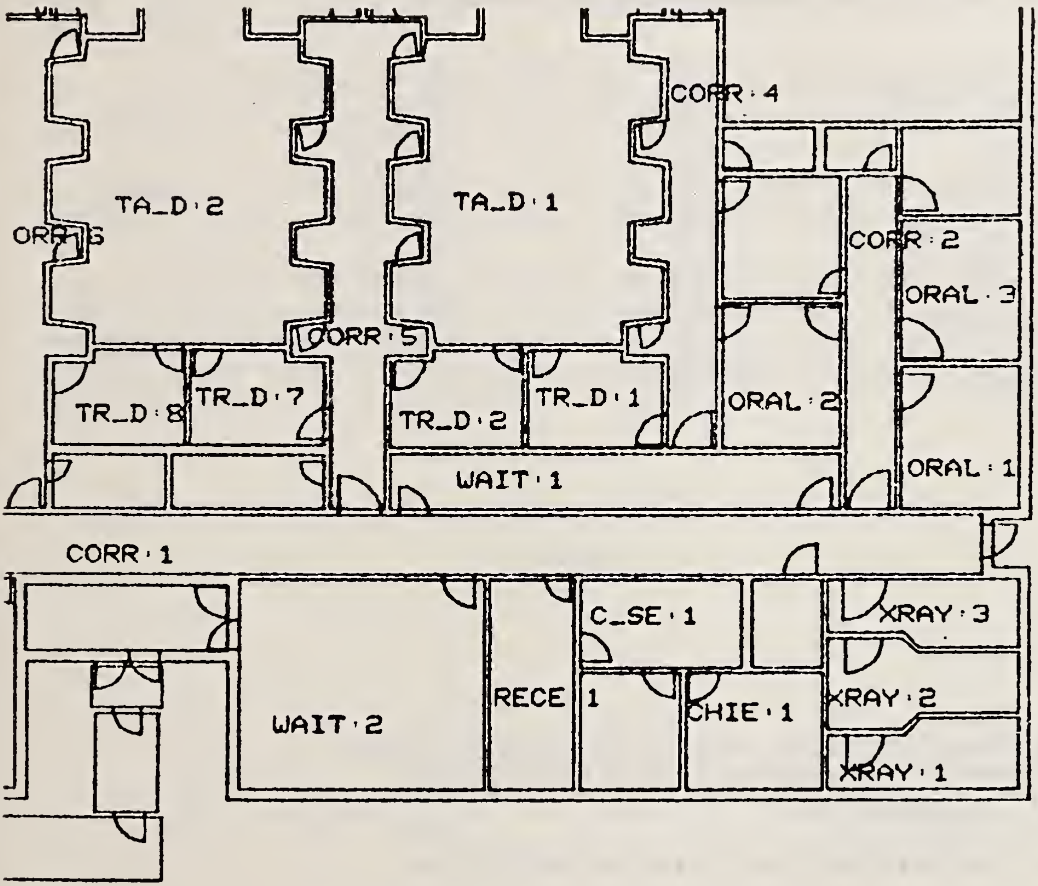

CORR·4
TA_D·2
TA_D·1
CORR·2
ORAL·3
CORR·5
TR_D·8
TR_D·7
TR_D·2
TR_D·1
ORAL·2
ORAL·1
WAIT·1
CORR·1
C_SE·1
XRAY·3
RECE
1
CHIE·1
XRAY·2
WAIT·2
XRAY·1

Figure 4

```
 REPORT CRITERIA AREA GROUP4;
***********************************
**   CRITERIA:AREA              **
**   C:DENT_B1                  **
***********************************

ACTIVITY----------MAX------MIN---PAGE--------
C_SECRETARY         100            DG101
CHIEF               125            DG13_45
NCOIC                90            DG13_45
ORAL_SUR            600      200   DG101          DG65
RECEPTION           160            DG101
TOILET              200            DG101
VESTIBULE            75            DG101
WAITING             450            DG101
XRAY                300      100   DG101          DG65
TOTAL              2100
```

Figure 5

```
 REPORT CRITERIA WALK ORAL_SUR WAITING;
***********************************
** CRITERIA:WALK                **
** C:DENT_B1                    **
***********************************

SPACE REL/W  SPACE TYPE       REQD  PAGE
ORAL_SUR
      RECOVERY     WALK_ALL       0  DG21
      WAITING      WALK_ALL      40  DG21
      XRAY         WALK_ALL      25  DG21
WAITING
      ORAL_SUR     WALK_ALL      40  DG21
      RECEPTION    WALK_ALL       0  DG22
      TR_DENTAL    WALK_ALL      40  DG22
```

Figure 6

An evaluation of the areas of spaces in the proposed layout for Group 4 activities is given in Figure 7. Note that deviations from criteria are shown under DIFF. Given this information, the Architect responsible for review of the design must decide whether to accept each deviation or require a change in the layout to bring it in line with criteria. The purpose of the evaluation as envisioned now is that it be an aid to a decision maker rather than a dictatorial product since judgement must always come into the picture in construction design.

The walking distance evaluation report is shown in Figure 8. The extent of a departure from criteria is given under DIFF. A blank indicates the distance falls within criteria. An "NA" denotes that there is no direct connection between two spaces through a corridor or other space in which passage is allowed. Access may, however, be possible through other rooms.

Other capabilities that currently exist under SEARCH include evaluation of acoustical separation and handicap access.

Added features planned for development include evaluation of emergency egress, traffic patterns, and visual control.

The SEARCH system was developed at the US Army Construction Engineering Research Laboratory by Bruce Dains, Janet Spoonamore, Dale Bryant, and Charles Growdon in cooperation with Robert Shibley of the Office of the Chief of Engineers in Washington, DC, who served as Technical Monitor for the work.

```
 REPORT EVALUATE AREA GROUP4;
************************************
** EVALUATION:AREA                **
** C:DENT_B1      D:DENT1         **
************************************

ACTIVITY----------MAX---ACTUAL------MIN-----DIFF---PAGE--------
C_SECRETARY        100     118 --------       18+   DG101
CHIEF              125     133 --------        8+   DG13_45
NCOIC               90      97 --------        7+   DG13_45

     ORAL: 1 --------      140      200       60-   DG65
     ORAL: 2 --------      143      200       57-   DG65
     ORAL: 3 --------      138      200       62-   DG65
ORAL_SUR           600     421 --------      179-   DG101
RECEPTION          160     152 --------        8-   DG101

     TOIL: 1 --------       50
     TOIL: 2 --------       25
     TOIL: 3 --------       27
     TOIL: 4 --------       44
     TOIL: 5 --------       42
TOILET             200     188 --------       12-   DG101
VESTIBULE           75     112 --------       37+   DG101

     WAIT: 1 --------      213
     WAIT: 2 --------      430
WAITING            450     643 --------      193+   DG101

     XRAY: 1 --------      100      100             DG65
     XRAY: 2 --------      117      100       17+   DG65
     XRAY: 3 --------       98      100        2-   DG65
XRAY               300     315 --------       15+   DG101
TOTAL             2100    2179
```

Figure 7

```
 REPORT EVALUATE WALK ORAL_SUR;
*************************************
** EVALUATION:WALK                 **
** C:DENT_B1      D:DENT1          **
*************************************
SPACE-REL/W/SPACE------TYPE--------REQD--ACTUAL----DIFF--PAGE
ORAL_SUR    : 1
      RECOVERY     : 1  WALK_ALL      0       18       18  DG21
      WAITING      : 1  WALK_ALL     40       15           DG21
      WAITING      : 2  WALK_ALL     40       48        8  DG21
      XRAY         : 1  WALK_ALL     25       NA       NA  DG21
      XRAY         : 2  WALK_ALL     25       NA       NA  DG21
      XRAY         : 3  WALK_ALL     25       17           DG21
      NO ACCESS TO  2 SPACES        DIFFERENCE TOTAL: 26

ORAL_SUR    : 2
      RECOVERY     : 1  WALK_ALL      0       13       13  DG21
      WAITING      : 1  WALK_ALL     40       11           DG21
      WAITING      : 2  WALK_ALL     40       55       15  DG21
      XRAY         : 1  WALK_ALL     25       NA       NA  DG21
      XRAY         : 2  WALK_ALL     25       NA       NA  DG21
      XRAY         : 3  WALK_ALL     25       24           DG21
      NO ACCESS TO  2 SPACES        DIFFERENCE TOTAL: 28

ORAL_SUR    : 3
      RECOVERY     : 1  WALK_ALL      0       13       13  DG21
      WAITING      : 1  WALK_ALL     40       21           DG21
      WAITING      : 2  WALK_ALL     40       53       13  DG21
      XRAY         : 1  WALK_ALL     25       NA       NA  DG21
      XRAY         : 2  WALK_ALL     25       NA       NA  DG21
      XRAY         : 3  WALK_ALL     25       22           DG21
      NO ACCESS TO  2 SPACES        DIFFERENCE TOTAL: 26
```

Figure 8

AUTOMATED SPECIFICATION PREPARATION SYSTEM (EDITSPEC)

The stand-alone phase of the automated specification system that is in the final stages of development by the Corps of Engineers is known by the acronym EDITSPEC. This system will replace current manual procedures. An economic analysis shows a savings of approximately 35% in resource expenditures in addition to an improvement in the quality of the specifications and resulting construction. In a follow-on phase of development, EDITSPEC will be integrated into CAEADS so as to automatically pull those guide specifications that apply to the facility being designed. Since the guide specifications do not provide all the answers for a project, it is necessary to have a capability to edit the initial file to satisfy all requirements and this process is facilitated through automated techniques.

At the present time, the Corps guide specifications are being loaded into a data base. They are also being updated which is a continuous process to keep them abreast of current technology. This data base will be made available to all users over a nationwide communications network and will always be current as compared with the current process which depends on writing and printing change documents and distributing to various design offices each of which must process these changes into its own reference file. This is a lengthy process that is fraught with opportunities for error and delay. The value of having a current version of the guide specifications available to everyone who utilizes them is readily apparent. The ability to assure that the latest criteria are being followed is also significantly enhanced.

The EDITSPEC system was developed by Mssrs. Wegener and Neely of CERL in cooperation with the Huntsville Division, Corps of Engineers, and the Multisystems, Inc.

FUTURE CAPABILITIES

An assessment of state-of-the-art developments in computer hardware and software indicates a growing capacity for expanding the use of automation in the design and review of construction plans and specifications. The basic test that will be applied all along the road toward innovation in this area is proof of cost effectiveness. The age old construction industry adopts new ideas slowly and, as has always been the case, will be more rigorous than others in assessment of such proofs. In the long run, however, there is no stopping full exploitation of the computer, new uses will continue to come onto the scene. What can we expect from what we know now?

There are systems in being that permit architects and engineers to accomplish design utilizing graphical terminals rather than conventional drawing boards. There is a capability to store in computerized digital format all information necessary to describe a facility in a three dimensional representation including all related attributes. This information can be processed through a variety of review processes to assure adherence to criteria, codes, and standards and results can be output in alphanumeric or graphical format to respond to user specified needs.

The Corps of Engineers has a long term plan to exploit the computer in improving the quality of construction, reducing construction costs, and increasing the productivity of designers. To achieve this goal CAEADS will have the capability to meticulously apply design and habitability criteria in both the preparation of contract plans and specifications by in-house work forces and in the review of these products which are accomplished in most cases by commercial Architect/Engineer firms.

CONSTRUCTION LABOR DEMAND SYSTEM: AN OVERVIEW

by

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Currently under development by the Department of Labor is an extensive modelling effort designed to provide accurate forecasts at a local level of future construction levels and on-site labor requirements. The Construction Labor Demand System (CLDS) is a computerized management information system that provides continuously updated forecasts for local regions, for specific types of construction, and for precise construction trades.

Actual construction project information is the nucleus of the CLDS system. Information on hundreds of thousands of current and planned projects are included in CLDS. Each project is time-phased to completion and estimates generated of the associated craft requirements.

Forecasts of construction initiations are accomplished through econometric modelling. Initiation forecasts are transformed into pseudo-projects within CLDS and pseudo-projects are combined with hard project data for the generation of forecasts of construction activity.

A conversion subsystem translates construction activity into demand for labor. Over 200 conversion profiles translate activity levels into time-phased flows of requirements by occupation.

Key words: Building trades, construction industry, forecasting, labor information systems, manpower projections, modelling.

INTRODUCTION

This paper reports on an innovative program under development within the U.S. Department of Labor that is to provide detailed forecasts of construction activity and construction labor demand. The Construction Labor Demand System (CLDS) was initiated in 1976 to meet the needs of a Department that requires accurate and comprehensive information for structuring labor programs and policies. However, the system was designed in a manner so as to have wide applicability for other public agencies as well as the private sector.

Construction Labor Demand System is the descriptive name of a series of submodels and data bases for forecasting the volume, type, and regional location of future construction activity and the associated on-site labor requirements. The function of the system is to: estimate construction activity by type in geographical regions and, translate the estimated construction volume into labor requirements by on-site craft by converting project characteristics (dollars, megawatts, etc.) into labor craft time.

BACKGROUND

Planning and policy making relative to construction has long suffered because of major data gaps. Dunlop and Mills (1)*, in a research paper in the early 1970's on manpower utilization in construction noted that, ".... improved planning awaits advances in the quality of information on which decisions can be based and the mechanisms by which the labor market situation is evaluated." A study paper on construction prepared by the Department of Commerce in 1966 for the President's Advisory Committee on Labor-Management Policy (2) had expressed a similar view, ".... we still lack the sure factual toehold which is so essential in appraising costs, prices, productivity, output, seasonality, unemployment and labor force characteristics. Our knowledge of the industry structure, especially in its detail, is far from adequate."

The notion of a computerized system that would provide advance and accurate information as to the type, location, labor mix, and timing of new construction projects was first brought to the attention of industry leaders at a 1975 conference sponsored by the Federal Energy Administration. It received wide endorsement, Martin Ward, General President of the United Association of Plumbers and Pipefitters (3), noting that such a system ".... would be a great benefit to the construction industry as well as to the country...so that people who were involved in construction could have some anticipated lead time not only for on-site locations but also insofar as material supplies are concerned ..."

Shortly thereafter, the Department initiated in earnest the development of CLDS. The design plan called for the system to be developed

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*The numbers in parenthesis refer to the citations listed in References.

on a modular basis, with subsystems being implemented as completed, rather than waiting for all components to be in place before providing output. The subsystems, themselves, were structured not only to improve and enlarge the statistical data base for construction but to facilitate the preparation of analytical reports and studies of practical use to the industry, construction owners and the public in general. Several major elements of CLDS became operative in 1978, with full implementation expected by mid-1980.

Assisting Labor in putting together the CLDS program have been the Tennessee Valley Authority and the Department of Energy. Both agencies are playing substantial roles in the development of the system as well as in its implementation.

OVERVIEW OF SYSTEM

CLDS is a computerized management information system that is designed to forecast the future volume, composition, geographic distribution, and associated labor requirements of construction activity. Incorporating both on-line and off-line capabilities, the system provides continuously updated forecasts for local regions, for specific types of construction, and for precise construction trades.

The system focuses primarily on the BEA economic areas of the United States (4), although it also provides data on a State, region and national basis. The areas - 183 in all and covering the entire U.S. - consists of a standard metropolitan statistical area (SMSA), that serves as a center of trade, and the surrounding counties that are economically related to the center. The BEA's do not divide SMSA's or counties but in some cases do cross State boundry lines.

Table 1 lists the major construction categories included in the CLDS system. The system has the capability, particularly for those types of construction associated with energy production, e.g. electric power plants, to provide forecasts at a more detailed level, for example, coal-fired electric generating plants. Table 2 shows the occupations included in CLDS at the present time. In the future it is planned to expand CLDS coverage to include technical and engineering classifications.

CLDS is being developed in two interrelated phases. Phase I, which will be fully operational in the next few months, provides an automated system capable of maintaining a data base of all "known" construction projects. Estimates of manpower demand are derived from valuations of construction activity. A construction craft conversion system translates dollars spent on construction into labor work-hours by craft. The system applies job progress patterns and craft profiles for each construction type to individual project records in order to obtain a time profile of labor demand by craft.

A labor market information system cannot rely exclusively on reports of individual construction projects because as the forecast horizon lengthens, the percentage of total construction activity accounted for by projects known at the time of forecast must decline (Figure 1). Phase II calls for the operation by mid-1980 of an econometric modeling system that forecasts construction initiations by region -- the Regional Construction Initiations Forecasting Model (RCIFM). The forecast horizon is five years, estimates given by month (1 yr.) and quarter (2-5 yrs.)

Forecasting initiation rather than activity has the advantage that it utilizes all existing project information, so that forecasts will be consistent with the levels of activity mandated by projects already begun. The initiations forecasts will be transformed into project level records by the Pseudo-Project Generator (PPG). Pseudo-projects will be combined with hard project information for the generation of forecasts of construction activity and labor demand (Figure 2).

PROJECT DATA BASE

Hard information on construction projects is the nucleus of the CLDS system. It plays a critical role not only for the assessment of the current situation in construction and its labor markets but for those types of construction featuring long-lead times and lengthy construction provides valuable insight to future levels of activity.

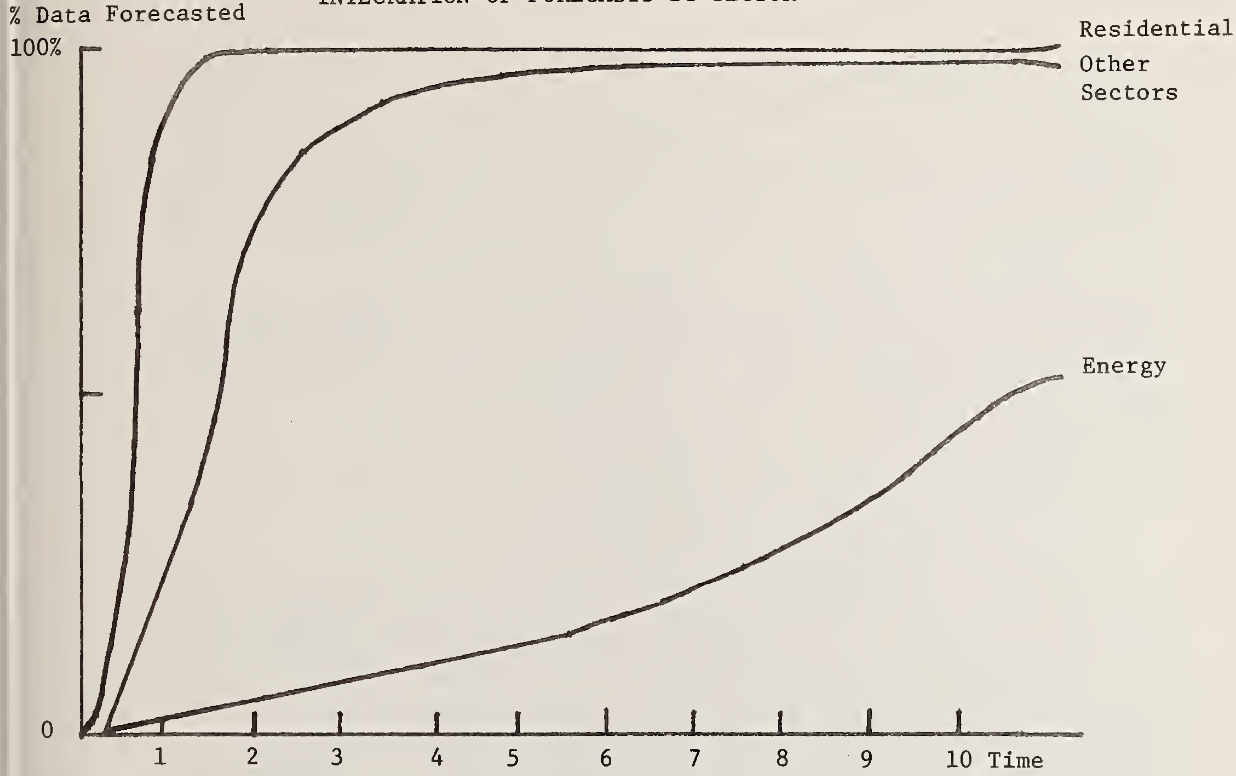
Project data is entered into CLDS from a number of private and government sources. In terms of quantity of project records the most important source is the monthly statistical file from the F.W. Dodge Division of McGraw-Hill Information Systems Company, Incorporated. A monthly magnetic tape from Dodge (Dodge Construction Potentials) provides hard information for some 280 structure types of projects about to begin construction. From Dodge sources, some 125,000-175,000 new projects are entered into CLDS each year.

Data on ongoing and forthcoming residential construction (1-4 family units) and on direct Federal construction is supplied by the Bureau of Census via monthly magnetic tapes. The Census data for residential construction is permits-based information. Since permits do not cover all ongoing new construction, CLDS estimates are made to obtain totals for new residential construction.

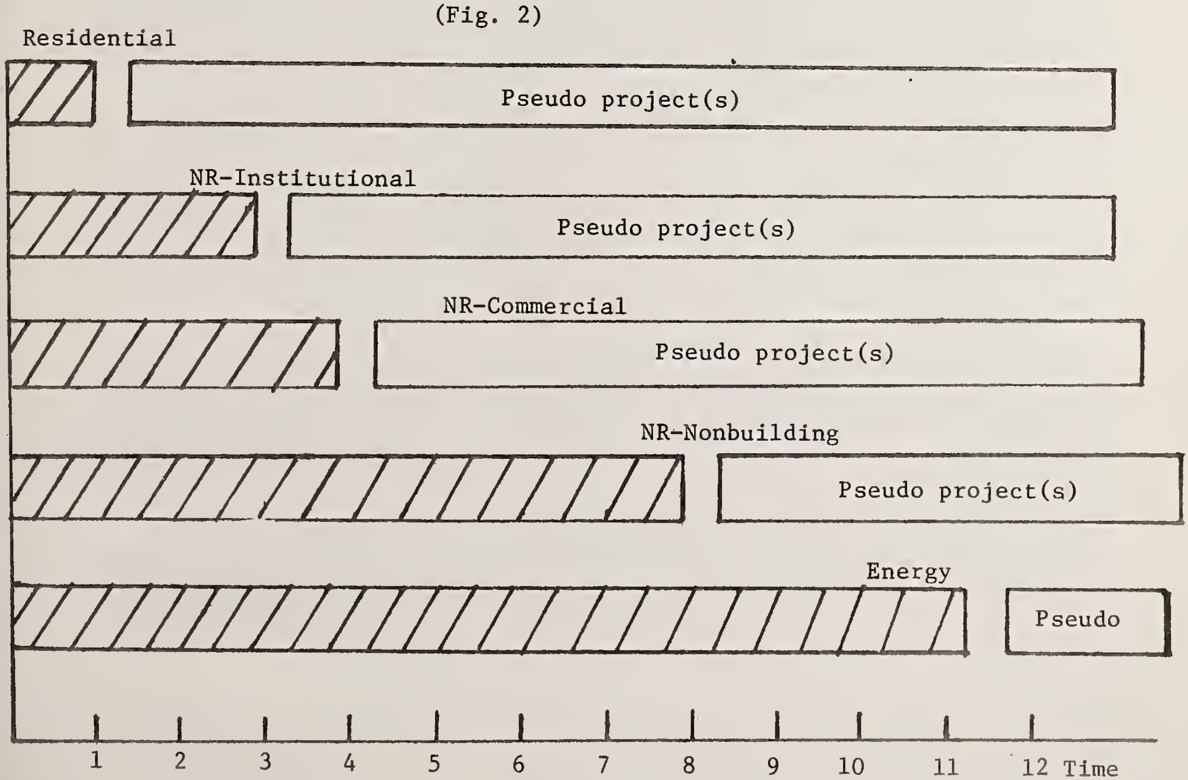
Information on planned energy-related construction projects is collected from secondary sources by the Denver and Pittsburgh offices of the Department of Energy and forwarded to CLDS where it is entered into the system. More detailed data on power plant projects are obtained from DOE's "Inventory of Power Plants in the United States" and the "Construction Status Report." Pending OMB approval, CLDS staff will contact owners of major projects ($25 million+) to obtain cost, industrial relations, and engineering data on each project and will also monitor changes in completion date, training output, and craft shortage data. A current project file will be maintained online at the Department of Labor's computer center.

(Fig. 1)

INTEGRATION OF FORECASTS BY SECTOR



PROJECT DURATION
(Fig. 2)



PROCESSING PROJECT INFORMATION

A labor conversion subsystem and other subsystems are used to transform the project file into estimates of labor requirements. One routine in CLDS permits aggregation of the data by geographic unit, the lowest level permitted being the approximately 3,100 counties in the U.S. Another routine time phases each project: each project converted to an appropriate time schedule of work which can be altered on an individual project basis as other information is obtained. The most sophisticated transformation utilizes engineering generated as well as survey collected information to convert this stream of construction activity by final use characteristics into labor requirements over time. A generalized table facility in CLDS makes the specification of these tables very flexible, so that they can be specialized as the information supports.

LABOR CONVERSION SUBSYSTEM

The conversion subsystem is that portion of the CLDS body of software that translates construction activity into demand for labor. Factors for accomplishing the conversion are derived from three sources: BLS surveys of labor and material inputs for selected types of construction, Amis Construction and Consulting Services, Inc. estimates of labor requirements for 19 types of construction, and profiles developed in consortium with the Bechtel Corporation's Energy Supply Planning Model for some 100 types of energy-related construction.

Since 1958, the Bureau of Labor Statistics has been conducting regular surveys of labor requirements for various types of construction. In addition to providing snapshot average conversion factors for various building types at any point in time, the repetition of surveys at intervals of three to eight years provides insights into the nature of changes over time. BLS has completed surveys for the following types of construction:

- college housing
- public housing
- multi-family housing
- single-family housing
- Federal office buildings
- elementary-secondary schools
- general hospitals
- Federal highways
- sewer works
- civil works

The estimating approach utilized by BLS involves a random sample of the population universe of a specific class of projects to obtain a statistically reliable number of projects in the sample. The sample projects' construction activities are then field monitored through actual observations or analyses of cost records to obtain a schedule of actual work forces employed.

The Amis and energy-related profiles of time-phased flows of manpower requirements by craft were developed on the basis of engineering evaluation of construction resources needed to build generic facilities. Principal information sources were based on past construction experience, literature and industry contacts. Amis developed factors, as with BLS, are structured in terms of manpower flows per $1,000 (1975 dollars) of project value. For energy construction, the labor requirements flow and duration for specific projects are a function of type, output, cost, and engineering criteria.

Approximately 120 separate conversion profiles are included in the nonenergy sector of CLDS. Over 100 manpower conversion profiles have been developed to translate current specific energy projects into time-phased flows of labor requirements by occupation.

FORECASTING

Future and as yet unknown construction initiations will be generated from models being developed for CLDS by the Tennessee Valley Authority for energy-related construction, and by the Institute for Defense Analyses (IDA) for other types of construction. The logic and assumptions underlying both the energy and nonenergy components are similar enough to allow aggregation when desired into one overall forecast for a designated geographical area.

In order to generate regional forecasts of construction activity, it is necessary to forecast general economic and demographic variables for each region. CLDS relies in large part on existing regional modelling systems for forecasting the economic and demographic environment. Among systems potentially filling this role for CLDS are: the Regional Energy, Activity, and Demographic (READ) Model (DOE), the MULTIREGION Model (Oak Ridge National Laboratory) and the National Regional Input Evaluation System (Commerce).

The forecasting system designed for CLDS by IDA (5) is hierarchical. The first stage is a forecast of national economic activity, generated by one of the major macroeconomic models (Wharton, DRI). This forecast is distributed regionally using READ, MULTIREGION, etc. The CLDS Regional Construction Initiations Forecasting Model (RCIFM) converts the regional forecasts of general economic activity into a detailed forecast of construction initiations.

The RCIFM consists of a set of forecasting equations, estimated regionally, which relate each type of construction to local income, industrial output, population, prices and costs. Because time series data for individual BEA regions are too few to permit independent estimates, pooling of BEA data within major Census regions is done to generate a sufficient data base.

The PPG converts annual forecasts for each type of construction to monthly forecasts of value and number of projects by size of projects. The appropriate distribution for each type of construction is estimated from historical patterns exhibited in the project data.

Psuedo-projects are merged with the known data to estimate continuous flows of construction labor requirements at the BEA level. Conversion factors will convert the activity estimates into labor requirements.

USES AND USERS OF CLDS

Any system that can forecast with reasonable accuracy future levels of construction activity and job openings by craft is going to have a great deal of uses and a large number of users. This is particularly true when these forecasts are specific for local geographical areas and for monthly/quarterly time frames. The first evidence of the magnitude of the demand for such a product surfaced in early 1978 when CLDS published its initial report (6), an analysis of estimated labor requirements through 1981 for constructing electric generating power plants. This analysis received worldwide interest and an update is now in preparation.

It should also be noted that the CLDS program is not limited to forecast activity. For example, also soon to be released by CLDS is a comprehensive analysis of seasonality and cyclicality in construction in the United States. The paper will report on the identification by the CLDS staff of seasonal, cyclical, and trend components in construction activity and employment data sets through the application of spectral analysis, regression, and general statistical techniques. Included in the report will be the results of component analysis in the identification of specific component shares of activity and their contribution to instability.

I believe the implications of CLDS for planning and policy development for construction in both the public and private sectors are enormous. In Table 3, I have listed a few potential uses of CLDS within public agencies. Many more obviously would be appropriate and perhaps an even larger checklist could be drafted for the private sector.

I would like just briefly to comment on one potential benefit of CLDS that perhaps is apt to be overlooked. CLDS can serve to restrain cost increases in construction by reducing uncertainties and increasing efficiency. Uncertainty as to future construction trends leads to hedging and price escalation (materials, money, labor). Increasing efficiency leads to improved productivity. Not productivity in the sense of more bricks being laid per shift or concrete poured, but in terms of enhancing the efficiency with which construction labor markets function and the industry and construction owners plan future projects.

Table 1.

CONSTRUCTION TYPES

Single-family housing

Two to four family housing

Hotel & motel buildings

College housing

Five or more family housing

Manufacturing buildings

Industrial buildings

Retail trade & store buildings

Service stations & repair garages

Parking buildings

Miscellaneous commercial/manufacturing buildings

Commercial warehouses (excluding manufacturer owned)

Amusement, recreation, & social buildings

Church buildings

Government administration

Miscellaneous nonresidential buildings (public service)

Miscellaneous nonresidential buildings (material handling)

Office buildings

School buildings (excluding housing)

Health & hospital buildings

Airports (excluding buildings)

Bridges (including elevated highways & railways)

Communication systems

Dams & reservoirs

Sewage & waste disposal systems

Water supply systems (excluding dams & reservoirs)

Streets & highways

Civil works (excluding sewers)

Miscellaneous nonbuilding construction

Electric generating plants & transmission lines

Coal mining, processing & transportation facilities

Uranium mining, processing, & storage facilities

Oil production, processing, storage, & transportation facilities

Gas production, processing, storage & transportation facilities

Other specialized energy development, production & transportation facilities

Table 2.

ON-SITE CONSTRUCTION OCCUPATIONS

1. Asbestos Workers
2. Boilermakers
3. Boilermaker-Welders
4. Bricklayers
5. Carpenters
6. Cement, Concrete Finishers
7. Drywall Installers
8. Electricians
9. Electricians-Linemen
10. Elevator Constructors
11. Glaziers
12. Ironworkers, Ornamental & Structural
13. Ironworkers, Reinforcing
14. Laborers
15. Lathers
16. Millwrights
17. Operating Engineers
18. Painters
19. Piledrivers
20. Pipefitters
21. Pipefitter-Welder
22. Plasterers
23. Plumbers
24. Roofers
25. Sheet Metal Workers
26. Softfloor Layers
27. Tile, Terrazzo, & Marble Setters
28. Truck Drivers
29. Other Construction Craftsmen

Table 3.

POTENTIAL UTILIZATION OF CLDS WITHIN PUBLIC AGENCIES

1. Evaluation of impact, cost and effectiveness of legislation, programs, and policies.

2. Planning and coordination of craft training programs with anticipated job needs.

3. Analysis of socioeconomic impact on communities of major construction projects.

4. Component analysis of construction unemployment rates, i.e. seasonal, cyclical, trend, and random for policy development.

5. Estimation of craft, geographic and intraindustry mobility in construction and potential labor supply.

6. Assessment of agency construction plans and time tables.

7. Assessment of regional trends in construction activity, production, and labor usage which are anticipated.

8. Analysis of capital, and labor, and materials implications of developing, storing, and transporting sources of energy (nuclear, coal, etc.) Implications for resource allocation of conservation and environmental initiatives.

9. Informational data base for assisting collective bargaining.

10. Long-range forecasts from ancillary models of CLDS, e.g., population shifts, employment shifts, demand and prices for fuels and electric energy.

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PROPOSED CRITERIA FOR ESTABLISHING ENERGY CONSUMPTION STANDARDS FOR EXISTING BUILDINGS

by

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Rising energy costs recently have compelled many municipalities and industries to undertake energy conservation programs in the hopes of reducing energy expenditures. The current lack of government and industrial standards specifying acceptable levels of energy use by existing structures, however, makes it difficult for these organizations to determine if their facilities are wasting fuel. This paper proposes that standards be established for the overall energy efficiency of existing buildings in terms of quantities which can be computed readily from available data, without need for elaborate computer programs and/or engineering analyses. The paper discusses the type of standards needed to meet these objectives, techniques for formulating the standards, and facility classifications (based upon building functions) for which guidelines should be developed. By being able to pinpoint buildings using excessive energy without costly or time-consuming analyses, government and business groups can direct conservation efforts and funding to the most inefficient facilities, where conservation programs will be of the greatest value.

Key Words: Conservation; energy cost; existing buildings, regulation, retrofit; standards.

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INTRODUCTION

The cost of all types of energy has increased dramatically in the last few years, particularly since the oil embargo during the winter of 1974. In the six-year span from 1970 to 1976, the well-head price of natural gas rose over 160%, from 17.1 cents per thousand cubic feet in 1970 to 44.5 cents per thousand cubic feet in 1976. During the same period, coal prices more than doubled, increasing to a cost of twenty dollars per ton in 1976 (1). Electric rates have climbed sharply in recent years, too. The Federal Power Commission reports that in just three years (1974 to 1977), electricity rates have gone up an average of 44 to 70 percent (2). As world-wide reserves of fossil fuels continue to diminish, energy prices can be expected to increase even further.

These high and ever-increasing energy rates have proven to be a serious problem to all segments of the United States economy. Industry, educational institutions, medical centers, businesses, and government groups all have been faced with severe budget strains due to unexpectedly high energy expenditures (3, 4). The problem is compounded by increasing consumer and taxpayer resistance to higher prices for goods and services.

In an effort to minimize the economic impact of further energy price increases, many organizations have initiated energy conservation programs to reduce fuel consumption (4, 5, 6, 7). Although these programs may be implemented in a number of ways, most include three distinct steps: (a) a preliminary energy-consumption survey in which facilities with a history of excessive fuel usage are singled out; (b) a detailed engineering analysis of the structures consuming excessive energy to determine the reason for the energy waste; and (c) an implementation of structural modifications and managerial techniques to reduce fuel usage. This type of program often runs into difficulty, however, when a determination must be made as to which of the facilities are operating inefficiently. Many of the currently available energy-consumption standards demand a complete engineering analysis of the buildings in question before the efficiency of the structures can be determined. Often, these standards do not permit the classification of entire structures as energy conservative or wasteful. Instead, the standards consist of performance guidelines or design criteria for the energy-consuming subsystems within the building. For many organizations it is not cost effective to perform a complete engineering analysis of every building they maintain, especially when the funds that can be devoted to energy conservation programs are limited. Full analyses also may take a long time to complete, demand specially trained personnel, and require sophisticated computing facilities that the organization may not posses. Clearly, a new system of energy consumption standards are needed for existing buildings that an organization can use to pinpoint existing buildings that are using fuel wastefully. These standards should be based upon data that can be obtained easily by the group conducting the study, and should be applicable without the need for outside help, sophisticated computer programs, or excessive expenditures of time and money. Such a system would enable more conservation funds to be channeled into energy-saving capital improvements for the inefficient facilities.

The following paper proposes the adoption of a series of energy-consumption standards for existing buildings that meets these requirements. Specialized building classifications for which the proposed standards should be established also are discussed.

EXISTING STANDARDS

The onset of the energy crisis has provided an impetus for the formulation of energy consumption standards for both new and existing buildings. For new buildings, the most significant system of standards promoting energy efficiency is ASHRAE 90-75 (8). This publication presents design criteria for energy-using subsystems such as heating, ventilating, air-conditioning, and hot water supply units, as well as for other building characteristics related to energy usage (interior lighting, roof and wall insulation, and so forth). A Federal Energy Administration (FEA) evaluation of the effectiveness of ASHRAE 90-75 in reducing energy consumption in new structures concludes that annual energy costs in typical new buildings can be reduced from $.20 to $.70 per square foot (9). This represents a reduction in fuel bills of 9 to 45 percent. The effect of partial or complete application of ASHRAE 90-75 standards to existing structures is not discussed.

Other important design standards recently developed for new buildings include the Department of Housing and Urban Development's Minimum Property Standards (HUD-MPS) for single family and low-rise multiple family dwellings (10) and the General Services Administration's (GSA) guidelines for energy-conservative design of new federal government office buildings (11). Like the ASHRAE 90-75 standards, these criteria are concerned specifically with the energy efficiency of individual subsystems and concentrate on proper initial design of the systems to reduce fuel consumption. The GSA standards are unique in that they present a goal for the energy performance of the entire building. This target value for new office buildings is 55,000 Btu per equivalent gross square feet.*

Several energy-consumption guidelines for existing buildings have appeared recently in the literature. These include the Federal Energy Administration's ECM-1 and ECM-2 manuals developed by Dubin-Mindell-Bloome Associates (12), the <u>Total Energy Management</u> publication of the National Electrical Manufacturers Association and the National Electrical Contractors Association (13), criteria for retrofitting buildings presented by the FEA (14), and GSA standards for energy use in existing

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*Equivalent gross square feet are defined as the number of square feet of all building areas that are fully climate controlled, plus one-quarter the number of square feet of all areas that are illuminated, but do not require complete heating or cooling.

office buildings (3). It is anticipated that the soon-to-be-released ASHRAE 100 series standards for energy consumption in existing buildings, like references 12, 13, and 14, will be similar in format to the ASHRAE 90-75 standards for new buildings, mandating minimal levels of energy efficiency by individual systems rather than setting performance goals for entire structures. The GSA standards (3) set a maximum level for fuel consumption in existing office buildings of 75,000 Btu per equivalent gross square feet.

All of the above guidelines for energy consumption in new or existing buildings present difficulties to the organizations employing them. Only the GSA standards set maximum limitations on energy usage for an entire facility. This means that in using current standards, institutions must spend considerable sums of money in uncovering energy waste in the buildings under their jurisdiction, reducing the funds that can be committed to capital improvements to reduce fuel usage. Additionally, detailed analyses create delays in the implementation of measures designed to reduce energy use. Finally, if a detailed study of a structure is needed before energy use criteria can be applied, few institutions would be willing to periodically reevaluate the energy consumption of their facilities in order to monitor changes in fuel use due to the application of conservation methods or modifications in the energy-consuming systems of the structure. This could seriously jeopardize the long-term effectiveness of any major conservation effort.

PROPOSED NEW STANDARDS

The problems associated with the present energy consumption criteria for existing buildings indicate the need for a new system of standards that set maximum energy consumption levels for buildings as complete units. In this sense, the proposed criteria would be similar to the Environmental Protection Agency mileage ratings for automobiles, since only the overall performance of a unit would be examined, not the individual efficiencies of each of the unit's components.

It is proposed that three different performance standards be established specifying acceptable energy-use levels in existing buildings The three categories for which standards should be developed are:

1. annual energy use per gross building area
2. annual energy use per gross building area per heating and cooling degree day*
3. annual energy use per occupant

The proposed standards would be given in units of BTU's, square feet, and degrees Fahrenheit for energy use, building area, and temperature,

*One heating degree-day is defined as a day in which the average temperature is one degree Fahrenheit less than 65°F. One cooling degree-day is defined as a day in which the average temperature is one degree Fahrenheit higher than 65°F.

respectively, in the English system: Kilojoules, square meters, and degrees Celsius would be the units used for metric standards. This will require the conversion of some energy usage (e.g. electricity use which normally is reported in kilowatt hours) to these units before the standards can be used. It should be noted that once numerical values have been determined for each of the three categories, energy cost standards can be established if local utility rates are known, simply by multiplying each quantity by cost per unit energy use.

The amount of energy consumption by any building is a function of many parameters. For this reason, it is suggested that buildings be classified according to their function, age, and type of fuel used, with appropriate energy consumption standards for each category.

The first classification of buildings would be according to function. Energy use standards should be developed for the following groups of buildings, based upon structural function:

1. office buildings
2. group domiciles (dormatories, nursing homes, etc.)
3. private residences
4. medical facilities
5. educational plants
6. recreation centers
7. storage locations (garages, warehouses)
8. industrial plants
9. public meeting area (auditoriums, churches)
10. commercial establishments

Additional building classifications can be employed as the need arises. For example, a study of energy consumption by existing buildings in Baltimore, Maryland (15) uses more specific functional classifications to categorize commerical structures (see Table 1).

Structures may also be classified according to the type(s) of fuel which they use. Two groupings are proposed: one for all-electric facilities and one for buildings using a variety of fuels.

Additional standards could be developed for structures based upon the type of construction used in the facility (wood frame, masonry, etc.) and/or the building's age (a criterion that would reflect changes in building methods throughout the years). It was concluded in reference 15 that energy use was a definite function of a building's age, with older facilities using less fuel than their newer counterparts. To avoid excessive complexity in the standards, these age and energy-use factors could be presented in the form of percentages so that a basic standard for a particular building function may be multiplied by the appropriate factor(s) to account for its age and fuel use.

The three categories proposed for energy-consumption standards for existing buildings each reflect a different aspect of a structure's energy performance. All three quantities need to be considered to get an overall picture of a building's energy-consumption efficiency. The first quantity, energy use per gross building area, has been used previously by various government and industrial agencies to characterize structural energy efficiency (4, 13, 15), and has been termed the Energy Use Index (EUI). The annual Energy Use Index provides a basis for comparison of several buildings of similar function within the same general climate region, since it readily portrays the effects of varying structure size. The EUI, when computed on a monthly basis, is useful also in determining seasonal variations in a structure's energy use.

The annual energy use per gross building area per heating and cooling degree-day is proposed as a second category for which standards should be established since one value may be set as the criteria for existing facilities of all climate regions - the difference in number of heating and cooling degree days from one building location to the next will account for differences in the thermal environment.

The final category for which energy-consumption standards should be established for existing facilities, annual energy use per occupant, reflects the degree of energy efficiency that an existing structure possesses in meeting the energy needs of the individuals using the facility. This standard would help to quantify the energy needed to maintain a reasonable comfort environment or perform a given task within a structure. This standard will vary greatly with building function, since the definition of occupant changes with structural function. The occupants in an office building may be the employees (plus, perhaps, the average number of visitors to the building), while at a school the occupants may be defined as the sum of the number of pupils and teachers.

The three proposed classifications for new energy-use criteria for existing buildings are such that organizations can compute the quantities needed for comparison with the three standards using data that is obtained easily. The amount of energy used may be read from utility bills or, if these receipts are missing, obtained directly from the utility company. Building areas can be ascertained from blueprints or actual measurements. Climate information for heating and cooling degree-days may be found at local weather stations or located in the monthly reports of climatological data published by the National Oceanic and Atmospheric Administration. Occupancy statistics will come from employment records and attendance files. This means that virtually any organization can compute the values needed using personnel without specialized training. Once the proper quantities have been calculated for each facility, they may be compared with the proposed system of standards to determine if a building is energy efficient. This will enable identification of inefficient structures whose energy deficiencies need to be corrected. These standards, once established, also may prove to be valuable to organizations when deciding upon energy-consuming equipment purchases. Since it should be easier to utilize these standards, organizations will be more likely to continually monitor changes in energy consumption in their facilities.

Before actual values for the three recommended energy-consumption standards can be developed for existing buildings, a two-phase program must be completed. First, the energy-use patterns of typical structures should be evaluated and catalogued. This data will help to indicate the average fuel-consumption levels of buildings before conservation efforts have been initiated. The second step is to reevaluate the energy usage of these buildings after the establishment of prudent conservation measures. In this manner, the magnitude of reductions in energy use due to the conservation programs can be determined and average fuel utilization rates of energy-efficient structures compiled. The energy-consumption of the modified structures then will serve as the statistical basis for the system of standards for existing buildings. Studies of this type should be conducted for each building function for which standards are to be established.

Two methods can be used to analyze the energy use of existing structures. These may be termed the empirical and the theoretical approaches. The empirical method deals directly with real buildings. Utility records of these structures are examined to determine how energy was used in the past. Then, conservation techniques are applied to the facilities, with operational and physical changes being used to reduce fuel use. Records of fuel use are compiled following these modifications to document the lower energy-consumption levels that can be achieved using proper energy management. Efficiency standards for existing buildings of a given functional classification can be developed when a sufficient number of structures have been examined. A limited number of studies have been published already which survey the energy-use patterns of existing buildings. (References 4 and 15 are examples.) Most of these empirical analyses compute EUI values for structures of various functions. Tables 1 and 2 present the results of two of these studies. Unfortunately, these reports do not document energy-consumption levels after the implementation of conservation methods.

The empirical technique has three disadvantages. First, in order to obtain a statistically significant data base, a large number of structures must be examined. Second, the funds needed to pay for capital improvements in each of the facilities being evaluated would be considerable. Finally, difficulties may be encountered in trying to select structures which are truly representative of the average facilities of each building classification.

The theoretical approach to developing standards for existing buildings substitutes a theoretical evaluation of models of typical structures (and their fuel-consuming subsystems) for the statistical examination of the energy use of actual buildings. A method similar to this has already been used to evaluate the impact of ASHRAE 90-75 and HUD-MPS standards upon new building design (9, 16). In this type of study, mathematical models would be developed to determine the fuel consumption of typical buildings in each function category. The models would describe the energy-consumption of structural subsystems (heating, cooling, etc.) and the heat transfer characteristics of the building envelope. After an analysis of the fuel use in the initial structural configuration, reasonable modifications to the unit would be incorporated into the model to correct the energy inefficiencies. The energy-use levels of these retrofitted structures then would serve to indicate the standards that should be established for the facilities. The theoretical technique for developing guidelines eliminates the need for an extensive analysis of the energy performance of actual buildings. Also, it does not require that conservation measures be implemented in real structures. A major drawback to this technique is that it may be difficult to establish exactly what type of construction, heating, ventilating, and air conditioning systems, amount of usage, age, etc. adequately represent an "average" building of a particular function. The measures used to determine typical structures for evaluating the ASHRAE 90-75 and HUD-MPS standards may be used as a starting point (9, 16), but it is much easier to model new buildings using the most recent construction techniques than attempting to represent typical subsystems and constructions of older structures built during various eras. The theoretical method also has the disadvantage of not having a statistical data-base derived from energy-use histories of real buildings to confirm the energy consumption values which it computes as proper for existing structures. As with the empirical method, the classification of buildings according to their function may pose some problems.

A better method for developing the system of standards recommended for existing structures might be a hybrid study which employs both empirical and theoretical evaluations of existing buildings. Statistical and qualitative examinations of actual buildings would yield energy-consumption histories and facility profiles that would serve as guidelines for development of mathematical models representing average structures. These models would then be modified theoretically to correct excessive energy usage and calculate the proper level of fuel use for various building classifications. These recommended consumption levels could be verified experimentally by selectively retrofitting some of the actual buildings and measuring the decrease in energy usage.

Regardless of what approach is actually adopted, a considerable expenditure of time, money, and manpower will be required to establish energy-use standards for existing buildings. A large undertaking of this nature demands that a technically competent coordinating group organize the effort. Two possibilities exist: either a government agency could initiate and control the program to develop energy consumption standards for existing buildings (e.g., the Department of Energy or the National Bureau of Standards) or one (or more) professional societies. could implement the study. The American Society of Mechanical Engineers, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, and/or the American Institute of Architects would be logical choices. A third possibility would be the formation of a joint government - professional society committee to develop the suggested standards.

SUMMARY

With the heightened interest in energy conservation in both the public and private sectors of the American economy, many groups have initiated programs to reduce energy use in existing facilities. Unfortunately, these efforts often are thwarted by the high costs, excessive time, and technical studies required to apply available standards for existing buildings. A set of generally applicable energy-consumption standards for entire buildings is needed. Three quantities are recommended for these standards:

1. Annual energy use per gross building area.
2. Annual energy use per gross building area per heating and cooling degree day.
3. Annual energy use per occupant.

Values for each of these standards would be established for various structural categories, based upon building function. Additional factors allowing for variations in the type of fuel used and building age would be developed. These standards would lead to more effective use of energy conservation funds, since inefficient facilities could be determined quickly and inexpensively, and the majority of the available money could be used to retrofit the wasteful units.

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TABLE 1

AVERAGE ENERGY USE OF BALTIMORE
CENTRAL BUSINESS DISTRICT COMMERCIAL BUILDINGS*

Use Type	Annual Average Energy Use (BTU/ft^2)	Number of Establishments Sampled	Number of Sq. Ft. Sampled
Restaurants	300,000	25	70,991
Night Clubs	253,192	23	42,479
Drug Stores	232,672	6	15,303
Food Stores	206,986	5	5,704
Department Stores	164,412	27	1,142,175
Hotels/Motels	146,597	6	950,400
Banks	144,634	15	68,743
Offices	124,647	87	6,477,049
Personal Services	117,318	26	46,299
Small Stores	95,378	132	383,443
Theaters	75,844	2	51,608
Warehouses	61,973	29	439,470

*Taken from "General Characteristics, Energy Consumptions, and Related Institutional Factors in the Commercial Sector," (Feb. 1977), reference (1

TABLE 2

ANNUAL ENERGY USE AND COST, BY CATEGORY, FOR CHARLOTTESVILLE, VIRGINIA, PUBLIC BUILDINGS (1976-77 FISCAL YEAR)*

Functional Category	Annual Energy Use (Btu/ft^2)	Number of Buildings	Total Area of All Buildings (Sq. Ft.)
Administrative	100359	3	26934
City Parking Garage	15837	1	217851
City Warehouse	52058	1	44400
Fire Department	129861	2	17172
Libraries	47969	4	25540
Parks and Recreation	102590	8	62909
Public Centers	89525	2	43305
Public Works Maintenance	144065	4	131501
Schools	60956	12	983658

*Taken from "An Evaluation of Energy Use in Charlottesville Public Buildings and Facilities (1972-1977)", (Dec. 1977), reference (4).

PROPOSED SOLAR ENERGY LEGISLATION LIKELY TO AFFECT THE BUILDING REGULATORY PROCESS

by

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A number of researchers have identified and discussed numerous legal barriers to the effective utilization of various types of solar energy. Much of the literature also makes specific recommendations for legislation directed at removal of these barriers to solar utilization. This paper discusses the context in which the legislation has been drafted, the key features of the legislation, and their potential effect on the building regulatory process. The objective is to give state and local building regulatory officials and code administrators an overview of what sorts of legislation may be introduced at the state and local level so that they may be better prepared to deal with both the legislative proposals, and their implementation.

Key Words: Building regulation; energy conservation; legislation; solar energy

INTRODUCTION

Something over 200 bills, resolutions, and the like dealing with solar energy have been introduced in various legislatures around the country. A few of them have been enacted into law. Many of them have certain commonalities and implications for the building regulatory process.

The purpose of this paper is to provide those concerned with the building regulatory process with a better understanding of solar energy measures that have been and are likely to be enacted into law. With a better understanding of what is here and what is yet to come, the reader will be better prepared to evaluate, react to, and implement the legislation.

The scope of the paper will be limited to generic groups of legislative approaches that have been suggested to remove already identified barriers to utilization of solar energy. Specific details of individual bills will not be addressed. Nor will the development of codes and standards *per se* be considered. (There are several such projects underway including a major one funded by the U.S. Dept. of Energy).

The background and origin of the types of legislation will be considered first. Then some of the general features of all legislation will be explained. Finally, the paper will consider the generic types of legislation, why they were enacted or proposed, and some likely implications for the building regulatory process.

ORIGIN AND NATURE OF LEGISLATION

A reasonably safe generalization is that any legislation is a proposal for a law to respond to a problem, and that in general, market forces, or the "common law" or both have proved inadequate to achieve certain desired results. Further, nearly all enacted legislation is a compromise. And, the flexibility or effectiveness of certain legislation may be questionable, due to technical unknowns. Nevertheless, with "solar energy" being a "buzz word" perceived to be quite popular with voters, a good deal of such legislation can be expected. Because of potential imperfections and compromises, building regulatory personnel should be prepared to contribute their technical expertise as appropriate

AMERICAN BAR FOUNDATION STUDY

A multi-year study by the American Bar Foundation (financed by the National Science Foundation) identified five somewhat intertwined legal issues relating to solar energy utilization at the state and local level. Indeed, "legal issues" may be but a euphemism for uncertainty, chaos, and substantial barriers. In any event, the legal issues were:
1. Regulation of building materials through codes and standards;
2. Financing and marketing; 3. The role of public utilities; 4. Land

use planning; and 5. Access to sunlight. All but the third item will be discussed, at least briefly, in this paper. In addition, we will address consumer and insurer protection as a separate item although it may be considered by some to be a part of the financing and marketing issue.

One of the end products of the American Bar Foundation (ABF) study was a series of model statutes. Rather well thought out, it is representative of the best sorts of legislation that has been introduced in the various state houses around the country. The legislation is intended as a model and guide for those jurisdictions wishing to effectively deal with the barriers identified in the report. A commentary accompanies the suggested language.

GENERAL LEGISLATIVE PROVISIONS

Nearly all legislation probably has (and certainly needs) certain prefatory sections. Definitions are important, and will, for example, determine the applicability of a specific law, e.g. does a given installation qualify for a tax credit? The ABF study defines "solar energy system" as:

> "A complete design or assembly consisting of a solar energy collector, an energy storage facility (where used), and components for the distribution for transformed energy (to the extent that it can not be used jointly with a conventional energy system). Passive solar energy systems are included in this definition, but not to the extent that they fulfill other functions such as structural and recreational. [Optional for certification] the definition includes only those systems which are certified by the [official/agency] or which meet criteria established by the [official/agency]."

Legislation may also may well include policy statements to better indicate legislative intent and to assist the law in passing constitutional muster. Legislative intent is useful for administrative implementation and judicial interpretation. Constitutional questions are inevitable in any preferential or regulatory situation . These "policy and purpose" provisions are generally broad, general, and far-reaching. It is of particular interest to note that the ABF study includes as one of the several policy findings that "the use of solar energy systems ... requires effective legislation and efficient administration of state and local programs to be of greatest value to the citizens ..." In addition, one of the enumerated purposes is "... to provide for fair and timely administrative proceedings on issues related to use of solar energy systems."

THE BUILDING REGULATORY PROCESS PERCEIVED AS A BARRIER TO SOLAR UTILIZATION

The building regulatory process has been looked upon with considerable suspicion as a potential impediment to energy conservation and utilization of alternate forms of energy. If nothing else, the scholars have sensed substantial institutional resistance. This may be the reason that the ABF legislation contemplates the establishment of a "Solar Energy Development Commission" to be tasked with conducting a comprehensive study of how a state can encourage the use of solar energy to satisfy the purposes of the act. The study is to include "the need to modify existing laws and regulations for the design, construction, alteration, or maintenance of structures in heating and cooling systems, to remove any unreasonable impediments for the installation and use of solar energy systems, and the desirability of promulgating standards for state certification of solar energy systems and the performance criteria that could be used if certification is deemed appropriate." The commentary to the ABF study notes that there appear to be several major potential problems with local building codes:

1. The requirement for costly, cumbersome, and arguably unnecessary energy system design (e.g. chimney and plumbing clearances, design temperatures for heating and cooling, inspection requirements for prefabricated or modular units or components, boiler inspection standards for glass and plastic substitutes.)

2. Code administrators with inadequate training or experience in dealing with solar energy.

3. Ambiguous codes and performance requirements.

4. Established interests supporting existing codes and the inherent resistance to change.

Those attacking existing codes and their administration on the above bases cite experiences with modular housing, condominiums, and plastic pipe.

Thus the statutes would ultimately <u>require</u> better and more timely reception of new technology by the code community. In the interim exceptions would be permitted, determined by a state agency or some "qualified expert."

SPECIFIC LEGISLATION

The barriers to solar energy utilization noted above are widely known and accepted. Most legislative proposals portend to cope with but one at a time.

<u>Tax Credits/Exemptions/Deductions</u>

By far the most prevalent type of legislation is that designed to remove financial barriers and encourage individual and corporate capital investment in solar energy systems. New Mexico has had an income tax credit since 1975. President Carter's Federal Energy Act proposes graduated credits. Key to the application to all of these statutes is just what sort of equipment qualifies for a tax incentive. Indeed, many of the bills and enacted provisions require some building regulatory agency to either define or certify qualifying capital investment.

Consumer/Insurer/Lender Uncertainty

The lack of protection for a substantial capital investment is part of the financial barrier to widespread utilization of solar energy. Consumers sense that some solar technology is new, evolving, and untested, with many new manufacturers. Efficiency, dependability, and safety are frequent legitimate questions. Insurers and lenders are also concerned about prospective risks. Widespread installation would seem to require input by code officials and not just privately retained engineers (to evaluate systems) and lawyers (to draft contracts). A possible corollary result will be changes in occupational licensing laws for installers.

Land Use Planning, Zoning and Solar Access

Assurance of an unblocked supply of sunlight is something every potential solar energy system investor will want. Because of the analogy and similarity to existing height, setback, and "bulk" regulations, it has been suggested that code and zoning agencies will become involved in determining and enforcing legislatively created "rights to sunlight," which are subject to complex definitions, descriptions, and restrictions.

Solar Equipment Standards and Codes

Three states (Connecticut, Florida, and Minnesota) have legislation which requires state agencies to set performance standards for solar systems. The Florida State Building Code provides that all new domestic hot water heaters be installed with a tee to allow easy solar retrofit. The Minnesota State Building Code provides a special allowance in energy budget calculations when solar is used.

Presumably many state and local agencies will be adopting the standards mandated by Section 8 of the Federal Solar Heating and Cooling Demonstration Act of 1974, which have been and are being developed by the National Bureau of Standards.

SUMMARY

Over a dozen states are conducting studies of varying degree and scope. Three states have enacted state code provisions dealing with certain elements of solar installations. It would seem that in the future there will be great pressure for innovation and that anyone involved in the building regulatory process is going to play a leading role in determining to what extent existing regulations need to be modified.

National codes and standards are being developed. They will be incorporated by reference into codes of many lesser jurisdictions.

The provisions for tax incentives will interface with the building regulatory process for definitional and perhaps certification purposes in over 20 states.

In conclusion, it seems that there are several common threads. One relates to definitional problems, e.g., what qualifies for a tax credit, for access to sunlight. It has to somehow be fully and fairly defined. Second, there appears to be a trend towards greater input from both the public at large and the political arena. Those involved in the building regulatory process should accept -- indeed welcome -- this "new" input and be prepared to effectively deal with it. It should always be remembered that codes and solar incentives share an important common purpose -- promoting the public health, safety and welfare.

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CRITICAL PERFORMANCE STANDARDS FOR PASSIVE SOLAR BUILDINGS

by

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An outline of a limited number of performance standards and evaluation riteria for passive solar buildings is presented. Three levels of criteria re described which are intended to categorize these into a few most needed riteria concerning basic thermal performance, health and safety, and two evels of additional criteria that are thought desirable to assess long term sefulness of passive installations. Status of development of the criteria s also discussed.

ey Words: Passive solar systems; performance standards; system classification

INTRODUCTION

The purpose of building codes and standards is to assure that people are provided with products, buildings, and systems that are safe, healthful and will perform to a reasonable level. The primary work of the National Bureau of Standards (NBS) is to assist in developing performance standards and methods of evaluation and measurement to be used in forming a sound and equitable basis for the nation's codes and standards.

Solar energy systems and more particularly passive solar energy systems represent a new aspect of building that offers promise for the effective use natural energies to benefit building occupants. Passive solar energy systems are buildings or components which use solar radiation to heat occupied spaces through natural heat transfer means (conduction, convection and radiation). An example is a south facing sunroom with insulating drapes for control and a massive stone interior wall designed for thermal storage. Along with the proi of energy conservation goes the responsibility to provide safe and reasonably effective installations. Consequently, a limited number of critical performai standards and criteria are needed to assist in the successful introduction of passive solar systems.

PERFORMANCE STANDARDS AND CRITERIA

The National Bureau of Standards develops performance standards and crit through research and investigation on the basic properties of materials, the function of systems and the processes of manufacture and construction. Based on such work reasonable methods of testing, evaluation and measurement can be evolved. These methods are usually offered to consensus standards-writing organizations to assist in their work of standards development. The organizations' tasks frequently involve committee deliberations, balloting of the membership and resolution of dissenting viewpoints. The NBS work assists this process by providing timely technical groundwork. Examples of NBS initiated standards are ASHRAE Standards 93-77 [1] and 94-77 [2] for testing collectors and thermal storage which are based on NBS documents NBSIR 74-635 [3] and 74-634 [4].

In considering passive solar installations, it is important to recognize that they often (but not always) are comprised of elements that are part of tl building construction and are also called upon to perform multiple functions-- their conventional building function and their solar heating or cooling role. An example of this would be a concrete thermal storage wall on the exterior of a building which absorbs solar energy and also carries roof loads and provides lateral bracing. Because existing codes and standards apply to the conventior performance of such building elements, those aspects of performance which are new or unusual because of their solar function may reasonably be considered within the scope of solar standards and criteria. Thus, it is a focused appro that is being used by NBS in developing criteria to apply to passive solar installations. This approach will, hopefully, introduce criteria that are needed to protect health and safety, and assure reasonable performance without burdening passive solar development with a multitude of cumbersome, restricti and redundant requirements.

In outlining an approach to this, we are considering the establishment of several levels of criteria for development. The first level contains the most needed criteria and the other two levels contain criteria which would be highly desirable but perhaps not essential for public protection. These criteria are outlined in Table 1. Also noted in the table is a statement of the concerns that these criteria are intended to address.

The Basic Thermal Performance Criteria (1st level) and the Detailed Thermal Performance Evaluation Criteria (3rd level) are currently under development at NBS and have been presented in detail at athe Second National Passive Solar Conference [5]. It is felt that the basic criteria represent the simplest level of evaluation that can provide a meaningful assessment of a passive installation's performance. It should be possible to make the needed measurements with a minimum of equipment.

The detailed criteria should provide a relatively clear understanding of how a system and its components work in a given environment. In developing these criteria, it was found helpful to establish a classification system for passive installations based on the manner in which energy is received and controlled and thus, its impact on conditions in the occupied space. The classification also reflects basic differences in the evaluation procedure. The categories are the following: 1) Direct Gain - in which the separation of collector, storage and space is difficult to thermally distinguish and measure and thus collected energy and aperture heat loss are determined from calculations based on outdoor and indoor conditions (insolation, temperatures, wind velocity) and the properties of the aperture; 2) Indirect Gain - in which it is possible to thermally separate absorber/storage from the space and evaluation can be made based on outdoor and indoor conditions and the properties of the absorber and storage (and any air flows involved) and; 3) Isolated Gain - in which there is distinct physical separation of all elements and evaluation can be made based on direct measurement of temperatures and flow rates.

The criteria for health and safety have been limited to those that appear to be applicable to passive installations. Many of the criteria have been developed in standards applied to active systems (see Solar Minimum Property Standards [6] and Interim Performance Criteria [7, 8]) and a growing experience with passive installations should allow for a tailoring of these criteria to the peculiarities of passive.

Of particular concern, because passive systems may utilize large areas in interior spaces (glazed apertures, solid or liquid storage masses), is the use of combustible materials for thermal purposes such as insulation, absorption or reflection. It is not difficult to consider that entire wall or ceiling areas will be covered with fixed or movable materials that may present a fire hazard, particularly in institutional or commercial applications, if not consciously designed with this hazard in mind. Also, in passive installations where natural air circulation is employed, large passages or chases may be desired to convey air at low velocities throughout a building. This may present a significant potential fire hazard because of the easy path for spread of fire. Studies are needed to correlate the type of hazard exposure presented in large, open, publicly occupied spaces such as glazed shopping malls and glazed atrium hotels with those of passive solar configurations. Such investigations could reasonably examine: occupancy, construction, fire load, location, suppression techniques, sensing/warning systems, mechanical ventilation, and natural convection flow (including velocities and temperature gradients).

Fire hazard is also a potential problem where wood and other cellulose materials are subject to sustained high temperatures (212°F or greater) for long periods of time (years) and become desiccated [9]. Under such conditions, it is possible for autoignition to eventually occur at the exposure temperature. Collector areas built integrally with the wood framework of a building pose a possible condition of this type. In such instances, venting under stagnation conditions and shading during periods when heat is not withdrawn from the collector area become important considerations.

Concern over temperature and pressure are probably limited to thermosyphon hot water heaters where boiling conditions can be developed. Also, with these systems, toxic fluids may be employed for freeze protection and thus safe separation from the potable water circuit becomes essential. Inhibitors and other additives may be employed in liquid storage elements or heat transfer loops to prevent corrosion or fouling. These materials may be hazardous and pose the problem of satisfactory disposal when cleaning, recharging or repairs are necessary. The requirements for these criteria are probably not greatly different from those of active [6, 7, 8], though static liquid thermal storage tanks (possibly containing inhibitors) may be drained only infrequently which lessens the extent of the disposal hazard.

Structural design will probably demand attention to unusual configurations rather than development of numerous new requirements. The concern is over the use of heavy thermal storage masses located within buildings in positions that are unusual. For example, either solid or liquid elements incorporated into walls or ceilings pose the need to consider seismic loadings and deflections that may be quite different from conventional construction practice. Excessive deflections can also result in glass breakage if careful attention is not given to framing details.

There are a few additional personal hazards that should be considered. Large glazed areas, though not new to buildings, may be located for thermal reasons in close proximity to pedestrian traffic areas and thus raise the need to consider the hazard of potential breakage. Also, when building surfaces are designed to absorb solar energy efficiently, there is the possibility that elevated temperatures may be developed. Occupants must be protected from these surfaces when they are above the hazardous temperature level.

The durability and reliability of a passive solar system is central to its long-term usefulness. For the most part, these installations appear to offer very attractive durability/reliability characteristics due to simplicity of operation and lack of moving parts.

To maintain this durability and reliability, attention should be given to a few potential problem areas. Thin film glazing materials (plastics) may be subject to thermal and ultraviolet degradation, wind flutter and low temperature embrittlement. Air infiltration problems may be more severe due to extensive use of glazing. Freeze protection may be required for storage or collector elements containing water which are subject to freezing temperatures (exposed locations and long cloudy periods with low outdoor temperatures).

Controls for passive solar systems range from extremely simple manual methods such as shutters or shades to automatic sensor controlled subsystems. An issue to consider with manual controls is whether or not the system will be self-protecting without human attention, that is, will it continue to collect, store and release energy (albeit with wide temperature swings) to an extent that will prevent unacceptable damage to the building and its contents. If this is true, under severe weather conditions, the need for auxiliary back up may be modified. On the other hand, use of fully automatic passive system controls introduces the concern for mechanical reliability.

The effectiveness of controls for passive systems is often made difficult due to the need to provide radiation cut-off or insulation of large areas of glazing or absorber surface. This requires moving large elements often comprised of fragile or flimsy insulating materials and to maintain tight edge seals for effectiveness. In addition, some window insulation techniques may introduce problems of moisture condensation and its potential resultant damage. Much ingenuity and effort has gone into developing such controls that are effective at reasonable cost.

Means of assessing the capability of a passive solar system to provide commonly accepted levels of comfort have not been agreed upon. Passive systems often (but not always) depend on significant internal temperature swings for their effective operation and some designs provide varying thermal conditions in different portions of the building. Such characteristics require an approach to comfort assessment that considers such factors as activity level, clothing and space use as modifiers of traditional steady state indicators.

Micro-climate characteristics and weather data present problems for research work in all areas of solar energy and energy conservation. Because the most effective passive solar systems are designed to take greatest advantage of environmental assets and to minimize environmental liabilities, a knowledge of these conditions is critical to good design and proper operation. Fog, smoke and haze (including urban air pollution) can significantly reduce available radiation, and snow cover can amplify radiation. The strength and direction of wind on the building can have major influences on winter heat losses and summer cooling effectiveness. Likewise, sources of moisture and humidity have importance for summer conditioning of passive buildings. Methods are needed to develop micro-climate data in a standardized format that can be used for design and performance evaluation.

In the actual development and application of these criteria there will need to be differences in some of the requirements because of the different building occupancies to which they are addressed. Thus, for example, fire safety requirements may very well be specifically developed for each occupancy such as: one and two family residential, multi-family residential, institutional, commercial or industrial.

The development of performance standards and criteria is based on the growing use of passive systems that provide the experience upon which to base evaluation. The work at NBS is keyed to the national demonstration programs of the Department of Energy (DoE) and the Department of Housing and Urban Development (HUD) both as an environment in which to learn and as programs which will benefit from the application of thoughtful criteria. It is planned to include needed criteria for passive solar buildings into the existing Interim Performance Criteria, the Intermediate Minimum Property Standards documents, and other test and evaluation procedures for use in the demonstrations, in the Department of Housing and Urban Development/Federal Housing Administration housing programs, and the Federal Solar Building Program and thus to make them available for use by consensus standards and codes groups on a nationwide basis. This effort should result in basic standards that can be interpreted and enforced by local building officials and which are practical and cost effective for designers, contractors and consumers.

TABLE 1

Critical Performance Criteria for Passive Buildings-First Level

	Criteria	Concern
Basic Thermal Performance	Auxiliary Energy Used o annual o per square foot o per degree day per sq. ft. Indoor Temperature Outdoor Temperature	- overall system performance, reduction in energy use, comparability of systems, comfort
Health and Safety	Fire Safety	
	o materials-fuel load, flame spread, products of combustion	- extensive use of plastics
	o configuration-penetrations (chases, fire dampers)	- path for spread of fire
	o conditions-autoignition	- desiccation of wood and cellulose materials
	Temperature/Pressure	
	o relief provisions	- thermosyphon systems-boiling
	Toxicity/Combustibility	
	o separation of circulation loops	- antifreeze fluids, inhibitors
	o disposal	
	Structural	
	o seismic	- heavy masses in elevated positions
	o deflection	- glass breakage
	Personal Hazard	
	o glazing	- large areas, hazardous locations
	o heated components	- over 140°F (60°C)

Critical Performance Criteria for Passive Buildings-Second Level

	Criteria	Concern
Durability/ Reliability	Exterior Envelope	- thin film materials
	Air Leakage	- large glazed areas
	Freeze Protection	- uninsulated storage, small passage components
	Solar Degradation	- fading of fabrics and finishes
Controls	Personal Operation vs. Automatic	- reliability
	Control Effectiveness	- leakage, losses
Habitability	Mean Radiant Temperature Temperature Swing Activity Level Air Distribution Glare	- comfort, usefulness of spaces, comparability of systems

Critical Performance Criteria for Passive Buildings-Third Level

	Criteria	Concern
Detailed Thermal Performance Evaluation	Performance Factors Describing o energy flow o component performance o system performance o comfort levels	- verify predictive methods, analytical studies to improve performance, analyze regional variation
Micro-Climate Characterization	Factors such as Degree Days, Typical Weather Year, Etc.	- comparability of evaluations, analytical base line
Maintainability	Service Procedures and Manuals	- long-term usefulness

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A CASE FOR MORE RATIONAL AND EXPLICIT BUILDING REGULATIONS

by

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Building regulations are unique in that they are as much a statement of social attitudes and policies as they are of engineering and technology. To be responsive to one concern is not enough. The consensus of the literature on the Beverly Hills Supper Club Fire in Southgate, Kentucky, was that the codes as written are adequate and that this incident should have not occurred. The fault was said to lie in the improper enforcement of the applicable codes. While this statement may be true, the broader social and policy issues were nowhere addressed.

Safety is a relative rather than absolute concept. No safety is obviously not acceptable; total safety is not affordable, if possible at all. To date, the building regulatory community has fixed the level of safety with minimal input or interest from the public at large. But inflation, the increasing cost of regulation, and the resistance to excessive government spending will lead to greater public interest in the regulatory process. Regulations will be scrutinized as to their necessity, effectiveness, and utility as a means of efficiently allocating protection costs between the public and private sectors.

The challenge for the building regulatory community is to recognize and meet this growing public concern.

Key Words: Building codes; code enforcement; fire prevention codes, fire safety; master planning; regulation; standards.

INTRODUCTION

The evolution of fire protection has been little more than a continuous reaction to disaster. The automatic sprinkler was born from the ashes of New England mills of "slow-burning" construction that burnt during the second half of the nineteenth century. The conflagrations in our cities at the turn of the century brought about the Municipal Grading Schedule and a building code philosophy that stresses structural stability and control of fire spread to adjacent structures. In 1948, fire at the Cocoanut Grove Night Club claimed 491 lives [1:67], but gave us the "means of egress," spawned the present day Life Safety Code, and taught us once again the ultimate reality that fire kills.

On May 20, 1977, the Beverly Hills Supper Club (Southgate) burned to the ground in Southgate, Kentucky taking 165 lives and injuring 70 more. [2:48] The loss was so great that, at least for a few days, life safety from fire was a topic of national discussion. But the discussion was a shallow one, for all people really wanted to know was "Could it happen here?" Once assured by our leaders that it could not, Southgate became a dead issue to the press and, therefore, to the public.

But we are the professionals, charged with the question: What will we learn from Southgate?

The title to a recent article in Fire Journal suggests: "Fire Offers No Fire Protection Suprises." This warehouse fire in Merkenick, Germany caused a loss of over 100 million dollars. [3:21-23] The Southgate fire offers no "fire protection suprises" because the engineering lessons of Southgate are the lessons of Cocoanut Grove.

The fires in Merkenick and Southgate resulted because existing knowledge was ignored. These fires, more than chemical reaction, were a statement of this society's pervasive apathy - fire protection is always someone else's responsibility.

The issues of Southgate, rather than technical, are emotional, political, institutional in nature.

THE LESSON OF SOUTHGATE

Technology alone cannot solve the problems of society, for knowledge without a commitment to act is an illusory gain.

Fire safety codes and standards are our statement of our knowledge. And after the Southgate fire, the code-writers were quick to note that their respective codes already required the engineering and technological solutions that were found to be lacking at Southgate. In the past, all that was done after a major fire was to add a few more sections to the codes. This time, however, there is nothing new to suggest.

The problem at Southgate was that what was in the codes wasn't in the building. Howard Tipton, Administrator of the United States Fire Administration (formerly the National Fire Prevention and Control Administration) at the time of the fire stated:

> The failure of our fire safety system, as demonstrated in Southgate, Ky., was not in the adequacy of codes and standards, but in the enforcement of existing standards that embody the lesson learned again and again in tragic fires around the world. [4:2]

Charles Morgan, President of the National Fire Protection Association, wrote an editorial in Fire Journal entitled "The Kentucky Lesson: Code Enforcement Crucial." He wrote, in part:

> What, then, is the lesson that the fire protection community should take from the Kentucky tragedy?
>
> Certainly, the answer is not that there is a need for more codes and standards, ... for at least in Kentucky the codes were not the problem. What is needed is more emphasis on proper enforcement of codes that are already in effect. [5:3]

But five years before the Southgate fire, the President's National Commission on Fire Prevention and Control wrote in America Burning:

> A law is effective only to the extent that it is enforced. [6:81]

If one lesson of Southgate is the need for code enforcement, the lesson, again, is not a new one.

The literature on the Southgate fire left the impression that our codes are fine, the fire fighters and fire suppression effective, and the technology complete; if only those people in Kentucky had just been a bit more diligent, everything would have been perfect. But it is grossly unfair to single out the state and local officials in Kentucky, for there are Southgates all over this country. They have always existed. Until there is a force sufficient to induce change, they will always remain.

After the Cocoanut Grove fire in 1942, a County Grand Jury impaneled to investigate the fire returned indictments against ten individuals, including four city officals. Besides the indictments, the Grand Jury issued the following statement:

> [W]e have found certain conditions which in the interest of public safety must be corrected as speedily as possible.
>
> Realizing that we, as a Grand Jury, have no power to correct such conditions ..., we wish to record certain conclusions which the evidence compels us to draw, even though such evidence may fall short of establishing will-

> fulness or corruption required to make neglect of duty a criminal offense.
>
> 1. We have found among members of various departments charged with the protection of public safety, laxity, incompetence, failure to fulfill prescribed duties effectively and also lack of complete knowledge of duties.
>
> 2. We have found shifting of responsibility and a tendency by various officials in different important departments to rely too much on their subordinates without exercising sufficient and proper checks on such subordinates. Officials in each department seemed to attempt to shift the responsibility to some other department and vice versa.
>
> 3. We have found no complete coordination between building department, fire department, police department and licensing board with respect to various types of inspections intended to be made to insure public safety in addition to protecting the public health, morals, etc. [1:72]

On August 2, 1978, the Special Grand Jury impaneled to investigate the Southgate fire issued its report, though it returned no indictments. Among its findings:

> There appeared to be a complete breakdown in inter-departmental communications [in the Fire Marshal's Office] causing not only double work, but also allowing certain deficiencies noted by one department to slip by another department unnoticed. ... [T]here seemed to be a breakdown in communications between various state agencies. [7:11-12]
>
> [I]t appeared that there was often a complete breakdown in communications between local agencies and state agencies. Each party frequently expected and/or thought the other had the duty to perform certain operations. [7:15]

These findings reflect scant progress for thirty-five years' effort. There is more to a code than engineering. A code is a law, and as such its administration and public acceptance is influenced by the powerful economic, social, and human and moral needs and wishes of the people. As regulators and protectors, we have forgotten the human element.

Our goal should be code compliance, not code enforcement. Code enforcement imparts an attitude of combativeness - an Us vs Them type of siege mentality. But researchers in a recent study of fire code inspections and fire prevention concluded that "the value of an annual inspection lies more in the persuasive effect of the inspector's presence." Yet though "almost everyone appears to believe that 'selling' fire prevention is the key to success in obtaining [code] compliance, inspectors have had little training and policy guidance on ways to accomplish this 'selling'." [8:50] Preliminary findings from another study of local code administration programs indicates that the interest and political support of top city officials is a major element of an effective effort. [9]

A change in attitude is not a panacea. For those who place profit above life safety, the only effective motivator will remain the the legal sanction. But our institutions must build upon the premise that most people will comply with the law if it is fair and well-reasoned, and that involvement, explanation, and communication will prove more successful than brute force and coercion.

Among the conclusions of the Southgate Grand Jury:

> The ... Commonwealth [of Kentucky] should consider legislation codifying the responsibilities of both local and state agencies, plus builders, architects and owners, requiring communication among all that obviously would be most advantageous, and presenting this legislation in a manner in WHICH it CAN BE UNDERSTOOD BY LAYPERSONS, because the lion's share of the work that is performed is by laypersons.
>
> Inspections of public buildings should be conducted when the buildings are ACTUALLY IN USE and not necessarily when most convenient for the inspector or the operator. Furthermore, there should be no notification that an inspection of any type will be made.
>
> Both local and state inspection and regulatory agencies should be granted by statute authority to mandatorily enforce regulations if necessary up to and INCLUDING the actual CLOSING of ANY ESTABLISHMENT THAT DOES NOT COMPLY with mandatory regulations. GRACE PERIODS of compliance SHOULD BE GRANTED SPARINGLY. [7:16-17] (emphasis added)

An informed public will act responsibly. But the ability to educate and motivate both private citizens and key officials is dependent upon clarity of purpose and thought.

THE CODES QUESTION: HOW SAFE WILL WE PAY TO BE ?

Implicit in the findings of both Grand Juries is the expectation or reliance on government officials to guarantee some acceptable level of public and personal safety. Yet this same "public" forced the repeal of the mandatory seat belt-ignition interlock, ignores the safety benefits of the 55 mph speed limit, and generally decries any governmental efforts to legislate morality and social responsibility through the guise of protecting the public welfare. On July 1, 1977, the then Governor of New Hampshire vetoed a bill mandating smoke detectors in new residential construction, calling the law "one more instance of government acting in a paternalistic, big brother attitude." [10]

This paradoxical attitude of the public towards government imposed safety must not be taken lightly. Codes constrain personal freedom by limiting the manner in which property and property rights may be used and enjoyed. A code is more than a recommended guide of acceptable engineering practices; it is a social, political and economic statement that distinguishes private right from public duty.

In reality, neither the patrons that sit in an overcrowded room with inadequate exits nor the proprietor that seats them ever give conscious thought to the likelihood of fire and the attendant danger. Yet the proprietor, not the patron, is held accountable by society should a fire occur. By law, the proprietor has the legal duty to act "reasonably" to protect the safety of patrons. The patron, in turn, has the right to rely upon this duty. [One must wonder whether the net effect has been to institutionalize public apathy towards fire?] The burden of personal safety from fire has been removed from the individual. Our citizens are not required to evaluate their immediate surroundings to decide whether the "risk" is too great or the danger "unreasonable."

The public relies upon others to decide what is safe and to define what acts are reasonable. In the area of fire safety, this decision-making process has historically been fulfilled by the voluntary consensus standards organizations such as the National Fire Protection Association, the American Society for Testing and Materials, and the model code organizations: Building Officials and Code Administrators International, Inc.; International Conference of Building Officials; and Southern Building Code Congress International.

For example, Section 102.1 of the 1976 Edition of the NFPA Life Safety Code states: "The purpose of this Code is to specify measures which will provide that DEGREE of PUBLIC SAFETY from fire which can be REASONABLY REQUIRED." [emphasis added] This language is significant because it embraces three fundamental concepts.

First, in the hypothetical cited above, the duty owed by the proprietor to the patron is not absolute. The actions of the proprietor, even when judged with the benefit of hindsight and measured to a high standard of care, must only be "reasonable." Compliance with applicable fire safety codes can be used as evidence of "reasonableness," thereby forcing the individual to bear his own loss. Second, doctrines of constitutional law dictate that government, in the exercise of its police powers, may inhibit the exercise of private rights and personal freedoms only to the extent necessary to protect the general welfare. A code which requires more than is necessary is open to challenge. This is why the model codes are sometimes referred to as "minimum" codes. Finally, the language illustrates that the code reflects the writers' collective judgment as to what society expects, or the economy can afford, in protecting life and property from fire.

This institutional arrangement, whereby the codes and standards adopted at the local level are developed at the regional or national level, has been acceptable for two major reasons. First, the level of safety provided has been acceptable to the public. Second, the costs to society have been affordable.

But the economic and political conditions upon which this institutional structure were built are slowly changing. Inflation runs rampant because an expansionist economy cannot be maintained with only limited resources. Despite great wealth, the nation can no longer afford the costs of fire, which include not only the direct and indirect losses from fire, but the cost to government of providing fire protection and the cost to business, ultimately the consumer, of regulation.

It is these latter costs, the cost to government and the cost of regulation, not the life and injury loss, that will fuel the call for change in our regulatory system. Willie Hammer, writing in the Handbook of System and Product Safety, notes that:

> Injuries and deaths are deplored, but more frequently the economic factors constitute the motivating force that produces corrective action. Injuries and death constitute an important factor and a moral requirement when safety is considered, but they lack the broad applicability that use of the dollar provides as a measure. [11:3]

And examples abound.

The hearings conducted by the United States Senate on the Voluntary Standards and Certification Act of 1976 [12] and the Voluntary Standards and Accreditation Act of 1977 [13] were in response to allegations that codes and standards were being used to foster anti-competitive business and marketing practices. Though legislation was not enacted by the Congress, the Federal Trade Commission has issued a Notice of Proposed Rulemaking which addresses similiar issues. [14]

One of the reasons sections of Local Law 5, the New York City "high-rise" code, was found at trial to be unconstitutional was the prohibitive cost of compliance. The court held that it was an unlawful taking of the landlords' property. Though this ruling was reversed on appeal, the issue will be raised again. [15]

The present structure of the insurance industry is not designed to deal with the problem of arson. Arson creates cash flow problems because money must be held in reserve until the claim can be resolved. Premium schedules do not account for the socioeconomic and criminal forces that underly the arson problem. Attempts by the industry to limit coverage not only bring charges of red-lining, but can even lead to more arson when insurance becomes unavailable or prohibitively expensive. The economic and political power of the insurance industry is immense. If necessary, the industry will intervene, and dominate, as it did at the turn of the century, to protect its economic well-being. [16]

During the Summer of 1977, budgetary constraints forced the District of Columbia government to reduce manning levels in various fire stations throughout the city on a rotating basis. Claims were made that this action resulted in losses of life that may otherwise have been avoided.

The paradox of Proposition 13 is that the cost of running and complying with government is expected to decrease, but without a reduction in services. This not only calls for greater efficiency and productivity, but clear and ordered planning.

Fire prevention and control master planning is a guide local governments can use in planning for their fire protection needs. Master planning involves nothing more than: 1) identifying the human and material population at risk [present and planned] 2) identifying the available resources, and 3) expressing the level of costs and losses the community is willing to accept. Only then are alternative approaches evaluated to identify feasible or optimal solutions. Key to the whole effort, though, is being able to predict the outcome of each proposed approach. [17]

Codes are important to this process because they can limit the maximum potential hazard that a community must address. Limitations on heights and areas, building set-back requirements, and bans on hazardous materials or processes are common examples. Codes can also be used to allocate fire protection costs and responsibilities between the public and private sectors.

If all the buildings in a given area had automatic sprinkler protection, the required fire flow would be lower than if the buildings had not been sprinklered. The city would save money on a smaller water supply [which is generally sized to meet fire protection and not domestic consumption needs] and fewer fire personnel and equipment. The property owner pays for the installation and maintenance of the sprinkler system. If every dwelling had a fire alarm system wired directly to fire dispatch headquarters [assuming proper installation and maintenance], smaller, quicker and cheaper fire apparatus, most likely with fewer personnel, would be adequate for most calls. Because of earlier detection, the fire should be smaller, so occupants of the burning dwelling have more time to safely escape, property damage is decreased, and fire fighters face less of a danger. The potential hazard is reduced, fire losses should decrease, and the city saves money on smaller equipment, fewer injured personnel, and lower manning levels. Again, the property owner, not the city, bears the cost of providing and maintaining the fire protection system.

This type of analysis should be made for <u>every</u> code section. For each provision, it should be possible to know: what it is supposed to accomplish, what it will cost, how safe it will make us, and what would would happen if it were removed from the code.

The legislative history of a statute, e.g., hearing transcripts, speeches, and other exhibits and documentation, is helpful in understanding and explaining the purpose [i.e., intent] and justification for the law. The legislative history can be useful in deciding whether a particular class of persons, activity or feature are within the scope of the law, and in resolving conflicting interpretations or ambiguities. Codes are laws [at least they are written with the expectation of subsequent legal adoption], but where is their legislative history? Where are the committee reports detailing their findings? Where are the hearing records and exhibits that show the issues actually considered, the assumptions made, and the data relied upon?

The Beverly Hills Supper Club had been constructed in stages. As the various additions were made to the Club, the effect of the new construction upon the existing portions was apparently never considered. The resultant arrangement of rooms and corridors made exiting haphazard and confusing. The same can be said for codes as well. One amendment is added to another, but the impact of these individual changes upon the entire code body is not given due consideration. The trend in codes today may be to place greater emphasis upon life safety, but the underlying code philosophy remains the protection of property from conflagration. A zero-based analysis of our codes is overdue.

These issues are highly relevant because efforts to restrict the use of property and to transfer costs to the private sector invite challenge both politically and in a court of law. Local officials [mayors, members of council, administrators], who often do not understand fire protection and building regulation, will be called upon to justify the soundness of the laws they pass and administer. They, in turn, will look to the local code official for explanation. But where can the code official turn for guidance?

SOUTHGATE: A CODE ANALYSIS

The argument against a "national" code has always been that local conditions are too varied to be addressed by "one" code. Climate, topography, land use practices, regional costs and availability of building materials, community wealth, and existing fire protection capabilities are relevant factors and codes should be compatible with local conditions. A code that is incompatible with local social attitudes and politics will never generate the community support necessary for voluntary compliance or the leadership support critical to vigorous administration and enforcement.

By definition, present-day codes must be different because the code-writers themselves resist uniformity. But how does a community chose the code it wants? In reality, the controlling factor usually is which model code organization has the closest home office. [Birmingham, Chicago, or Whittier] In theory, the code selected should be the one that best meets the needs of the community. This code analysis was completed to develop a sensitivity for the local official who would rather "master plan" an answer than simply pick a city. The fire problem to be controlled was a simplified version of the Beverly Hills Supper Club.

The study included the relevant portions of the major model building and fire prevention codes used in the United States today. The sponsoring organizations of these codes are: the American Insurance Association, the Building and Code Administrators International, Inc., the International Conference of Building Officials, and the Southern Building Congress International, Inc. The National Fire Protection Association's Fire Prevention Code and Life Safety Code [which is neither a building nor a fire prevention code] were also analyzed.

The topics considered were: height, area, and construction requirements; automatic sprinkler protection; emergency evacuation training of staff; alarm systems; posting of "maximum occupancy" signs; occupancy permits; number of exits and exit capacity, and occupant loading. The analysis of exiting requirements and occupant loading was limited to the Cabaret Room because all but two of the people that died were found in this room. [18:53] The study included the codes current around 1970, when the club underwent a major rebuilding after a fire, as well as 1977, when the large loss-of-life fire occurred. The Cabaret Room was not built until after the 1970 renovation, so only the exiting requirements for the codes in effect during 1977 were studied. The code requirements have been summarized in three charts included in the appendix to this paper. A list of assumptions made and a floor plan of the Cabaret Room have also been included.

Each reader must reach his or her own conclusion as to the ease or difficulty of analyzing and comparing the various codes. Though I found the exercise to be difficult, both in gleaning the specific requirements from the code and in analyzing these requirements once collected, there is no way to know how typical these problems truly are. What is confusing or ambiguous to one may be clear to another. [There were instances, though, during a technical review of the code analysis when four fire protection engineers either could not agree or understand what the code required.] I would like instead to highlight certain points that typify the difficulties I encountered and illustrate the real-world relevance of this exercise.

The fire prevention codes do not address such major topics as height, area, allowable construction classifications, automatic sprinkler protection, and exiting. Either by their silence or specific reference to the building code, these codes make the dangerous assumption that first, there is a building code in force, and second, that the structure has been or will be constructed according to the code.

With the exception of the 1970 edition of the Life Safety Code, this structure would not have met any of the height, area, and construction requirements, even with sprinkler protection. By 1977, the Life Safety Code had been amended, so that the structure was no longer in compliance with any of the codes. Exiting capacity was insufficient under all codes.

If the building were in the plan review stage, and if the official responsible for administering the fire prevention code had the opportunity to participate in the review process, it is a simple enough matter to apply the provisions of the building code. But if the building was an existing structure, then it is typically "grandfathered" or exempted, and the building code would not apply. Other than a few obscure sections and vague phrases about "distinct hazard" and "imminent peril," there are no standards or guidance provided to help the local official evaluate the safety of existing buildings. Without meaningful measures, how does one convince a judge [or anyone else] that a business that has been operating for years poses an "imminent peril" to the community?

Even if the structure complied with the building code at the time of construction, if the conditions were unacceptable such that a code change was warranted, then how can the continued operation of that structure be justified? If the condition is hazardous, it would seem to be a valid exercise of the police power to either order the condition corrected or cause the use of the structure to be discontinued. If the condition can truly be tolerated, perhaps the new code provision cannot be justified.

There were instances where the written word appeared to be inconsistent with the intent of the code. The 1976 Edition of the Life Safety Code provides a typical example.

Section 8-1.6(c) provides that "in buildings of noncombustible construction, a class C assembly [50-300 people] shall be permitted [only] AT the level of exit discharge." (emphasis added) The converse of this provision is that a class A assembly [1000 or more people] is not permitted in a building of noncombustible construction, even if sprinklered.

Section 8-1.6(d), however, says that " In buildings of ANY TYPE construction, a class A, B, or C place of assembly shall be permitted in any story BELOW the level of exit discharge if the ... place of assembly ... [is] provided with complete automatic sprinkler protection." (emphasis added)

If a class A place of assembly located on the ground floor of a sprinklered unprotected noncombustible structure is not permitted, why or how does it become safe, and therefore acceptable, if it is moved to the basement? [The level of exit discharge is normally the street level.] Again, under Section 8-1.6(d), if there were no "opening between the level of exit discharge and the exits serving the place of assembly," the structure above the class A place of assembly could be as poor as unprotected wood frame with no automatic sprinkler protection.

The most difficult part of the analysis came when the codes were placed side by side and compared. The exiting requirements were essentially identical, but this is where the similarity ends. With sprinklers present in the structure, the allowable heights and areas varied from "not permitted" to 16,000 sq. ft./two stories in height. One code would allow a one story structure of an unlimited area. Only two buildng codes would require an alarm system; only one regular staff training. All but one fire prevention code requires an operating permit, and all but one building code requires that the maximum safe occupancy be clearly posted. Unfortunately, the "all buts" refer to different codes.

The only meaningful technique to compare the codes was to first independently study each code. [Read the data in the three charts as columns rather than rows.] The difficult aspect of this method is finding an overall design approach or philosophy towards fire safety from the individual code sections. None was explicitly stated. [Though these sections have been placed in a neat chart for this analysis, they are scattered, in reality, throughout the text of the code.] But once the design approach was identified, it became much easier to compare one code to another and to assess the code's usefulness to the community.

For example, the 1976 edition of the Life Safety Code does not require automatic detection, automatic sprinklers, or manual alarm systems for public assembly occupancies. It does, however, focus upon staff training, exit capacity, flammability of interior finishes, and permissible types of construction.

The Southern Standard Building Code emphasizes automatic sprinklers and manual alarms, and allows increased heights and/or areas. Construction types and interior finish requirements are less strict, and staff training is not required. The exit capacity requirements are only slightly more demanding than those of the Life Safety Code [3 vs 2 independent exits; 6.5 vs 6.0 units of total exit capacity].

These two approaches are not the same. While the Life Safety Code emphasizes passive fire protection [features inherent to the structure itself], the Standard Code relies upon dynamic protection systems [mechanical or electrical systems added to the structure]. The Life Safety Code relies upon a trained staff to notify building occupants of a fire [the only code to require staff training], while the Standard Code requires a manual alarm system. The Standard Code requires automatic sprinklers; the Life Safety Code controls the type of construction and its interior finishes. A community with a strong water supply may wish to require sprinkler protection over more expensive construction or smaller buildings. If the places of assembly experience a large turnover of personnel, it would appear unwise to rely upon such a force in the event of an emergency.

Both of these approaches are valid engineering solutions, and a community should be able to fully understand and exercise the choices before it. But even the level of sophistication to be able to compare one code to another is inadequate. In the example above, a community with a strong water supply and a stable work force could not take advantage of both without amending either of the codes. While local amendment of a model code is common practice, altering the code without an understanding of how the sections interrelate or the code-writers' original purpose could have unknown consequences on the overall fire protection system. There should be the flexibility to chose among different solutions to specific problems.

If one approach was specifically considered and rejected, this decision should be so stated and the reason(s) given. Otherwise, the codes should embrace all approaches available with today's knowledge and technology.

The United States Congress, in legislation creating the United States Fire Administration, declared "(F)ire prevention and control is and should remain a ... local responsibility." [19] To discharge this responsibility effectively, officials must be able to either select or modify a code that meets unique local needs. Given that codes today state no goals or assumptions, have no documentation, offer no design alternatives, and evidence, without searching and guessing, no coherent design strategy, and considering that many local jurisdictions, particularly smaller and rural communities [like Southgate], lack technical expertise, the prognosis for rational code planning is not good.

SOUTHGATE: THE SOLUTION IS CLEAR

Having previously cited code enforcement as the primary factor in the Southgate fire, Mr. Morgan went on in his editorial to state:

> But this call for more emphasis on code enforcement should not be interpreted as an attempt to let those of us who write codes off the hook. Like it or not, we too have responsibilities when it comes to code enforcement. We must initiate a dialogue with code-enforcement agencies to ensure that the latter understand not only the details, but the intent of the codes we write. [5:3]

This is the true lesson of Southgate. To say that code enforcement was the problem is to only state the effect, not the cause.

The responsibility Mr. Morgan speaks of is owed to far more than "code-enforcement agencies." What about builders, architects, engineers and property managers? City planners, mayors, city councils, attorneys, and judges? What about the public, who ultimately bears the loss? Every facet of the building regulatory process is hampered by this lack of understanding and documentation of the codes.

A fire prevention inspector cannot be an effective motivator and educator if he can only cite the letter of the law.

Code officials cannot generate the political support necessary when they are unable to rationally show the benefits and purposes of their regulations. Adequate support improves the likelihood of adequate resources, necessary to improve the quality and quantity of personnel. It also increases the effectiveness of the "stick," which is still too often required.

Unless the public understands the purpose of a code program, there will be no pressure to encourage [or require] elected officials to have a strong program and to commit limited municipal resources. Fire regulations, particularly fire prevention codes because they are concerned with operating businesses, are often seen as another instance of government strangling the free enterprise system. An irritated business community carries far more clout than a code official. Where the local economy is dependent upon one or two major industries, the resistance can be even stronger. Were this the case in Southgate, the people should have been made to understand that a vigorous code program was intended to protect this local treasure, not destroy it. A lax program may appear politically appealing in the short term, but the price for this lack of understanding is a pile of rubble instead of a job.

The shift from specification to performance codes is affected because design professionals do not know their design objectives. Code officials are wary of leaving the safety of the black letter of a code to accept innovative designs when they have no explicit basis for comparison between the design and the code.

Once a building is in operation, the continued vitality of the built-in protection is lost when fire doors are blocked open and holes are poked through floors and walls. These acts are done both in ignorance of the implications and a belief that fire protection is a nuisance. The law requires features of safety, but makes no attempt to see that owner or occupant are aware and understand the purposes of these requirements.

Most importantly, this lack of clear intent makes it impossible for a city to rationally plan for its fire protection needs. If Southgate were on the drawing board today, no code would have permitted it to be built. If the city was committed to its existence, then either additional public protection (e.g., another fire station) would have to be provided or the risk of an inadequately protected structure would have to be accepted. If the building were within the parameters of the codes, then there is little guidance to select or modify the appropriate code. If Southgate had already been built, the building would most likely be exempt from the building code and the fire prevention codes offer no guidance.

The list is endless but the message is always the same. Until the intent of codes can be understood, their adoption, administration, acceptance, and enforcement will be met either by resistance or apathy.

The function of code-writers is to express a social policy in engineering terms. The policy which is developing calls for fewer regulations and less money for government. The code community must respond to this challenge through clear and purposeful regulations.

Historically, the public interest in building regulation is aroused only after a major loss. The opportunity to educate and motivate the public in a calmer forum is to be welcomed and used to full advantage.

LIST OF CODES ANALYZED

1. American Insurance Association (AIA)

   Chart 1 - National Building Code - 1967 Edition
   National Fire Code - 1970 Edition

   Charts 2 & 3 - National Building Code - 1976 Edition
   National Fire Code - 1976 Edition

2. Building Officials & Code Administrators International, Inc. (BOCA)

   Chart 1 - Basic Building Code - 1970 Edition
   Basic Fire Prevention Code - 1970 Edition

   Charts 2 & 3 - Basic Building Code - 1975 Edition with 1976 Supplement
   Basic Fire Prevention Code - 1975 Edition with 1976 Supplement

3. International Conference of Building Officials (ICBO)

   Chart 1 - Uniform Building Code - 1970 Edition
   Uniform Fire Code - 1971 Edition

   Charts 2 & 3 - Uniform Building Code - 1976 Edition with 1977 Supplement
   Uniform Fire Code - 1976 Edition with 1977 Supplement

4. National Fire Protection Association (NFPA)

   Chart 1 - NFPA 101 - Code for Safety to Life from Fire in Buildings (Life Safety Code) - 1970 Edition

   Charts 2 & 3 - NFPA 101 - Code for Safety to Life from Fire in Buildings (Life Safety Code) - 1976 Edition
   NFPA 1 - Fire Prevention Code - 1975 Edition

5. Southern Building Code Congress International, Inc. (SBCC)

   Chart 1 - Standard Building Code - 1969 Edition

   Charts 2 & 3 - Standard Building Code - 1976 Edition with 1977 Supplement
   Standard Fire Code - 1976 Edition with 1977 Supplement

GENERAL ASSUMPTIONS

Throughout this exercise, all assumptions were made in favor of compliance with the code or the least stringent code provision was applied.

The assumptions made were:

- Occupancy Use: public assembly.
- The structure complied with all requirements for unprotected noncombustible construction. Several codes would have required one-hour floor-ceiling assemblies.
- The structure was outside the fire limits.
- The stage in the Cabaret Room was a "non-working" or "non-theatrical" stage.
- The structure was considered to be two stories in height.
- There were no exposures so that area increase credits for separation were applied when available.
- There was fire department access to two sides (or 50% of the perimeter) of the building; area increase credits were applied when available.
- For Chart 1, the net floor area was estimated to be 16,000 sq ft; the net floor area for Chart 2 was simply taken to be 50% of the gross floor area.
- For purposes of Charts 1 & 2, the minimum occupant load was taken to be 15 sq ft per person. The actual occupancy was taken to be approximately 2000 people.
- The intent of Question 1a. of Charts 1 & 2 is whether total sprinkler protection was required under the code. While some of the requirements for partial sprinkler protection have been noted, the list should not be considered exhaustive.

CHART 1 - THE BUILDING AS IT EXISTED IN 1970

<u>ACTUAL AREAS</u>:

Basement: 9,400 sq. ft.
First Floor: 27,500 sq. ft.
Second Floor: 2,800 sq. ft.

	BOCA BLDG	BOCA FIRE	ICBO BLDG	ICBO FIRE	SBCC BLDG	SBCC FIRE	AIA BLDG	AIA FIRE	NFPA LSC #101	NFPA FIRE PREV #1
1a. Given height, area, occupancy & use, could the building have complied with the code without sprinklers? (yes/no)	NO	N/A	NO	N/A	NO	*4	NO	NO *6	YES	*9
1b. What would have been the maximum permissible size without sprinklers? (area - thousands/height - stories)	3.6/1	N/A	N/P	N/A	16/1		6/2	N/A	U/2	
2a. Given height, area, occupancy & use, could the building have complied with the code with sprinklers? (yes/no)	NO	N/A	NO	N/A	NO		NO	N/A	YES	
2b. What would have been the maximum permissible size with sprinklers? (area - thousands/height - stories)	3.6/1	N/A	N/P	N/A	16/2		21/2	N/A	U/2	
3. Would a fire alarm system be required? (yes/no)	NO	NO	NO	NO	YES		NO	NO	NO	
4. Would regularly practiced fire evacuation procedures be required for staff preparedness? (yes/no)	NO	NO *1	NO	NO *2	NO		NO	NO *7	NO *8	
5. Would "Maximum Occupancy Signs" be required? (yes/no)	YES	YES	YES	NO *3	YES		NO *5	YES	YES	
6. Would a building operation permit be required? (yes/no)	NO	YES	NO	YES	NO		NO	YES	NO	
7. Which edition of the code was used?	1970	1970	1970	1971	1969		1967	1970	1970	

U - Unlimited In Area   N/A - Not Applicable   N/P - Not Permitted

1. Section F2851.0: Fire appliances training only.
2. Section 26.109: Fire appliances training only.
3. Section 26.112(a): "The number of persons ... shall not exceed the amount specified in the building code."
4. First edition of the Code was about 1973.
5. Section 103.1: "The Certificate of Occupancy must show ... the number of occupants that may be accomodated."
6. See Section 14.4(b)(2): Sprinklers required in basement.
7. Section 27.12: Fire appliances training only.
8. See Section 17-2111: Regular practice not required.
9. First edition of the Code was about 1975.

CHART 2 - THE BUILDING AS IT EXISTED IN 1977

ACTUAL AREAS:

Basement: 9,400 sq. ft.
First Floor: 50,000 sq. ft.
Second Floor: 3,928 sq. ft.

	BOCA BLDG	BOCA FIRE	ICBO BLDG	ICBO FIRE	SBCC BLDG	SBCC FIRE	AIA BLDG	AIA FIRE	NFPA LSC #101	NFPA FIRE PREV #1
1a. Given height, area, occupancy & use, could the building have complied with the code without sprinklers? (yes/no)	NO	N/A	NO	N/A	NO	N/A	NO	N/A	NO	N/A *6
1b. What would have been the maximum permissible size without sprinklers? (area - thousands/height - stories)	N/P	N/A	N/P	N/A	16/1	N/A	N/P	N/A	N/P	N/A
2a. Given height, area, occupancy & use, could the building have complied with the code with sprinklers? (yes/no)	NO	N/A	NO	N/A	NO	N/A	NO	N/A	NO	N/A
2b. What would have been the maximum permissible size with sprinklers? (area - thousands/height - stories)	6/2	N/A	N/P	N/A	16/2 *2	N/A	36/1	N/A	N/P	N/A
3. Would a fire alarm system be required? (yes/no)	NO	NO	NO	NO	YES	YES	YES	NO	NO *5	NO
4. Would regularly practiced fire evacuation procedures be required for staff preparedness? (yes/no)	NO	NO	NO	NO	NO	NO	NO	NO *4	YES	NO
5. Would "Maximum Occupancy Signs" be required? (yes/no)	YES	YES	YES	NO *1	YES	NO *3	NO	YES	YES	NO
6. Would a building operation permit be required? (yes/no)	NO	YES	NO	YES	NO	YES	NO	YES	NO	NO
7. Which edition of the code was used?	1975 w/ 76 Supp	1975 w/ 76 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976	1976	1976	1975

N/A - Not Applicable N/P - Not Permitted

1. Section 10.103(b): "The number of occupants ... shall not exceed the permitted or posted capacity." See also Sections 26.112(a)-(b).
2. Section 403.2(3)(d)(1): A one story structure could be unlimited in area.
3. Section 103.1: The Certificate of Occupancy must show the occupant load.
4. Section 27.9: A copy of the evacuation plan shall be on display snd all employees shall be instructed as to their duties.
5. Section 8-3.3: Requires stages, as defined in Section 8-1.2, be equipped with an alarm. See also Section 8-3.5.1.4(e).
6. Section 1-2.5.1: Arguably adopts the Life Safety Code.

SPECIAL NOTES FOR CHART 3

In completing this section of the analysis, several additional assumptions or decisions were made.

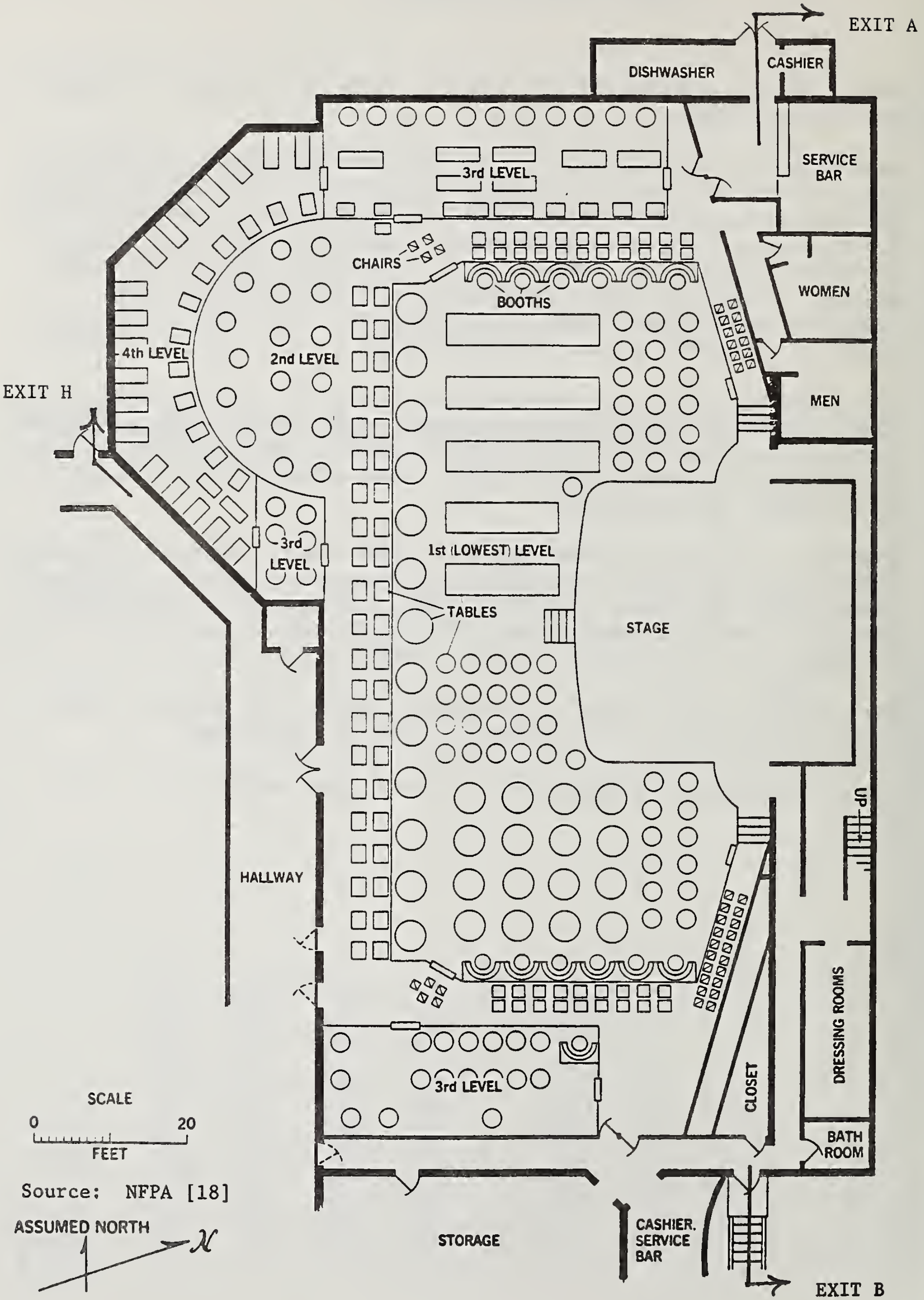
- Exit H was 1.5 units (level). The NFPA report, addressing the total capacity of the night club, merely showed these units as serving both the Garden and Cabaret Rooms. The Cabaret Room was credited the full 1.5 units, as opposed to 0.75 units, because the various codes only recognize ½ units when added to one or more full units. The effect is only a matter of degree because there was insufficient exit capacity in any event. Note also that Exit H was reported as being locked at the time of the fire. [18:8,67]

- The following floor plan shows that the Cabaret Room was divided into four "levels." If railings are assumed to be at the borders between levels, then there is a major obstacle to free movement between levels and through the aisles to the exits. Note also the chairs located at the steps between levels.

  However, it is not believed that the codes really intended to require exits from each level. Therefore, the required number of exits was computed for the room as a whole. What you have is the "best case" analysis. Were independent exits from each level required, the answers to Questions 3 and 4 would rise by a factor of 2 - 3.

- The occupant load, number of independent exits, and number of exit units were computed on the basis of 15 sq ft per person.

- Actual occupancy of Cabaret Room: 1200 - 1300 people.



Source: NFPA [18]

CABARET ROOM

CHART 3 - THE CABARET ROOM AS IT EXISTED IN 1977

ACTUAL ROOM OCCUPANCY:

ESTIMATED 1200 - 1300

ACTUAL EXIT CAPACITY:

Exit A: 2 units (level)
Exit B: 1.5 units (stairs)
Exit H: 1.5 units (level)

ACTUAL AREA:

7,669 sq. ft. (net)	BOCA BLDG	BOCA FIRE	ICBO BLDG	ICBO FIRE	SBCC BLDG	SBCC FIRE	AIA BLDG	AIA FIRE	NFPA LSC #101	NFPA FIRE PREV #1
1. What would have been the maximum number of people permitted in the room based upon the exits actually available?	462	N/A	483	N/A	462	N/A	462	462	462	N/A *5
2. Given the size of the room assuming adequate exits, what would have been the maximum number of people permitted?	511	*1	511	*3	511	*4	511	N/A	511	N/A
3. Given the size of the room, how many separate independent exits would have been required to comply with the code?	3	N/A	3	N/A	3	N/A	2	N/A	2	N/A
4. Given the size of the room, what would have been the number of units of exit width required (22" per unit)?	6.0	N/A	6.5 *2	N/A	6.5	N/A	6.5	N/A	6.0	N/A
5. Which edition of the code was used?	1975 w/ 76 Supp	1975 w/ 76 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976 w/ 77 Supp	1976	1976	1976	1975

NA - Not Applicable

1. Section F-1600.4: "The number of occupants shall be determined by ... the building code."
2. The Uniform Building Code defines exit capacity in feet rather 22" units. 6.5 units equals exactly the required 12 feet.
3. Section 26.112(a): "The number of persons ... shall not exceed the amount specified in the building code" but may be increased up to 10% when "additional exit facilities" are provided.
4. Section 15.03(b), 30.113(a): Number of persons limited to the amount specified in the building code.
5. Section 3-4.1 adopts the provisions of the Life Safety Code.

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FORMULATION AND EXPRESSION ANALYSIS OF STANDARDS AND REGULATIONS

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ABSTRACT

A systematic technology for the translation of a standard, building code, regulation or specification into a graphical network and decision tables is presented. This technology leads to a clear concise expression which aids in the understanding of the document. It may also be used to improve the clarity, consistency, completeness of the provisions. A brief example is used to illustrate the process of using the technology.

KEYWORDS: Decision tables; Formulation analysis; Information networks; Regulations; Standards

INTRODUCTION

Standards, building codes, specifications, and regulations are used to describe detailed provisions governing the construction, installation and manufacture of the built environment. The objective of this study is to improve the national productivity by making standards easier to understand and by improving the probability of their correct and efficient use. The technology herein is applied to standards but could be equally used to translate building codes, regulations, or specifications. The immediate objective of this study is to provide the writers of standards with the technology which will assist them in producing clear, correct and complete documents. This same technology will permit the user of a standard to translate it into a more understandable form and thereby comprehend what is literally stated by the document.

APPROACH

The written document, herein called the "textual expression," is a linear sequence of words describing the provisions desired for a built facility. The entities being regulated often have very complicated interrelationships. These cross-references tend to confuse the user. The approach described here provides for the translation of the textual expression of any standard (propos or existing) into a technical expression consisting of a graphical display of the precedence, called the information network, and a set of tabular displays of logical meaning, in the form of decision tables.

BACKGROUND

The use of the information network and decision table to express the mean (precedence and logic) of a specification derives principally from the work of Fenves, Gaylord and Goel [1]* and Nyman, et al [2,3]. The computer assisted transformation was developed by Harris, et al [4,5,6]. Applications of the technology [10] lead to many of the policies on which this presentation is bas

TECHNOLOGY

The technology for literal translation of a textual expression consists o three basic tools; the decision table for expressing the functional and logic relationships in a document; the information network for expressing the preced relationships; and the outline classification, which is used to develop the arrangement and scope of the provisions. The latter is described by Harris [1 and is not presented herein.

4.1 Decision Table

There are many forms of decision tables, however, the limited entry table with a single output datum is used in this study. A limited entry decision table is composed of conditions, actions and rules. A condition is a logical statement which may have only one of two values--true or false; an action is

*The number in parenthesis refers to the list of references.

in a general sense, any operation; that is, it may be the assignment of a value to a variable by means of a formula or a statement of control that may indicate that the next procedure is to be initiated. A rule is a statement that describes a set of conditions in order that a specific action can be performed. The decision table is a structure for defining a set of rules. The conventional structure of a decision table is shown in Fig. 1. The condition stubs list each condition in the table, one per row. The action stub does the same for the actions. The condition entry lists the combinations of values of conditions. Each column in the condition entry defines a rule. The action entry indicates the action to be executed for each rule. The rule can be thought of as a logical "AND" function, that is, the rule is not satisfied unless each of the condition entries is matched.

The entries may be true (T), false (F), or immaterial (I). The immaterial is used when a particular rule does not depend on the value of the condition. It is also advantageous to use implicit entries in the rules when a condition is implicitly true (+) or implicitly false (-). For example, in Fig. 8, if the condition "welded splices" is true, it follows that the condition "mechanical splices" is false, therefore, the minus sign is used rather than the FALSE.

The decision table may also be displayed in the form of a decision tree (also see Fig. 8). Each node of the tree represents a condition having a true branch and a false branch. Each path is a rule leading to an action or an ELSE. The ELSE indicates that a table is incomplete and that for the given entries of the conditions along that path, no action has been specified. Most but not all, of the else rules can be easily explained. For example in Fig. 6, if the condition "Axial Compressive Force not > 0.1 f'_cAg" is not true, the ELSE 1 is obtained, implying that the member is a column and not a beam. The use of implicit true or false automatically eliminates many ELSE paths in the decision tree.

The decision table is an excellent aid in determining the uniqueness of a verbal expression and evaluation of completeness of a document. The uniqueness is lost when two or more rules have identical condition entries, or when immaterial and implicit entries result in effectively allowing two rules to have identical condition entries. This situation is referred to as a redundant rule.

4.2 Information Network

The information network is a graphical presentation of the precedence of a document. The nodes on an information network are data items which are identifiers, or qualifiers and modifiers, or perhaps are a condition such as a boolean fact, which may be true or false. These data items which immediately pertain to a particular datum are called the ingredients of that datum. Conversely, the the datum is dependent upon its ingredients. This precedence is specified by attaching each of the ingredients to the datum of the data list, as shown in Fig. 3. The resulting information network is shown in Fig. 4.

4.3 Bases for Precedence

There are two major bases for definition of the precedence of the data items in the information network. The format which pertains to the physical order of the textual expression and the logic which is defined primarily by the meaning of the information network.

Precedence based on format relies on the concept that the textual expression establishes precedence through the order and arrangement of the statements in the document. For example, "provisions of this section" would have as its ingredients the various provisions appearing physically in that section.

Many data items are descriptors which qualify, categorize or limit in some form the scope of some other data item. These descriptors are attached as ingredients to the data item which they describe. Precedence may also be based on what is called equivalence. The writers of the document may use a variety of words to make the document more readable, and yet mean the equivalent with these words. In defining equivalence, it is necessary for the analyst to determine one of the words as being the base word and then attaching the other words t the base datum and identify them as having the equivalent meaning in this particular position in the document.

The precedence is also defined through decision tables, figures and equation The decision tables are developed having a single dependent which is the outcome of the decision table. All of the data items in the conditions, and the ingredients to the actions become ingredients to that dependent datum in the information network. Precedence is defined by the input variables that are necessary to evaluate the output datum of each table given in the document. Similarly, the input data items for an equation are obviously the ingredients for the dependent output datum of an equation. Thus, the format and logic of the text is used to define the precedence of the information network. In some cases the ingredients are obvious; in other cases, several trial decision tables are developed before all the ingredients are evident.

PROCESS OF ANALYSIS

A systematic process for translating the verbal expression into a technical expression has evolved. The process is essentially a cyclic process within a cyclic process. The outer cycle consists of:

1) Analysis, that is a translation from textual expression to technical expression, which produces decision tables, and information networks, and an index or data list.

2) Commentary, which produces an explanation of the decision tables, information network and index.

3) Interaction with the writers of the document which produces a new textual expression of the document.

The outer cycle is repeated until a consensus is reached.

The analysis step above is itself an iterative process consisting of:

1) Indexing, which produces a linearly indexed data list;

2) Precedence, which establishes the ingredience of the information network, and produces the information network;

3) Logic in which the rules, conditions, and actions of the decision tables are defined and the decision tables are a product of this step.

This translation step is iterative in that additional data items will be added to the data list as the decision tables are produced and the decision tables will aid in the definition of the ingredients of the information network. The information network is a guide in defining what decision tables should be written.

The order of these steps has been the object of considerable debate, but it is really not important since every analysis involves several iterations after which time, where you start is of no consequence. The user of a standard usually is prohibited from changing the document but would find the analysis step beneficial in understanding the document.

Indexing

The first step in the indexing is to underline the textual expression. This underlining was done to identify conditions, provisions, descriptors, qualifiers, actions, which might be candidates for the data list. The next step is to linearly sequence by ten or some other increment, thus allowing for additions and still permitting the maintenance of a linear sequence in the data list. The major advantage of maintaining a sequential listing of the verbal expression is that this provides an immediate cross-reference between the information network and the decision tables and the textual expression thus tying the technical expression to the verbal expression, in a manner in which it is easy to go back and forth. This aids the iterative process of producing the technical expression.

For large documents, several chapters may be indexed separately, again maintaining a sequential numbering system within chapters or sections with the last two or three digits, and letting the thousands and ten-thousands digits indicate chapter.

The policy on what is a datum is not an exact science and requires a good deal of compromise between benefit of detail and the cost of detailed analysis. The problem is similar to the problem that the accountant has in definition of accounts or the planner has in definition of activities.

COMPUTER AIDS

There are two computer aids which have been developed to aid in the analysis of a document. One, called TABLE, is used to develop decision tables and the decision trees. The second is a program, called NETWORK, used to produce a graphical display of the information network. There is no question that the decision tables, decision trees, and the information network could be produced by hand. However, due to the iterative process involved in developing a technical expression of the document, the computer programs become very helpful, if not essential, because it is so easy to make slight changes to data for the computer program and produce a new network or a new decision table and decision tree, and experiment with various technical expressions. A more detailed description of these programs is presented in Structural Research Series 423, 424, and 425 [4,5,6].

The input to the TABLE program are conditions, rules and actions as shown in Figs. 5 and 7. The output is a decision table and decision tree such as shown in Figs. 6, 8 and 9. A subset of the input to the information network is shown in Fig. 3, and the resulting information network is shown in Figs. 4a and

ILLUSTRATION

The illustration comes from a study conducted for the Applied Technology Council (ATC), on a document called "Recommended Comprehensive Seismic Design Provisions for Buildings." The example comes from Chapter 11: Reinforced Concrete, Section 5, Categories C and D, Construction, and specifically, the Section 11.7, Flexural Members of that document. This example was part of a large study performed and sponsored by the National Science Foundation and the Nation Bureau of Standards.

7.1 Indexing

An example of a subsection of seismic provisions documents is shown in Fig with the underlined data and the sequence numbers. A subset of the resulting data list is shown in Fig. 3. Again, the numbering of the textual expression clearly identifies the location of each decision table datum. Sometimes an assumed datum, a phrase not in the text, is added to clarify meaning, such as 2332, which separates a provision being required, 2330, from the provision bein met, 2332. Each assumed datum may also be added to the document.

7.2 Defining

The format and logic rules are both used to define the precedence. Node 2 is an example of a definition of flexural members; Node 2330 indicates that fle ural members are those members which have an axial compressive force less than Node 2350, 10% of f'_c times the gross area. The conditions of the decision tabl shown in Fig. 6 all become ingredients to the dependent datum 2332, "Dimensions Flexural member acceptable." Each of these conditions become ingredients as sh in Fig. 4a, "Node 2332." In addition, cross-references are shown. For example 2490, "Spiral Reinforcement," is an ingredient to 2470, "Lap splicing," but it is also an ingredient to 2540, "Lap splices." The minus sign indicates that th datum item has been previously referenced. The asterisk following it in Fig. 4 indicates that this has a tree following it which is not reproduced at that poi but the user is referred to the first use of the datum item to see the entire t This permits tremendous economy in representing the information network. In Fig. 4a, Node 1320, the section on ordinary moment frames, is attached to the requirements for Section 11.6, which is required for longitudinal reinforcement. These cross-references may not only refer to other sections of the document, bu also to other references outside the document. For example, in the case of Node 2610, "Ref. 11.1," which happens to be from the ACI 318 Specification for Reinforced Concrete and refers to a section of that document, which must be met in order to have longitudinal reinforcement acceptable, as defined in Node 2602.

7.3 Logic

Development of decision tables involves identification of conditions, definition of actions, and the rules leading to those actions. In Fig. 9 is an an illustration of the use of a multiple action having really only one output, namely, "Maximum Hoop Spacing," but it is defined by several equations, thus, all of the ingredients to the equations are ingredients of datum node 2930, "Maximum Hoop Spacing in Flexural Members." The ingredients of the conditions are also ingredients of the output datum of the table.

In Fig. 8, the dots indicate that the condition is immaterial. The letter "I" is used on input (see Fig. 7), but using the dots on output is clearer than the letter "I." The minus sign is used for implied false, both on input and output.

Conditions 4 and 5 of "Dimension of Flexural Members Acceptable" Node 2332 is an example of an "OR clause, which is literally what the text states. In all probability the authors of the text really meant to use an "AND." It is essential that the analyst translate literally in the translation step and then question the meaning in the commentary phase. The less interpretation done by the analyst the more useful the technical expression and commentary will be to the writers of the document. Especially since arguments of interpretation between analyst and authors tend to destroy the objective of the entire exercise.

The first four conditions of Node 2540, "Lap Splices Permitted," Fig. 6, could be reduced to a single condition simply by connecting the conditions with an "AND." This is usually not apparent during the development of the table and once the table is finished the reduction would serve no useful purpose.

The ELSE rules could be eliminated by adding an action called "Lap Splices Not Permitted," but again, once each else is understood the addition of the extra rules and actions to make the table complete is unnecessary.

CONCLUSION

A systematic technology for formulation and expression analysis has been presented. This translation allows both users and writers of standards and regulations to view what is literally stated in the verbal expression. It is our opinion that this technical expression will not only encourage and aid in the generation of more complete, clear, and understandable standards, but will also foster the correct and efficient application of this standard to the built environment.

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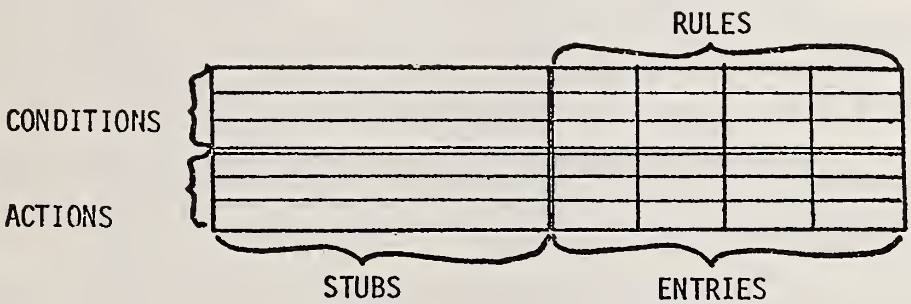

Figure 1, Regions of a Decision Table

2210 Sec. 11.7 SPECIAL MOMENT FRAME REQUIREMENTS

2250 Special Moment Frames shall be designed and detailed in accordance with the
2260 provisions of this Section.

2270 For determining the required lateral reinforcement in components of special moment
2280 frames in which the shear stress due to seismic forces is equal to or greater than one-
2290 half of the total design shear stress and the axial compressive force due to dead loads 2300
2310 and seismic forces is less than $0.05 f'_c A_g$, the concrete shear stress v_c shall be assumed 2320
to be zero.

2330 11.7.1 FLEXURAL MEMBERS

2340 The axial compressive force on the member shall not exceed $0.10 f'_c A_g$. The clear
2360 span for the member shall not be less than four times its effective depth. The width-to-
2380 depth ratio shall not be less than 0.3.

2390 The width shall not be less than 10 inches or more than the width of the sup-
2410 porting member (measured on a plane perpendicular to the longitudinal axis of the flexural
2420 member) plus lengths on each side of the supporting member not exceeding three-fourths of
2430 the depth of the flexural member.

2440 (A) LONGITUDINAL REINFORCEMENT. Longitudinal reinforcement shall comply 2440
2450 with the requirements of Sec. 11.6 and the additional requirements given in this Section. 2460

2470 Lap splicing of tensile reinforcement is permitted only if hoop or spiral
3500 reinforcement is provided over the lap length. The maximum spacing of the transverse rein- 2510
2520 forcement over the length of the splice shall not exceed the smaller of 4 inches or d/4. 2530
2540 Lap splices shall not be used, (1) within the joints, (2) within a distance of twice the 2560
2570 member depth from the face of the joint, or (3) at locations where flexural yielding may 2580
occur in connection with inelastic lateral displacements of the frame.

2600 Welded splices conforming to Ref. 11.1 Sec. 7.5.5.1 and approved mechan- 2620
2630 ical splices conforming to Ref. 11.1 Sec. 7.5.5.2 may be used for splicing provided not
2640 more than alternate bars in each layer of longitudinal reinforcement are spliced at a 2650
2660 section and the distance between splices of adjacent bars is 24 in. or more measured along
2610 the longitudinal axis of the frame component.

3480 Beam longitudinal reinforcement terminated in a column shall be extended 3490
3500 to the far face of the confined column core and anchored to develop the strength of the bar 3520
3540 by means of adequate straight embedment length and, if required, a standard hook. 3550

2700 (B) SPECIAL LATERAL REINFORCEMENT. Special lateral reinforcement shall comply 2700
2710 with the requirements given below. The design shear force shall be determined assuming 2720
2730 that ultimate resisting moments of opposite sign act at the joint faces and that the member 2740
2750 is loaded with the tributary gravity load along its span. The ultimate resisting moments 2760
2770 shall be calculated using the properties of the member at the joint faces without strength 2780
2790 reduction factors and assuming that the stress in the tensile reinforcement is equal to 2790
2900 1.25fy.

2810 Hoops shall be provided in the following regions: 2820

2830 Over a length equal to twice the member depth measured from 2840
the face of the supporting member toward midspan, at both ends
of the flexural member. 2850

2860 Over lengths equal to twice the member depth on both sides of 2870
2880 a section where flexural yielding may occur in connection with
2890 inelastic lateral displacements of the frame.

2900 Wherever compression reinforcement is required.

2910 The first hoop shall be located not more than 2 in. from the face of a
2920 supporting member. Maximum spacing of the hoops shall not exceed (1) d/4, (2) eight times 2940
2950 the diameter of the smallest longitudinal bars, (c) 24 times the diameter of the hoop bars, 2960
2970 or (d) 12 inches.

2980 Where hoops are required, longitudinal bars shall have lateral support 3000
3010 conforming to provisions for ties in Ref. 11.1 for members subject to bending and axial 3030
load.

Figure 2, Textual Expression

```
222C "LATERAL REINFORCEMENT" 2230
223C "CONTINUED THROUGH THE JOINT"
224C "SEC. 11.7 - SPECIAL MOMENT FRAME REQUIREMENTS" 2250
225C "SPECIAL MOMENT FRAMES" 2260
2260 "PROVISIONS OF THIS SECTION" 227C 2330 3040 4050
227C "LATERAL REINFORCEMENT" 2280 230C
228C "SHEAR STRESS DUE TO SEISMIC FORCES" 2290 2320
229C "TOTAL DESIGN SHEAR STRESS"
230C "AXIAL COMPRESSIVE STRESS" 2310
2310 "0.05 F'C AG"
232C "CONCRETE SHEAR STRESS, VC"
2330 M37"11.7.1 - FLEXURAL MEMBERS" 2332 2340 2440 2700
2332 AM36"DIMENSION OF FLEXURAL MEMBER ACCEPTABLE" 2360 2380 2390
234C "AXIAL COMPRESSIVE FORCE" 2350
2350 "0.10 F C AG"
236C "CLEAR SPAN" 2370
237C "EFFECTIVE DEPTH"
2380 "WIDTH-TO-DEPTH RATIO"
2390 "WIDTH" 2400 2410 2420 2430
2400 "10 INCHES"
241C "WIDTH OF THE SUPPORTING MEMBER"
2420 "LENGTHS"
243C "NOT EXCEEDING 3/4 DEPTH OF FLEX. MEMBER"
2440 "11.7.1(A) LONGITUDINAL REINFORCEMENT" 2450 2460
2450 "REQUIREMENTS OF SEC. 11.6" 1320
2460 "REQUIREMENTS GIVEN BELOW" 2540 2602
2470 "LAP SPLICING OF TENSILE REINFORCEMENT" 2480 2490 2510
2480 "HOOP"
2490 "SPIRAL REINFORCEMENT" 2500
250C "LAP LENGTH"
251C "MAXIMUM SPACING - TRANSVERSE REINFORCEMENT" 2520 2530
252C "FOUR INCHES"
253C "D/4"
254C M32"LAP SPLICES" 2480 2490 251C 2550 2560 2580
2550 "WITHIN THE JOINTS"
2560 "WITHIN A DISTANCE OF" 257C
257C "MEMBER DEPTH"
2580 "LOCATIONS WHERE FLEXURAL YIELDING" 2590
259C "INELASTIC LATERAL DISPLACEMENTS"
260C "WELDED SPLICES"
2602 AM34 "LONGITUDINAL REINFORCEMENT ACCEPTABLE"
2602 2470 2540 2600 261C 262C 2630 264C 2660
261C "REF. 11.1 SEC. 7.5.5.1"
262C "APPROVED MECHANICAL SPLICES"
2630 "REF. 11.1 SEC. 7.5.5.2"
264C "ALTERNATE BARS" 2650
265C "LATER"
266C "DISTANCE" 2670
2670 "SPLICES OF ADJACENT BARS" 268C 2690
268C "24 INCHES"
2690 "LONGITUDINAL AXIS"
270C "11.7.1(B) SPECIAL LATERAL REINFORCEMENT" 2710
2710 "REQUIREMENTS GIVEN BELOW" 272C 2760 2810 2930 2982
272C M38 "DESIGN SHEAR FORCE" 2730 2750
2730 "ULTIMATE RESISTING MOMENTS" 274C
2740 "JOINT FACES"
275C "TRIBUTARY GRAVITY LOAD"
2760 M39 "ULTIMATE RESISTING MOMENTS" 2770 2780 2790
277C "JOINT FACES"
2780 "STRENGTH REDUCTION FACTORS"
279C "STRESS" 2800
2800 "1.25 FY"
281C M40 "HOOPS SHALL BE PROVIDED" 2830 2860 2900
1820 "FOLLOWING REGIONS"
2830 "LENGTH" 2840 2850
2840 "MEMBER DEPTH"
285C "BOTH ENDS OF FLEXURAL MEMBER"
2860 "LENGTHS" 2870 2880
287C "MEMBER DEPTH"
2880 "FLEXURAL YIELDING" 2890
2890 "INELASTIC LATERAL DISPLACEMENTS"
2900 "COMPRESSION REINFORCEMENT REQUIRED"
2910 "FIRST HOOP" 2920
2920 "SUPPORTING MEMBER"
2930 M41 "MAXIMUM SPACING OF THE HOOPS" 2910 2940 2950 2960 2970
2940 "D/4"
295C "DIAMETER OF SMALLEST LONGITUDINAL BARS"
296C "24 X DIAMETER OF HOOP BARS"
2970 "12 INCHES"
298C "HOOPS"
2982 AM42 "HOOPS ACCEPTABLE" 2980 299C 3010
2990 "LONGITUDINAL BARS" 3000
300C "LATERAL SUPPORT"
3010 "PROVISIONS OF TIES" 3020 3030
3020 "REF. 11.1 "
303C "MEMBERS BENDING AND AXIAL LOAD"
304C "11.7.2 - MEMBERS SUBJ. TO BENDING AND AXIAL LOAD"
```

Figure 3, Data List

```
GLOBAL INGREDIENCE OF NODE***

EXTREME LEVEL FROM OUTPUT

 0    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25

  ...............1050  11.5.2 - FRAMING LIMITATIONS
                    !.1060  MOMENT FRAMES
                    !    !.1070  SEISMIC RESISTING SYSTEM
                    !    !.1080  SPECIAL MOMENT FRAMES
                    !         !.1090  PROVISIONS OF SEC. 11.7
                    !              !.2240  SEC. 11.7 - SPECIAL MOMENT FRAME REQUIREMENTS
                    !                   !.2250  SPECIAL MOMENT FRAMES
                    !                        !.2260  PROVISIONS OF THIS SECTION
                    !                             !.2270  LATERAL REINFORCEMENT
                    !                             !    !.2280  SHEAR STRESS DUE TO SEISMIC FORCES
                    !                             !    !    !.2290  TOTAL DESIGN SHEAR STRESS
                    !                             !    !    !.2320  CONCRETE SHEAR STRESS, VC
                    !                             !    !.2300  AXIAL COMPRESSIVE STRESS
                    !                             !         !.2310
                    !                             !.2330  11.7.1 - FLEXURAL MEMBERS
                    !                             !    !.2332  DIMENSION OF FLEXURAL MEMBER ACCEPTABLE
                    !                             !    !    !.2360  CLEAR SPAN
                    !                             !    !    !    !.2370  EFFECTIVE DEPTH
                    !                             !    !    !.2380  WIDTH-TO-DEPTH RATIO
                    !                             !    !    !.2390  WIDTH
                    !                             !    !         !.2400  10 INCHES
                    !                             !    !         !.2410  WIDTH OF THE SUPPORTING MEMBER
                    !                             !    !         !.2420  LENGTHS
                    !                             !    !         !.2430  NOT EXCEEDING 3/4 DEPTH OF FLEX. MEMBER
                    !                             !    !.2340  AXIAL COMPRESSIVE FORCE
                    !                             !    !    !.2350  0.10 F C AG
                    !                             !    !.2440  11.7.1(A) LONGITUDINAL REINFORCEMENT
                    !                             !    !    !.2450  REQUIREMENTS OF SEC. 11.6
                    !                             !    !    !    !.1320  SEC. 11.6: REQMTS FOR ORD. MOMENT FRAMES ASSND TO CAT. B
                    !                             !    !    !.2460  REQUIREMENTS GIVEN BELOW
                    !                             !    !         !......2540  LAP SPLICES
                    !                             !    !         !         !.2480  HOOP
                    !                             !    !         !         !.2490  SPIRAL REINFORCEMENT
                    !                             !    !         !         !    !.2500  LAP LENGTH
                    !                             !    !         !         !.2510  MAXIMUM SPACING - TRANSVERSE REINFORCEMENT
                    !                             !    !         !         !    !.2520  FOUR INCHES
                    !                             !    !         !         !    !.2530  D/4
                    !                             !    !         !         !.2550  WITHIN THE JOINTS
                    !                             !    !         !         !.2560  WITHIN A DISTANCE OF
                    !                             !    !         !         !    !.2570  MEMBER DEPTH
                    !                             !    !         !         !.2580  LOCATIONS WHERE FLEXURAL YIELDING
                    !                             !    !         !              !.2590  INELASTIC LATERAL DISPLACEMENTS
                    !                             !    !         !.2602  LONGITUDINAL REINFORCEMENT ACCEPTABLE
                    !                             !    !              !.2470  LAP SPLICING OF TENSILE REINFORCEMENT
                    !                             !    !              !    !-2480  HOOP
                    !                             !    !              !    !-2490* SPIRAL REINFORCEMENT
                    !                             !    !              !    !-2510* MAXIMUM SPACING - TRANSVERSE REINFORCEMENT
                    !                             !    !              !-2540* LAP SPLICES
                    !                             !    !              !.2600  WELDED SPLICES
                    !                             !    !              !.2610  REF. 11.1 SEC. 7.5.5.1
                    !                             !    !              !.2620  APPROVED MECHANICAL SPLICES
                    !                             !    !              !.2630  REF. 11.1 SEC. 7.5.5.2
                    !                             !    !              !.2640  ALTERNATE BARS
                    !                             !    !              !    !.2650  LAYER
                    !                             !    !              !.2660  DISTANCE
```

Figure 4a, Information Network

```
:                                       :   :                  :.2670  SPLICES OF ADJACENT BARS
:                                       :   :                            :.2680  24 INCHES
:                                       :   :                            :.2690  LONGITUDINAL AXIS
:                                       :   :.2700  11.7.1(B) SPECIAL LATERAL REINFORCEMENT
:                                       :        :.2710  REQUIREMENTS GIVEN BELOW
:                                       :              :.2720  DESIGN SHEAR FORCE
:                                       :              :     :.2730  ULTIMATE RESISTING MOMENTS
:                                       :              :     :     :.2740  JOINT FACES
:                                       :              :     :.2750  TRIBUTARY GRAVITY LOAD
:                                       :              :.2760  ULTIMATE RESISTING MOMENTS
:                                       :              :     :.2770  JOINT FACES
:                                       :              :     :.2780  STRENGTH REDUCTION FACTORS
:                                       :              :     :.2790  STRESS
:                                       :              :           :.2800  1.25 FY
:                                       :              :.2810  HOOPS SHALL BE PROVIDED
:                                       :              :     :.2830  LENGTH
:                                       :              :     :     :.2840  MEMBER DEPTH
:                                       :              :     :     :.2850  BOTH ENDS OF FLEXURAL MEMBER
:                                       :              :     :.2860  LENGTHS
:                                       :              :     :     :.2870  MEMBER DEPTH
:                                       :              :     :     :.2880  FLEXURAL YIELDING
:                                       :              :     :     :     :.2890  INELASTIC LATERAL DISPLACEMENTS
:                                       :              :     :.2900  COMPRESSION REINFORCEMENT REQUIRED
:                                       :              :.2930  MAXIMUM SPACING OF THE HOOPS
:                                       :              :     :.2910  FIRST HOOP
:                                       :              :     :     :.2920  SUPPORTING MEMBER
:                                       :              :     :.2940  D/4
:                                       :              :     :.2950  DIAMETER OF SMALLEST LONGITUDINAL BARS
:                                       :              :     :.2960  24 X DIAMETER OF HOOP BARS
:                                       :              :     :.2970  12 INCHES
:                                       :              :.2982  HOOPS ACCEPTABLE
:                                       :                    :.2980  HOOPS
:                                       :                    :.2990  LONGITUDINAL BARS
:                                       :                    :     :.3000  LATERAL SUPPORT
:                                       :                    :.3010  PROVISIONS OF TIES
:                                       :                          :.3020  REF. 11.1
:                                       :                          :.3030  MEMBERS BENDING AND AXIAL LOAD
:                                       :.3040  11.7.2 - MEMBERS SUBJ. TO BENDING AND AXIAL LOAD
:                                       :.4050  11.7.3 - JOINTS
:.1200  ALL FRAME COMPONENTS
     :.1210  AXIAL COMPRESSIVE FORCES
     :     :.1220  0.10 F C
     :.1230  REQUIREMENTS OF SEC. 11.6.2
           :.1870  11.6.2 - MEMBERS SUBJECTED TO BENDING AND AXIAL LOAD
           :.1875  MEMBERS SUBJECTED TO BENDING AND AXIAL LOAD
                 :.1880  MEMBERS
                       :.1890  ORDINARY MOMENT FRAMES
                       :.1900  DESIGN AXIAL COMPRESSIVE FORCE
                       :     :.1910  0.10 F C AG
                       :.1930  LATERAL REINFORCEMENT
```

Figure 4b, Information Network

```
C         FILE M32
C
TITLE "USE OF LAP SPLICES PERMITTED"
NUMBER OF RULES 2 CONDITIONS 6 ACTIONS 1
RULES
 1 T T T T T I 1
 2 T T T T F T 1
CONDITIONS
 1 "NOT USED WITHIN JOINTS"
 2 "NOT USED WITHIN DISTANCE"
   "2D FROM JOINT FACE"
 3 "NOT USED WHERE YIELDING"
   "MAY OCCUR"
 4 "HOOP REINFORCEMENT OVER"
   "LAP LENGTH,     OR"
   "SPIRAL REINFORCEMENT OVER"
   "LAP LENGTH"
 5 "MAXIMUM SPACING OF"
   "TRANSVERSE REINFORCEMENT"
   "NOT > 4 INCHES"
 6 "MAXIMUM SPACING OF"
   "TRANSVERSE REINFORCEMENT"
   "NOT > D/4"
ACTIONS
 1 "USE OF LAP SPLICES PERMITTED"
END
```

Figure 5, Input data for Node 2540

```
                              2332
         DIMENSIONS OF FLEXURAL MEMBERS ACCEPTABLE

                  2340                       1  2
 1 AXIAL COMPRESSIVE FORCE NOT        *  T  T
   >0.10 f cAg  2350                  *
 2 CLEAR 2360 SPAN NOT < 4d  2370     *  T  T
 3 WIDTH TO DEPTH RATIO NOT 2380      *  T  T
   < 0.3   2390                       *
 4 WIDTH NOT < 10 INCHES 2400         *  T  F
 5 WIDTH NOT > (WIDTH SUPPORTING 2410 *  .  T
   MEMBER* + LENGTHS EACH SIDE 2420   *
   NOT > 3/4 OF FLEXURAL  2430        *
   MEMBER                             *
   *MEASURED ON PLANE                 *
   PERPENDICULAR TO                   *
   LONGITUDINAL AXIS OF               *
   FLEXURAL MEMBER                    *
******************************************
 1 DIMENSIONS OF FLEXURAL             *  X  X
   MEMBERS ACCEPTABLE                 *


DECISION NETWORK SUCCESSFULLY COMPLETED

DERIVED DECISION NETWORK

C1  + + + C2  + + + C3  + + + C4  + + + R1
 -         -         -         -
 -         -         -         -
 -         -         -         -  - - - C5  + + + R2
 -         -         -                   -
 -         -         -                   -
 -         -         -                   -  - - ELSE
 -         -         -
 -         -         -
 -         -         -  - - ELSE
 -         -
 -         -
 -         -  - - ELSE
 -
 -
 -  - - ELSE
```

Figure 6, Decision Table for Node 2332

```
C              FILE M34
C
TITLE "LONGITUDINAL REINFORCEMENT ACCEPTABLE"
NUMBER OF RULES 2 CONDITIONS 5 ACTIONS 1
RULES
 1 T - T I T T T T 1
 2 F T I T T T T T 1
CONDITIONS
 1 "WELDED SPLICES"
 2 "APPROVED MECHANICAL SPLICES"
 3 "CONFORMS TO ACI 318-71"
   "SEC. 7.5.5.1"
 4 "CONFORMS TO ACI 318-71"
   "SEC 7.5.5.2"
 5 "NOT MORE THAN ALTERNATE"
   "BARS IN EACH LAYER SPLICED"
   "AT SECTION"
 6 "DISTANCE BETWEEN SPLICES"
   "AT ADJACENT BARS < 24 INCHES"
 7 "USE OF LAP SPLICING ACCEPTABLE"
 8 "TNESION SPLICING ACCEPTABLE"
ACTIONS
 1 "LONGITUDINAL REINFORCEMENT"
   "ACCEPTABLE"
END
```

Figure 7, Input Data for Node 2602

```
        LONGITUDINAL REINFORCEMENT ACCEPTABLE   2602

                                            1  2
 1 WELDED SPLICES   2600                 *  T  F
 2 APPROVED MECHANICAL SPLICES 2620      *  -  T
 3 CONFORMS TO ACI 318-71 2610           *  T  .
   SEC. 7.5.5.1                          *
 4 CONFORMS TO ACI 318-71 2630           *  .  T
   SEC. 7.5.5.2                          *
 5 NOT MORE THAN ALTERNATE 2640          *  T  T
   BARS IN EACH LAYER SPLICED 2650       *
   AT SECTION 2660                       *
 6 DISTANCE BETWEEN SPLICES 2670         *  T  T
   OF ADJACENT BARS < 24 INCHES          *
 7 USE OF LAP SPLICING ACCEPTABLE 2540   *  T  T
 8 TENSION SPLICING ACCEPTABLE 2470      *  T  T
*******************************************
 1 LONGITUDINAL REINFORCEMENT            *  X  X
   ACCEPTABLE                            *

DECISION NETWORK SUCCESSFULLY COMPLETED

  DERIVED DECISION NETWORK


5  + + + C6   + + + C7   + + + C8   + + + C1   + + + C3   + + + R1
-         -          -          -          -          -
-         -          -          -          -          -
-         -          -          -          -          -    - - ELSE
-         -          -          -          -
-         -          -          -          -
-         -          -          -          -    - - - C2   + + + C4   + + + R2
-         -          -          -                     -          -
-         -          -          -                     -          -
-         -          -          -                     -          -    - - ELSE
-         -          -          -                     -
-         -          -          -                     -
-         -          -          -                     -    - - ELSE
-         -          -          -
-         -          -          -
-         -          -          -    - - ELSE
-         -          -
-         -          -
-         -          -    - - ELSE
-         -
-         -
-         -    - - ELSE
-
-
-    - - ELSE
```

Figure 8, Decision Table for Node 2602

```
            MAXIMUM HOOP SPACING IN F.M. 2930

                 2910                           1
 1 FIRST HOOP WITHIN 2 INCHES           * . T
   FROM FACE OF SUPPORTING              *
   MEMBER 2920                          *
***************************************
 1 MAX HOOP SPACING =                   *   X
   MIN(a1, a2, a3, a4)                  *
   WHERE:                               *
   a1 = d/4 2940                        *
   a2 = 8 x DIAMETER OF 2950            *
   SMALLEST LONGITUDINAL                *
   BAR                                  *
   a3 = 24 x DIAMETER OF 2960           *
   HOOP BARS                            *
   a4 = 12 INCHES 2970                  *


DECISION NETWORK SUCCESSFULLY COMPLETED




 DERIVED DECISION NETWORK


 C1  + + + R1
  -
  -
  -  - - ELSE
```

Figure 9, Decision Table for Node 2930

LIFE-CYCLE BENEFIT-COST ANALYSIS OF HOUSING SAFETY REGULATIONS

by

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Increasingly the public is demanding that proposed building safety regulations be justified by evidence that they generate benefits commensurate with their costs. This paper discusses a methodology developed by the author to assess the life-cycle costs and benefits of performance standards for increased safety in the home. The methodology was developed, under contract with the Department of Housing and Urban Development, for the assessment of the life-cycle costs and benefits of proposed performance standards for mobile homes. However, with appropriate modifications, it can be applied to the analysis of virtually any building regulations for increased safety.

The need for life-cycle analyses of building regulations is being increasingly acknowledged, and some excellent efforts have been made to develop comprehensive practical methodologies, but not all of the fundamental issues have been addressed at this time. Therefore, this paper focuses principally on fundamental conceptual issues. A secondary purpose is to describe the basic methodology for actually measuring the costs and benefits of regulatory options.

Key Words: Building codes; building regulations; cost-benefit analysis; life-cycle analysis; safety regulations.

1.0 INTRODUCTION

In July of 1976, Technology + Economics, Inc. was awarded a contract with the Office of Policy Development and Research at the Department of Housing and Urban Development to perform a Life-Cycle Cost-Benefit and Risk Analysis of the Results of Mobile Home Safety Research.[1] The principal objective of the research was to assess the life-cycle costs and benefits of potential changes in the Federal Mobile Home Construction and Safety Standards for increased fire and wind safety in mobile homes.

For both the fire and wind safety studies, T + E was to be given a set of proposed performance standards that were more stringent than the existing standards; subject typical mobile homes to detailed engineering analyses to determine the most probable design responses to the proposed standards; then perform a comprehensive life-cycle benefit-cost analysis to determine which of the alternative standards was most cost-beneficial. To accomplish the last of these requirements--the life-cycle benefit-cost analysis--a comprehensive methodology had to be developed. A review of the literature on the economic impacts of building codes indicated that at that time very little had been done to develop a life-cycle benefit-cost methodology. Consequently T + E set out to develop such a methodology.

As with all such research, the first step was to determine if related methodologies had been developed by others for use in ascertaining the economic impacts of other types of safety regulations. Fortunately, some work had been sponsored, principally by the Department of Transportation, on life-cycle benefit-cost analysis of safety measures,[2] and this work became the foundation of the methodology eventually developed by T + E. This foundation has been built upon by integrating the results of related safety research performed by T + E for the Consumer Product Safety Commission[3] with basic principles of economic analysis concerning the marginal costs and benefits of government or private action. The resulting methodology was first applied to the analysis of a hypothetical set of proposed fire safety regulations for mobile homes in the winter of 1977 and is continuing to be used, with modifications, for the analysis of many proposed mobile home structural changes for increased safety.

The T + E effort is only one manifestation of increased interest in ways to understand the economic impacts of building regulations.

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[1]The guidance of James C. McCollom of the Office of Policy Development and Research is gratefully acknowledged.

[2]Available through NTIS under the key words: benefit-cost analysis; life-cycle analysis; safety analysis.

[3]Robert F. Stone, et al., "A Systematic Program to Reduce the Incidence and Severity of Bathtub and Shower Injuries," CPSC Contract #P-74-334, June 1975; and Robert F. Stone, et al., "Injury Cost Project," CPSC Contract #C-75-0102, September, 1976.

Another significant effort has been underway at the National Bureau of Standards. In fact, a paper was presented at the NBS-NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process in 1976, entitled "Economic Impacts of Building Codes" that reported on the first stages of the NBS effort.[4] As the first substantial published effort to develop a methodology for the analysis of the life-cycle, economic impacts of building codes, the NBS report has set the framework for discussion of such analyses. However, as the seminal effort in this area, the NBS report provides only the foundation of a comprehensive life-cycle benefit-cost methodology. This paper is intended to build upon that foundation.

The principal purpose of this paper, then, is to expand upon the conceptual framework for assessment of the economic impact of building codes that was first presented to the conference two years ago by John McConnaughey of the National Bureau of Standards. A secondary purpose is to discuss some of the major operational methodologies developed by T + E to actually complete an analysis of the kind outlined.

2.0 DISTINCTION BETWEEN BENEFIT-COST ANALYSIS AND OTHER FORMS OF POLICY ANALYSIS

As noted in the McConnaughey paper in 1976, the National Bureau of Standards suggests three general categories of building code economic impacts; (1) benefit and cost impacts associated with specific building code provisions, (2) building code impacts which affect income distribution, and (3) aggregate impacts of the building code system upon the construction industry as a whole.[5] This paper focuses on the methodology needed to analyze the first set of these impacts, but there is need for a brief discussion of how it differs from the other two types of analyses.

Cost-benefit analysis is a formal procedure for determining the relative economic efficiency of alternative policies (or regulations). The terms *cost* and *benefit* are defined more narrowly than in general English usage so that the analysis focuses only on changes in the quantities of resources that must be committed for specific purposes. In addition, the formal comparison of costs and benefits is based upon specialized principles and procedures which are mostly derived from economic theory.

In contrast, an analysis of the effects of building codes on income distribution is not principally concerned with questions of economic efficiency. A distributional analysis deals only with changes in some peoples' well-being at the expense of others, an issue which is basically political and requires that the dollar gains of one group be weighed against the dollar losses of another.

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[4] John S. McConnaughey, Jr., "Economic Impacts of Building Codes," National Bureau of Standards, Washington, DC, January 28, 1977.

[5] McConnaughey, p.1.

Finally, an analysis of the aggregate impacts of the building code system upon the construction industry as a whole is different from a cost-benefit analysis because it does not consider the benefits derived from regulation, and looks only at the impact on one set of actors that might be affected by the regulations. Such an analysis is only partially concerned with allocation efficiency and only partially concerned with the political ramifications of regulation.

All three types of analysis are components of overall policy analysis and all three deal with economic issues, but only cost-benefit analysis deals exclusively with concepts of allocative efficiency according to traditional economic principles.

3.0 THE BASIC CONCEPTUAL FRAMEWORK FOR LIFE-CYCLE BENEFIT-COST ANALYSIS

The methodology being discussed here is one that can be used to assess the costs and benefits of a specific building code designed to increase the safety of housing. Thus the goal is to compare the additional costs that might result from a new regulation with reductions in loss-of-life, personal injury, property damage, and associated costs that would result from the regulation during the useful economic lifetimes of the homes. The appropriate methodology is marginal economic analysis of the life-cycle effects of regulation.

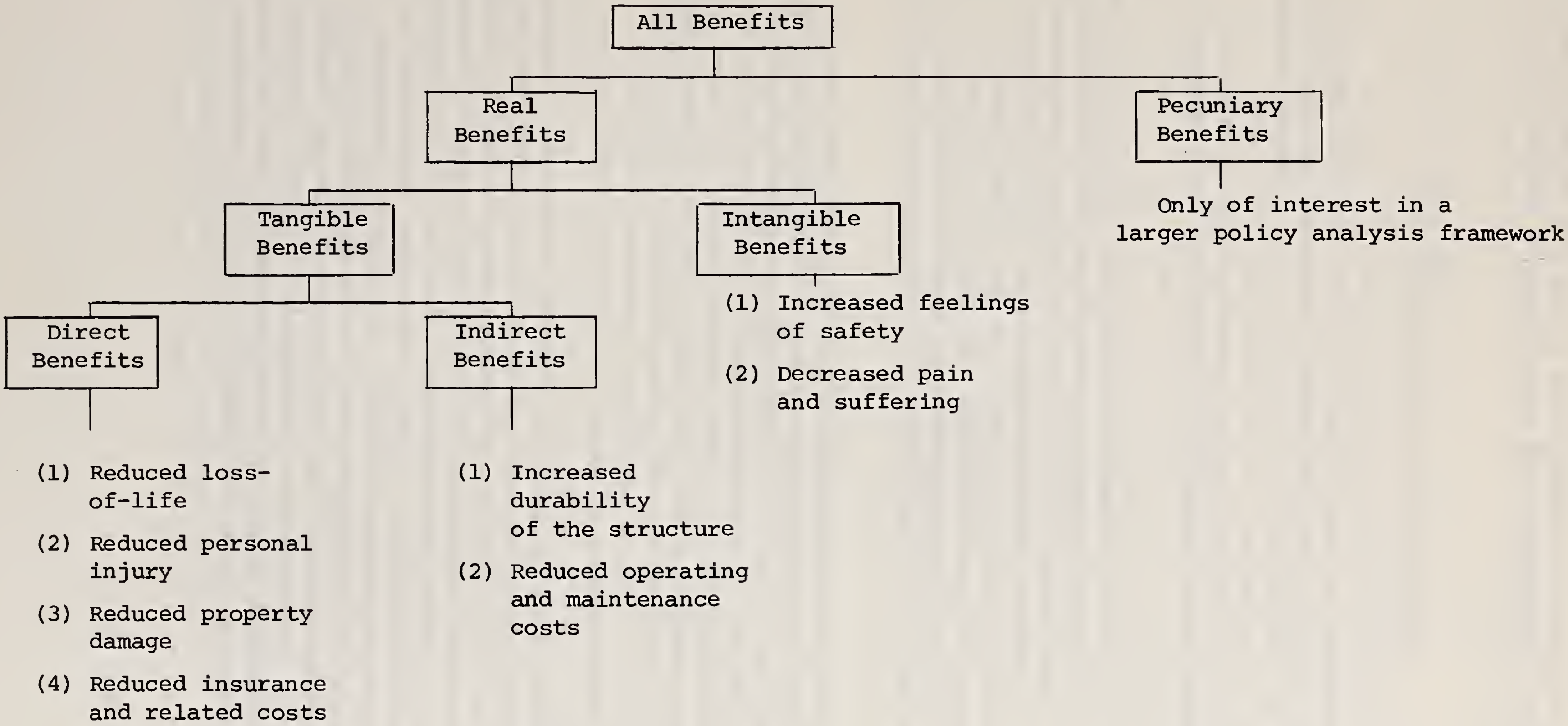
To be comprehensive in estimating the marginal costs of a regulation, the analysis must consider the incremental costs incurred by (1) governments--to develop, implement, and enforce the new regulation; (2) manufacturers and retailers--to produce and sell the structure; (3) consumers--to operate and maintain their homes over the lifetimes of the structures; and (4) consumers--who are no longer able to purchase homes because the price has been raised by regulation.

In estimating the incremental benefits of a regulation, a number of steps must be taken. First, data must be obtained concerning the costs currently being borne by home owners and the public because homes are not as safe as they would be if the regulation were in effect. (Estimates of these costs are necessary because they indicate the magnitude of the benefit that could be derived from a totally effective safety regulation.) Once these potential benefits have been estimated, the second step must be to determine the proportion of them that could actually be achieved by the regulation. A variety of techniques are available depending upon the nature of the safety concern and the amount of experimental or experiential data available.

To be successful, both the cost and benefit analyses must rest on a set of well-defined concepts and methodologies. As noted by McConnaughey, a significant reason for conflicting opinions concerning the impact of building codes is "the lack of a consistent language or set of specific definitions concerning building codes and their

Figure 2

T + E CONCEPTUAL FRAMEWORK FOR CONSIDERATION OF LIFE-CYCLE BENEFITS OF BUILDING SAFETY REGULATIONS



impacts."[6] The following are definitions of all key concepts that are integral to the understanding of a cost-benefit analysis of a residential safety regulation.

3.1 GENERIC TYPES OF COSTS AND BENEFITS

The T + E benefit-cost methodology is based upon four general cost and benefit distinctions. The first distinction is that costs or benefits may be real or pecuniary. Real costs are those incurred as the result of the withdrawal of resources from other uses. Real benefits are those derived by the final consumer of the regulated product, and others who may be affected, which reflect an addition to community welfare.

In contrast, pecuniary costs and benefits are those derived from changes in relative factor prices occasioned by market adjustments to the regulation. They result in the accrual of gains to the owners of some factors of production that are offset by the losses of others. Consequently, pecuniary costs or benefits do not reflect gains to society as a whole. They are relevant, therefore, only if one is interested in examining the distributional consequences of the regulation. In the T + E methodology, only real costs and benefits are taken into account.

A second distinction can be drawn between direct and indirect costs and benefits, also called primary and secondary effects. Direct costs and benefits are those associated with the main regulatory goals, whereas indirect effects are generally considered to be by-products of regulation. Thus building regulations for increased fire safety, for example, should have such direct benefits as reduced personal injury, fewer deaths, and decreased property damage, but they may also produce the indirect benefits of increased structural durability or decreased operating and maintenance costs.

A third distinction can be drawn between tangible and intangible costs and benefits. Tangible costs or benefits are those that can be valued in the market, whereas intangible impacts cannot be assigned a market value. Given appropriate detailed data, it should be possible to determine the economic value of reduced death, personal injury, or property damage resulting from a safety regulation. Consequently, these benefits are considered tangible. In contrast, increased feelings of safety or satisfaction felt by the consumers of housing built to a new safety standard are much more difficult to quantify, and are therefore considered to be intangible. It must be left to those who are ultimately responsible for instituting, or not instituting, a safety regulation to assess the importance of these intangible factors.

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[6] McConnaughey, p. 1.

categories of cost are likely to be incurred due to a new safety regulation: direct initial costs, direct recurring costs, and indirect recurring costs.

Direct Initial Costs

These are incurred only once, when the regulatory authority develops and implements the regulation, and, in response, private organizations alter their operations to comply. These include standard development costs, standard implementation costs, and standard compliance costs.

Standard development costs include all resources allocated by governments and the private sector to develop the proposed standard. At the local level, these costs could be quite small because the local government may simply adopt a model code developed by a national code making organization, but at the Federal level, the resources allocated to the development of a standard--the Mobile Home Construction and Safety Standards, for example--can be substantial. Included would be the services of engineering and economic consultants such as T + E; the services of administrators and engineers at HUD that are directly applied to regulation development; the services of expert witnesses and the testimony of private sector representatives; and supplies, secretarial and clerical, and even office rental costs that are devoted to formulating the regulation.

Standard implementation costs include the resources initially allocated by government to put the regulation into effect. They may include reorganization of government; training of individuals to oversee the regulatory process; conferences and contacts with representatives of the private sector; initial intense enforcement of the new regulation; and adjudication costs for defense or clarification of the regulations in court.

Standard compliance costs include the resources utilized by organizations or individuals in the private sector to respond to the regulation. They could include the following specific types of costs: research and development, reorganization, and capital costs. Research and development costs are unlikely to be substantial if the new regulation is a prescriptive materials standard; but they could be substantial if the regulation is a performance standard allowing a variety of hardware or design responses. Reorganization costs could be incurred if organizations found it necessary to create new units to deal exclusively with paper work or issues directly associated with the new regulation. Initial capital costs could be incurred if (1) firms were forced to prematurely scrap or retire existing capital equipment in favor of new equipment; (2) firms were forced to purchase new types of capital equipment that had a higher depreciation value per home produced than the equipment replaced; or (3) firms were forced to apply more of the same types of capital per home produced.

Finally, a distinction can be drawn between initial and recurring costs and benefits. Initial costs are those incurred only once by government and private organizations when a new regulation is being developed and implemented. Initial benefits are those enjoyed by consumers of the regulated structure when the structures are first purchased, and are obtained only once.

In contrast, recurring costs and benefits occur every time a home is produced, or every year it exists. A recurring cost from a new regulation, for example, could be the additional materials needed to meet the regulation every time a new home is built. Alternatively, recurring benefits are those that accrue to consumers and to the public every year that residences built to the new regulation are lived in. For example, a regulation that increased the fire safety of housing would make this housing safer every year, and consumers and the public would annually accrue the benefits of decreased property damage, loss-of-life, injury, and related costs.

It should be noted that the NBS paper presented at this conference in 1976 also refers to initial and recurring costs and benefits. According to the NBS paper "initial costs are direct labor, materials, equipment, overhead and profit costs. Recurring costs are future maintenance, repair, and operating costs."[7] The NBS and the T + E definitions of these terms differ due to a difference in analytic perspective. The NBS benefit-cost methodology is designed to assess only the direct impact of a regulation on the initial price of a structure and the ensuing costs of using the structure over its lifetime. In contrast, the T + E methodology is designed to address all the incremental costs associated with developing, instituting, enforcing and complying with a regulation. Thus in the T + E framework, both the initial and recurring costs referenced in the NBS paper are considered to be recurring costs, and initial costs in the T + E framework have an altogether different meaning. Figures 1 and 2 should assist in demonstrating this distinction and the following detailed definitions should further clarify the overall T + E conceptual framework.

3.2 SPECIFIC TYPES OF COSTS TO BE ESTIMATED

The correct measure of costs is always opportunity cost--the value of foregone alternatives. Thus the cost of any building regulation should be assessed in terms of the resources that must be withdrawn from other uses to be applied to its development, implementation, enforcement, and compliance. In terms of the cost distinctions drawn in the preceding section of this paper, three

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[7] McConnaughey, p. 5.

Direct Recurring Costs

In contrast to direct initial costs, direct recurring costs are incurred more than once in response to a new regulation. They are incurred on a continuing basis as resources are reallocated for enforcement and compliance.

Enforcement costs include salaries, fringes, and direct expenses that must be applied to enforcement of the regulation in question. If a new regulation could be enforced by an existing regulatory team without additional expense, then the marginal enforcement costs for a new regulation would be zero.

Recurring compliance costs are the additional operating costs incurred by housing producers for direct labor, materials, administration/overhead, and profit to meet the requirements of the new regulation. These cost increases are likely to be the largest single component of additional costs due to regulation. In fact Weidenbaum, in a study of the costs imposed by Federal regulation of all types, found that in 1976, compliance costs were about 20 times the administrative costs for regulatory agencies.[8]

Indirect Recurring Costs

These costs are not incurred in the course of developing, implementing, or directly complying with a regulation change; rather, they are possible unintended results of regulation. The extent to which indirect costs are considered in a cost-benefit analysis of a new regulation depends upon whether the analysis is considered to be general or partial. General analyses attempt to trace the effects of a regulatory change through all sectors of the economy; whereas partial analyses concentrate on the more immediate interdependencies within the sector under analysis. The impacts of a single building code regulation, especially if effected at the local level, will not have significant widespread impacts. Therefore, a partial analysis is both more practical and more appropriate.

In a partial analysis framework, the indirect costs of regulation that are of most concern are as follows: (1) potential increased consumer operating and maintenance costs (operating and maintenance costs for a home could rise due to a fire safety regulation, for example, if wall or ceiling materials with a lower frame spread rating but with greater maintenance needs were required to replace materials with a higher flame spread rating but lower maintenance needs); and (2) possible exclusion of marginal housing consumers from the purchase of a home (if the price of a home were raised due to regulation, some potential customers would be precluded from purchasing a home because they could no longer afford the higher down payments or the greater monthly installments; thus some individuals would be forced

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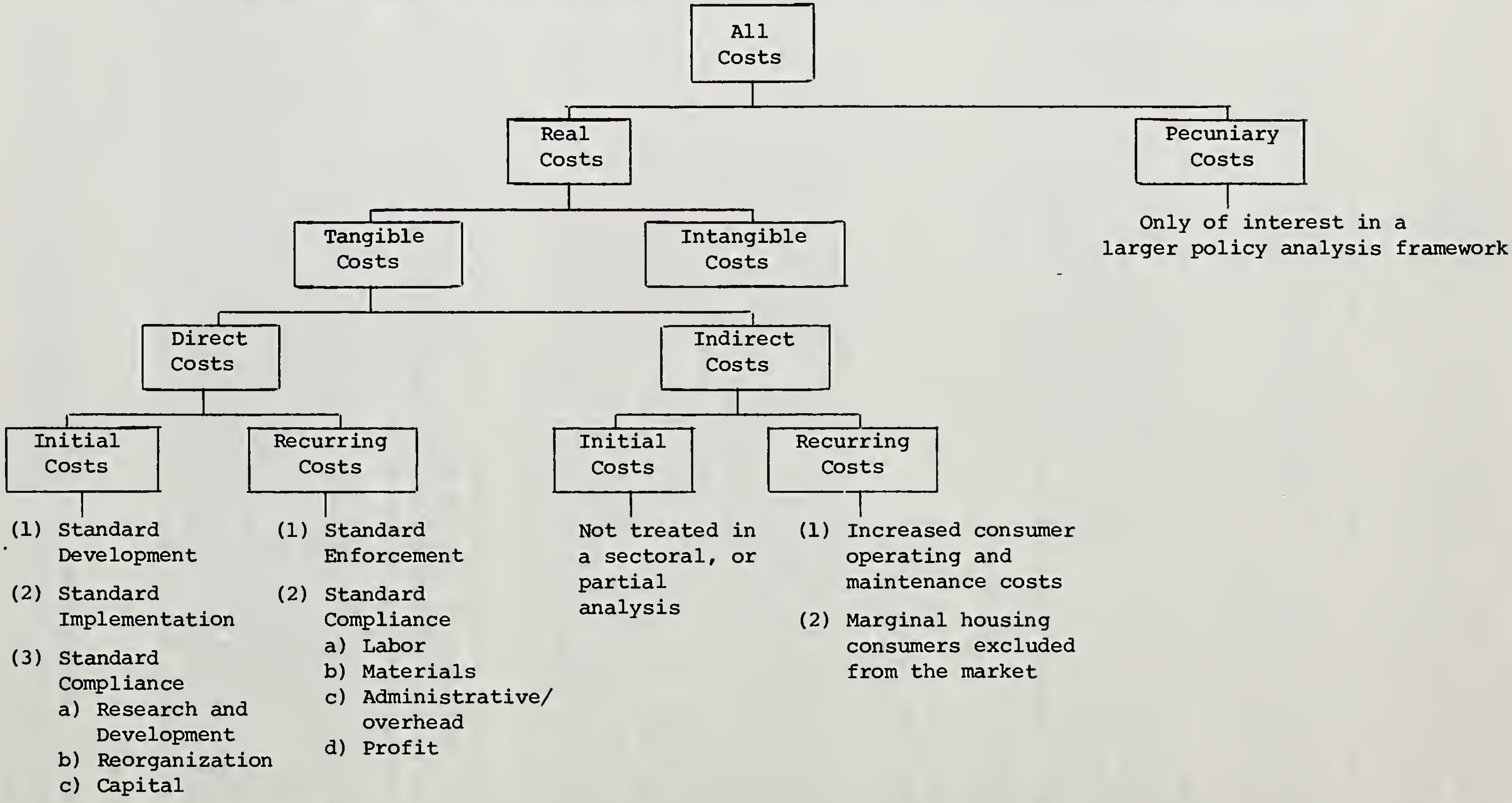
[8] Murray L. Weidenbaum, "On Estimating Regulatory Costs" in "Regulation" Journal, May/June 1978, American Enterprise Institute, Washington, DC, p. 17.

Figure 1

T + E CONCEPTUAL FRAMEWORK FOR CONSIDERATION OF LIFE-CYCLE COSTS OF BUILDING SAFETY REGULATIONS



to live in housing that had lower utility to them than the home they would have purchased. The resulting loss of consumer satisfaction would be a cost of regulation).

3.3 SPECIFIC TYPES OF BENEFITS TO BE CONSIDERED

In assessing the benefits derived from a residential safety regulation, no distinction need be drawn between initial and recurring effects because benefits accrue in a stream over the lifetime of the homes that are affected. In considering benefits, the essential distinction is between those that are direct and those that are indirect.

Direct benefits, as defined earlier, are those intended by the imposition of the regulation--its major purpose. In contrast, indirect benefits are those considered to be by-products of the regulation--not directly intended, but nevertheless a result of the regulation. These benefits can be either tangible (i.e., quantifiable) or intangible (non-quantifiable).

Direct Tangible Benefits

The principal goal of residential safety regulation is to reduce accidential loss-of-life. The magnitude of this reduction can be estimated by contrasting the number of lives that would have been lost in the absence of regulation with the number that might be lost if the regulation were effected. This estimate must be made for every year that the safety regulation is expected to be effective.

A second anticipated benefit of safety regulations is a reduction in the costs of personal injuries due to the safety problem being addressed. These costs can be decreased either through a reduction in the frequency of personal injuries or through a decrease in their average severities. Thus the pre-regulation incidence and average severity of injuries must be contrasted with estimated post-regulation incidence and severity figures.

A third major goal of residential safety regulations is to decrease property damage. If the regulation is effective, two types of property damage will be reduced: direct damage to the home, and damage to the personal effects of the occupants. As with personal injury costs, property damage costs can be reduced in two ways: through reductions in the frequency of damage, or through reductions in the average severity of damage.

Increased life safety and decreased property damage are generally accepted to be the principal goals of safety regulation, but they are not the only beneficial results of an effective regulation. Other direct effects will include reductions in insurance costs, post-damage clean-up costs, alternative lodging costs, and foregone income. The sum of these reductions could be substantial.

The reference to reduced insurance costs is not to lower damage payments made by insurance companies--these reductions are counted in estimating lower life-safety and property damage costs. Instead, the reference is to reduced insurance company costs of adjusting and processing claims due to the reduced number of such claims.

Post-damage clean-up costs refer to the resources that must be allocated to clean-up and repair items not directly a part of or in a home but that are damaged nonetheless. Such items include shrubs, utility connections, telephone hook-ups, lawns, and related improvements. A new regulation that reduces either the incidence or severity of a safety problem is likely to reduce the incidence and severity of clean-up costs as well.

Similarly, when a home is damaged so severely that the occupants are required to seek alternative lodging while their home is being repaired or replaced, the occupants are likely to incur increased lodging costs. The difference between direct expenditures for alternative lodging and the costs that occupants would have incurred for lodging in their usual home is the marginal cost of alternative lodging that must be considered. Reductions in these costs will come from reductions in the number of safety problems that are severe enough to warrant alternative lodging.

Finally, when a residential safety problem occurs, even in the absence of personal injury, the occupants often must take time from their usual productive activities to negotiate with claims adjusters, find alternative lodging, oversee the clean-up and repair of their homes, find alternative schooling or transportation for their children, etc. This time away from work frequently results in a direct loss of income to the occupant. New safety regulations that reduced the frequency or severity of damage to homes would almost certainly reduce the amount of income foregone by its occupants.

Indirect Tangible Benefits

Regulations often produce unintended results that may be either advantageous or detrimental. Those that are advantageous are deemed to be indirect benefits. If these benefits are capable of being assigned a value, then they are considered tangible. Two types of indirect, tangible benefits could result from a residential safety regulation: increased durability of the structure, and reduced operating and maintenance costs.

Increased durability could be manifested through an extension of the useful economic life of the home or through higher resale value as the home ages (independent of resale value changes due to increased safety). To estimate the impact of a safety regulation on durability, the specific changes must be compared with the types of structural features that are known to increase durability.

As noted in Section 3.2, a new building safety regulation could increase maintenance or operating costs. However, a regulation could just as easily result in a decrease in these costs. Only by assessing the specific regulation can the impact on operating and maintenance costs be assessed.

Intangible Benefits

In addition to producing the types of direct and indirect tangible benefits described above, a safety regulation could produce less obvious and less measurable benefits. The two most likely intangible benefits are increases in occupants' feelings of safety, and decreases in pain and suffering.

If a new safety regulation made homes noticeably "safer," the purchasers of these homes would probably feel safer. These increased feelings of security would be an intangible benefit of the regulation.

A decrease in the number of lives lost or the frequency and severity of personal injuries due to a regulation would certainly be accompanied by a decrease in the amount of pain and suffering felt by residential occupants, their friends, and relatives. This decrease in suffering and pain would be a substantial intangible benefit and should be considered when deciding whether to institute a new safety regulation.

4.0 TECHNIQUES FOR MEASURING LIFE-CYCLE COSTS AND BENEFITS OF POTENTIAL REGULATIONS

The conceptual framework described in Section 3.0 assures that all important costs and benefits are considered in analyzing the effects of a residential safety regulation, but it does not describe the actual procedure for accomplishing a life-cycle benefit-cost analysis. Actually, there can be no guide book which provides detailed instructions regardless of the regulation or the regulatory setting because each regulation and each setting has its unique characteristics. Nevertheless, there are a set of basic operational steps that must be taken to successfully accomplish a life-cycle benefit-cost analysis. The following is a list of these steps.

1) Determine existing costs of the safety problem to be addressed by the regulation.

2) If the regulation is a performance standard, perform engineering analyses to determine the most probable structural responses to the standard.

3) Estimate the costs of standard development, implementation, enforcement and compliance (life-cycle).

4) Determine the impact of structural changes on existing safety costs, i.e., estimate all life-cycle benefits.

5) Compare the potential costs and benefits of the regulation.

All of the specific actions that must be taken to assure that each of these steps is correctly taken cannot be described here, but some of the key considerations can be mentioned.

4.1 DETERMINATION OF EXISTING COSTS OF THE SAFETY PROBLEM

Since the direct benefits of a regulation are reductions in the costs of a safety problem, the first requirement of a benefit-cost analysis is an estimate of how great the safety problem would be in the absence of any new regulation. The appropriate baseline data, then, are drawn from the experience of homes that are most like the ones that would exist if the regulation were not put into effect. Two basic pieces of information are needed regardless of the type of baseline cost being considered: the frequency with which the cost is incurred annually (for example, the frequency of fires in housing and the frequency of loss-of-life due to fires) denoted as FD_{ij}--the frequency of damage for cost type j in year i; and the average annual cost of the damage when it occurs (for example, the average cost of property damage due to fire, or the average cost of fire injuries) denoted as ACD_{ij}--the average cost of damage for cost type j in year i.

With this information it is then possible to estimate the expected annual cost of damage (ECD_{ij}) for each cost type as follows:

$$ECD_{ij} = FD_{ij} \cdot ACD_{ij}$$

These estimates then provide the foundation for determining the net present value of the expected costs of the safety problem over the lifetime of the average baseline home. The expected, future, annual costs of each type of damage must be discounted by an appropriate discount rate to obtain its present value. Then these present values must be summed as follows:

$$\begin{array}{l}\text{Total present value of}\\ \text{the expected costs of}\\ \text{the safety problem with-}\\ \text{out new regulation}\end{array} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{ECD_{ij}}{(1+r)^i} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{FD_{ij} \cdot ACD_{ij}}{(1+r)^i}$$

Where m = the expected life of the home; n = the number of cost categories; and r = the real discount rate.

The use of expected cost figures reduces the cost-benefit analysis to a comparison of the costs and benefits of regulation that would accrue to a single average home. This approach presents certain minor computational problems at some points, but advantageously eliminates the need to make projections of future annual sales of regulated homes or deal with other aggregate market data.

4.2 ESTIMATION OF THE COSTS OF REGULATION

Methodologically, attention must be focused on initial costs--those incurred only once--and recurring costs--those incurred every time a home is built--because these two costs types must be treated differently in estimating the regulatory costs that are generated for each home that is produced.

Initial costs are incurred only once by government and private organizations when a regulation is effected, but these costs will enable government and industry to assure the production of a great many homes in conformance with the regulation. Thus the magnitude of these costs is relatively meaningless unless their value per home produced is estimated. The following equation provides a way to estimate the value of initial costs per home produced.

$$TIC = \sum_{i=1}^{m} \frac{H_i \cdot x}{(1+r)^i}$$

Where TIC = the total initial cost of regulation; H_i = the number of regulated homes produced in year i, x = the value of initial costs per home produced; r = the real discount rate; and m = the number of years the initial cost changes will be effective.

In contrast to the relatively complex technique needed to determine the value of initial costs per home produced, estimation of the direct recurring unit costs is quite straightforward. The additional costs of labor, material, administration/overhead, and profit needed for the production of each home are the recurring unit costs. These costs can be ascertained through direct engineering cost analyses.

Estimation of indirect recurring costs requires knowledge of the price elasticity of demand for the housing in question and the impact of the regulation on operating and maintenance costs. The latter requirement only calls for engineering cost analysis, the former requires detailed market data. Reasonable estimates can be made without detailed market data, however, by assuming a reasonable range of price elasticities.

4.3 ESTIMATION OF THE BENEFITS OF REGULATION

To estimate the total life-cycle benefits of a regulation both direct and indirect benefits must be determined. The direct benefits of a safety regulation are reductions in the costs of property damage, loss-of-life, and injuries that would otherwise occur. As noted earlier, the expected cost of damage (ECD) is a function of the frequency of the damage (FD) and the average cost of such damage (ACD). Thus, all other things remaining the same, a decrease in the expected cost of damage will result from a decrease in the values of either of these parameters. To estimate the magnitude of these decreases due to regulation, a number of approaches can be taken. Decision tree analysis is an excellent technique as is its companion, fault tree analysis. Analyses of case study materials and engineering tests are also quite useful.

Once the reductions in the magnitude of FD and ACD have been estimated for each cost type j, it is then possible to compute annual expected costs of damage and obtain their present values as indicated in Section 4.1.

$$\text{Total present value of the expected costs of the safety problem after regulation} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{ECDR_{ij}}{(1+r)^{i}}$$

Then,

$$\text{total direct benefits} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{ECD_{ij} - ECDR_{ij}}{(1+r)^{i}}$$

Indirect benefits can then be estimated through engineering cost analyses.

5.0 CONCLUSION

A number of forces--for example, high rates of inflation, and the development of increasingly more sophisticated building technologies--are prompting consumers, housing producers, and elected officials to demand evidence that proposed building regulations are reasonable. At a minimum a regulation can be said to be reasonable if it generates economic benefits that at least equal the costs of regulation.[9] The conceptual framework for life-cycle benefit-cost analysis described in this paper is presented to further the use of this minimum criterion for determining reasonableness and to assure the appropriate costs and benefits are identified and measured correctly.

The widespread application of life-cycle benefit-cost analysis to the consideration of building safety regulations will require increasing integration of economic theory with building engineering analyses, and will require the development of texts that outline practical approaches to these analyses. The data requirements of these analyses will be considerably greater than the data needs for the current regulation development processes (unless generally accepted multipliers or coefficients can be developed), and consequently, analytical costs will be higher. However, these costs should be more than recovered through increases in the efficiency of new regulations. It cannot be argued that the existing regulation development procedures are adequate because there is an error towards too much safety. Over-regulation requires that consumers purchase costly safety features that are not efficient. Conversely, under-regulation means that more resources could be advantageously employed to reduce safety damage.

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[9] See McConnaughey, p. 6 for other criteria of reasonableness.

REGULATORY IMPLICATIONS OF ADOPTING A METRIC BUILDING CODE FOR THE PROVINCE OF ALBERTA, CANADA

by

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With the notable exception of the United States and Canada the majority of the world's countries use the metric system of measurement. Canada is now converting to the metric system on a voluntary basis. The period of conversion is spread over a number of years with each section of the economy establishing its own targets. The construction industry established January 1, 1978 as the date to begin using metric measurements. The Province of Alberta is experiencing a rapid and smooth transition from foot-pound units to SI (metric) units and the construction industry is in the forefront.

The Alberta Construction Association receives major credit for its educational programmes and government has co-operated fully by responding to the industry's requirements rather than by dictating its own ideas. The province introduced a metric building code in April 1978 with no opposition because it was supported by all groups involved in construction.

Key words: Building codes, construction, metric.

INTRODUCTION

In 1970 the Canadian government decided that the SI (metric) system should become the predominant measurement system in Canada. The construction industry developed a timetable for implementation of the metric conversion process. January 1, 1978 was selected as the date when new construction projects would start to be tendered and built in the SI (metric) system of measurement. The construction industry and the government of the Province of Alberta accepted this timetable and have successfully met the challenge. This paper reviews the background for metric conversion, outlines some steps to encourage general acceptance of the new system, discusses timing for introducing metric units into building codes, and concludes with some suggestions which can help other regulatory agencies who may be involved in metric conversion.

METRIC SYSTEM STARTS

Until the french revolution measurement systems were highly individual to specific countries and could vary even within the boundaries of one country. Standards of measurement were often set by and related to the king or ruler. Although standard weights and measures were often kept at a central location it was no easy matter to verify the accuracy of measurement at remote locations. With the coming of the revolution in France, those who had overthrown the king also wished to replace the measurement system associated with the king's regime with a system more closely attuned to the common man. The length standard was chosen as one ten millionth part of a meridian between the pole and the equator. Most other standards were defined in terms of natural phenomena. In addition to the selection of the measurement standards they decided to base the multiples and submultiples of their base units on powers of ten.

It took many years and restrictive legislation before the french people accepted their new system. As other countries experienced revolutions and overthrow of monarchical regimes the new authorities frequently modelled their systems on the french example and the metric system of measurement was usually adopted. The United States is one of the few countries that did not adopt the metric system after a revolution.

SOME COUNTRIES WHO DIDN'T CONVERT TO METRIC SYSTEM

By the middle of the twentieth century Canada, other members of the British Commonwealth, and the United States were about the only countries left who had not converted to the metric system. However even in these countries the metric system was used in scientific circles and most people had some elementary knowledge of metric terminology. Since 1873 two measurement systems were legal in Canada, the foot-pound system in common use and the metric system in scientific use. Virtually all legislation was written in foot-pound units and most business and commercial transactions were undertaken in these units.

In recent years these countries found themselves in an increasingly isolated position as more and more international trade was conducted in metric units. Without the dubious benefit of a revolutionary regime to order a change of units, industry and government started to discuss methods of implementing a conversion process to the metric measurement system. In a totalitarian regime it would be simple to decree a change to a new system but in democratic societies government and business have to be responsive to and responsible to the citizens of the country.

CANADA DECIDES TO CONVERT TO THE SI (METRIC) SYSTEM

Although the United States is Canada's largest trading partner the balance of her international trade is carried on with countries who use or are in the process of converting to the metric system. In recent years nearly all other Commonwealth countries, such as Great Britain, Australia, and New Zealand had decided to convert to the metric system. Canadian industrialists approached the government of Canada and recommended that Canada should also convert and that the sooner it was done the less traumatic it would be.

Thus, in January 1970, a white paper "Metric Conversion in Canada" was tabled in the federal parliament. This paper stated that it was the government's intention that the international system of measurement known as SI, based on the metre, would become the predominant system but that the conversion process would be voluntary and that the costs of conversion would have to be absorbed by those undertaking the conversion process. In this way government accepted and endorsed the change but hoped that it would not attract a negative response from the citizens at large as would have happened if it had introduced the new system by direct legislation.

Once the decision was made to convert it was obvious that good co-ordination would be needed to make sure that the best possible system would be developed. In 1971 a Metric Commission and a Standards Council of Canada were established to lead and co-ordinate the change to the SI (metric) system. It was the intention of government that regulations and other legislation would respond to the decisions of industry.

PLANNING FOR METRIC CONVERSION

Many sectors of the economy were defined, one sector being the construction industry. Committees of volunteers, experts in the relevant fields, were established to develop rational and co-ordinated plans. Each sector established a metric conversion plan, including target dates arrived at by a consensus of the committee members involved. By 1975 the construction industry had established a conversion plan and soon thereafter decided that January 1, 1978 should be termed M-Day. This was defined as "the first day of Metric Construction Year in which the Canadian Construction Industry will work in SI (metric). Following M-Day, drawings and specifications, materials and components which are necessary in metric terms will become available".

It must be emphasised that at that point in time neither federal nor provincial governments had passed any legislation which would force the metric system on the construction industry. The decisions had originated from industry. Although government representatives were involved in many committees they did not control the decisions of the committees.

The canadian construction industry in general is not an exporting industry and so had no ready market other than in the foot-pound system. The construction industry sector approached all levels of government and requested that action be taken to ensure a market in 1978 for metric materials in sufficient quantity to justify a conversion process. Without an assured market few companies could absorb the costs of conversion. The federal and provincial governments and many large municipalties assured the construction industry that after January 1, 1978 all plans and specifications for new construction that was funded by them would be issued in SI (metric) units.

ALBERTA ESTABLISHES A METRIC CONVERSION BRANCH

The government of the Province of Alberta was aware at an early stage that the metric system was coming and established a metric branch to assist Alberta citizens and business convert to SI (metric) as easily as possible. It was the intention that government would respond to public initiative although it was inevitable that certain commitments would have to be honoured to maintain unity with other provinces and with the federal government.

One of the early tasks of the metric branch was to review all government legislation and identify all cases where dimensions occurred. This review produced a book with nearly 300 pages. Dimensions in Acts and regulations of the province could be identified easily enough but in the case of national documents, such as standards and codes, referenced by the regulations, no attempt was made to list dimensions on the assumption that the committees writing those documents would do so and make the necessary conversion.

BUILDING CODE LEGISLATION

The majority of construction projects are regulated by building codes which set out the requirements that must be satisfied before construction can proceed. A building code is a piece of legislation enacted by a political body. In Canada the federal government has no authority over building legislation, this authority was retained by the provinces at the time of confederation. Until recently all canadian provinces had delegated the authority to enact building legislation to each municipality but the increasing complexity of building codes and their administration and demands by the construction industry had convinced many provinces that they should establish uniform provincial building codes.

In Canada since 1941 there has been a model building code known as the National Building Code of Canada. The National Building Code, sponsored by the National Research Council of Canada, had no force unless adopted by a provincial or municipal government. Although it was slow to gain acceptance at first, it gradually reached the position that by 1970 it was adopted in whole or in part by most municipalities in Canada.

Alberta became the first province in Canada with a uniform provincial building code when it enacted The Alberta Uniform Building Standards Act in January 1974 and the Alberta Building Regulations in April 1974. The Alberta Building Regulations adopted, with minor variations, the 1970 edition of the National Building Code of Canada. In the 1970 National Building Code of Canada measurements were in the foot-pound system together with approximate metric values in parentheses.

In 1975 the Building Standards Branch, which is responsible for administering the building standards legislation, knew that the metric system was on the way but was also faced with a new (1975) edition of the model code (The National Building Code of Canada) referenced by the building regulations. A decision was made to introduce the new edition of the model code, after consultation with the construction industry, but to leave decisions on introducing metric values until the construction industry indicated that it was ready. It was obvious that this would happen in 1978 but that was well in the future. Because of lengthy discussions with some members of the construction industry and the need to resolve numerous conflicts between the model building code and other provincial legislation it was March 1977 before the 1975 edition of the National Building Code of Canada was adopted.

ALBERTA CONSTRUCTION ASSOCIATION EDUCATES ITS MEMBERS IN THE METRIC SYSTEM

By 1977 the Alberta Construction Association had assumed a lead role in educating its members for the coming impact of metric conversion. At first seminars titled "Metrics for the Construction Industry" were conducted in many cities of the province to introduce senior management to the metric system and show them how their companies could improve productivity and simplify their operations. These seminars attracted representatives from manufacturers, contractors, architects and engineers. Although many were highly sceptical of metric conversion before the seminars the majority were convinced of the value of the metric system by the end of a seminar.

Further series of worskshops titled "Work Metric" were given across the province to help estimators and job superintendents understand the cost implications and the effect of metric conversion on day to day operations. A final series of workshops titled "SI and the Construction Industry" were offered to people such as specification writers and secretaries to help them understand the technical usage of various terms so that an accurate communication process between designer and contractor would be established.

The Alberta Construction Association state that the key to their highly successful programme has been the co-operation of the Alberta government metric branch. Instead of mandatory regulations the metric branch offered assistance and encouragement to an industry association and then helped that industry move in the right direction. The metric branch supported the Alberta Construction Association by encouraging all government employees involved with construction to attend their seminars and workshops rather than developing in house programmes.

The seminars and workshops of the Alberta Construction Association were so well received that they have been requested and conducted coast to coast in Canada as no other construction association had developed anything as successful. In large part the acceptance of metric values by the construction industry in Alberta is due to these seminars and workshops.

DESIGNERS START TO USE METRIC DIMENSIONS

Simultaneously with the Alberta Construction Association's educational programmes the Provincial Government and Municipal Governments started plans for metric dimensioned projects. Consultants designing projects for tendering after January 1, 1978 were required to design and detail the projects in SI (metric) units. Once these designers encountered the simplicity of the SI (metric) system they started using it for projects for non-government clients as well.

As designers started on projects in metric units the question arose concerning the legality of the units when the building code was in foot-pound units. It was explained to these designers that the main interest of the building code is safety and that their designs were fully acceptable as long as the magnitude of the metric dimension gave results the same as or safer than the foot-pound value.

NATIONAL CODES AND STANDARDS INCLUDE METRIC VALUES

As soon as the construction industry established a conversion plan, standards and code writing organizations started the process of converting their documents to metric values. Close co-operation between industry and these organizations was essential to make sure that measurements related to product sizes would apply after the products themselves were converted to the metric system.

The committees responsible for the National Building Code of Canada had started on a new cycle of code revision in 1975 and decided to treat the code revision and metric conversion as related items but not to integrate both in one document. In July 1977 the latest edition of the Code was published and in it all dimensions were in the foot-pound system. A separate document was published giving recommended metric equivalents to most dimensions and a list of standards which were written with metric values. Because there is a time lag of several months between the writing and the publishing of the National Building Code of

Canada the editors were unable to reference the metrically converted standards which were published in 1977 and for many materials were able to only soft convert the values pending manufacturers' agreements on hard conversion values.

ALBERTA CONSIDERS A METRIC BUILDING CODE

By mid 1977 the construction industry in Alberta had accepted the proposed conversion to metric and the Building Standards Branch were requested to develop proposals for implementation of a metric building code. The Building Standards Branch reviewed available documents, met with industry representatives and drafted a number of proposals for public comment. The proposals were presented at a public meeting in November 1977 to which representatives of all groups in the construction industry were invited.

The concensus of the meeting was

(a) that a further series of code changes should not be introduced at the same time as the SI (metric) system;

(b) that as far as possible the values recommended in the metric supplement to the 1977 National Building Code of Canada should be adopted;

(c) that the equivalent foot-pound values be placed in parentheses after the SI (metric) value to help code user's relate to familiar sizes while becoming familiar with a new system and that the equivalent foot-pound values should be consistently rounded off to two decimal places (fractions would not be used to be consistent with decimal usage in the SI (metric) system;

(d) that the latest standards would be referenced, particularly those using SI (metric) units; and

(e) that the metric building code should be introduced as soon as possible.

ALBERTA INTRODUCES A METRIC BUILDING CODE

As soon as the Building Standards Branch had the support of the construction industry of the province for the introduction of metric values in the Building Code the staff started to prepare the necessary documentation. It was soon evident that there were 2000 individual numbers, over 120 tables and charts and 130 references to standards which had to be considered. In the case of dimensions related to products many phone calls had to be made to manufacturers to determine the sizes they would be producing if they intended to make changes at the same time as converting to metric values. Standards writing organizations had to be contacted frequently to determine what stages they had reached for metric conversion of specific standards.

In establishing metric values the following rules were kept in mind:

(a) dimensions which could be relaxed with no serious effect upon safety were rounded off and relaxed i.e. a permissible building area of 6,000 sq. ft. was rounded off to 600 m^2 to keep familiar numbers in front of the code user, this appears in the regulation as 600 m^2 (6 458.35 sq ft) and thus is a 7.6% relaxation.

(b) metric dimensions which had been established by the National Building Code committees were maintained to promote national unity in the construction industry except where manufacturers had established rational hard converted sizes not recognized in the National Building Code.

In less than 6 weeks a draft of a regulation was prepared and submitted to the government's legal staff for review. Although the content was acceptable the legal staff had just developed new rules for the writing of legislation to help make it more understandable to the user and they insisted that the building regulation be revised completely to agree with the new style. Further time elapsed during the rewriting and then the regulation was submitted in February to the legislators for approval and adoption. Because of the construction industries wholehearted support no delays were experienced and the province had a metric building code in force by April 15, 1978.

STATUS OF METRIC ACCEPTANCE IN ALBERTA

The Alberta Construction Association expects that by the end of 1978 over 80% of all new building construction starts in the Province of Alberta will be in SI (metric) terminology. This is far in advance of any other province in Canada and the Alberta Construction Association attributes it to the excellent co-operation between their industry and the provincial government. It is also due to the fact that general contractors are insisting that their suppliers quote on metric products and frequently refuse to do business with suppliers who have not yet converted to metric. The mechanical and electrical contractors have lagged behind but are now catching up.

At the beginning of July the realty companies decided to convert all their listings to metric terminology and the two major mortgage agencies operating in the Province have set September 1, 1978 and January 1, 1979 as dates after which they will not advance financing unless the project is defined and detailed using SI (metric) terminology.

It appears that the target date of January 1, 1980 for complete conversion will be achieved in Alberta with the exception of some alterations to existing privately owned buildings.

CONCLUSION

The lessons we have learnt in Alberta and the regulatory implications you should keep in mind as you are on the threshold of metric measurements are:

1. In a democratic society government must respond to the citizens.

2. The potential users of the metric system must be educated to understand the system and must convince themselves that there are advantages in the system.

3. In converting a building code the dimensions for materials must be established in consultation with the manufacturing industry.

4. Where dimensions in the building code, such as permissible building areas, travel distances and setbacks are of an arbitrary nature and have been established to give convenient values in the foot-pound system they should be rounded off in the metric system to give equally convenient metric values.

5. Unless it can be established that a foot-pound value cannot be relaxed without serious effect upon safety the rounded off metric value should be relaxed and not made more stringent.

6. Where a model code is referenced by local legislation the local authority should not attempt to develop metric values which differ from those of the model code. This implies that the model code agencies must lead the way in preparing documentation.

7. The first time a building code is issued in metric mode equivalent foot-pound values should be retained in close proximity to the metric value because citizens should be given a choice of dimension system until they learn the metric system and because many users of the code will need familiar benchmarks until they understand the magnitudes of unfamiliar units.

8. Good communication and sound educational programmes must precede the introduction of a metric building code so that it can be used and accepted when it becomes law.

AN APPROACH TO THIRD PARTY
APPROVAL FOR INDUSTRIALIZED HOUSING

by

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The Commonwealth of Pennsylvania a few years ago found themselves in a unique position of trying to determine which agenices were qualified to represent the state for the evaluation and inspection of industrialized housing products to be sold in the state. This paper is a summary of the experience of Pennsylvania in this area. The use of Third Party agencies was not created by Pennsylvania, but it is believed that the approach used by Pennsylvania deviated from previous practices at the time.

It is the hope of the writer of this paper that by summarizing the Pennsylvania experience, others will be stimulated to refine the approval process for selection and use of third party agencies.

Key Words: Agencies; approval process; evaluation; industrialized housing products; inspection; regulation; third party.

BACKGROUND

The year of 1972 found Pennsylvania joining the ranks of many other states across the country. It was the year that legislation was passed and signed into law requiring industrialized housing products, including mobile homes, to be regulated at the state level. Unlike many other states that had taken this route, Pennsylvania had very little experience with operating statewide building regulatory programs. In fact, the department assigned the responsibility of administering these programs, had had no previous experience in this area. The result of this inexperience was the need for a long period of research and development. This of course delayed the implementation of the programs.

The word "programs" means two pieces of legislation passed because, while a mobile home is an industrialized housing product, it is built to a different standard from the other products.

This paper does not deal with the total development of the Pennsylvania programs, but instead focuses on one specific phase of development. This paper deals with the third party approval process as utilized in Pennsylvania.

THIRD PARTY DEFINED

Over the past decade, the term third party has become very common among many state and federal building regulatory officials around the country. The term "third party", has taken on special meaning with the growth of industrialized housing as a state regulated industry.

I believe no paper on this subject would be accurate without giving North Carolina credit for their role in the development of this concept. North Carolina was one of the first states to pass legislation requiring the in-factory inspection of industrialized housing products. They quickly recognized that their standard on-site method was not practical. The high volume production of many factories would require the state to have a full-time inspector assigned to them. They also recognized that the units would have to be inspected at the factory because when the homes arrived at the site, much of the work could not be inspected. There was also the problem of factories being located outside of the state's boundaries, but were shipping units into the state for erection. North Carolina resolved their problem by utilizing the service of a large nationally recognized testing laboratory to do the in-plant inspections. The use of this agency can be considered the origin of the third party system of industrialized housing regulation.

THE NEED FOR AN APPROVAL PROCESS

A number of years passed between the time North Carolina initiated their program and the passage of the Pennsylvania legislation. During that time, many of the states started programs and many agencies began to perform third party tasks. The agencies were of a great variety. Some used staffs composed of professional engineers, while others used technicians or a combination of both. Most agencies adopted the state's personality of their initial approval.

When Pennsylvania decided to use the third party approach, they were bombarded with requests for agency approval. This was due to the over one hundred factories located in Pennsylvania. There were also many plants outside of Pennsylvania selling units into the state. Pennsylvania made inquiries to some of the states having third party programs as to what was their method of approval. They found a wide variety of considerations, but the most common practice was to rely on an agency's reputation. To start the Pennnsylvania Mobile Home Program, this was the approach used and a limited number of agencies were approved. However, it was quickly learned that the selection process that had worked in other states would not work in the Commonwealth. Many of the agencies not selected protested the decisions made by Pennsylvania and threatened with law suits.

Pennsylvania was not the only state faced with this problem. The third party's approval process in general was being questioned. With a crisis point near at hand, the states, thru NCS/BCS and the National Bureau of Standards, encouraged the American Society of Testing and Materials (ASTM) to formulate a committee to develop a criteria or standard for the approval of third party agencies.

By the time the first draft of the ASTM standard came off the press, Pennsylvania was in desperate need of an approval system. There was an interim mobile home in operation, but the Pennsylvania Industrialized Housing Program had been delayed for more than two years. Drawing upon the experience gained from the mobile home program and the consulting team that was used to design the industrialized housing program, all elements were in place except the approval process for the third party agencies. This same consulting team was called upon to undertake the problem. They used the ASTM draft as a base and added the necessary Pennsylvania requirements.

INITIAL AGENCY APPROVAL

The consulting team, along with the Pennsylvania staff met to define the steps that would be necessary for approval. The steps agreed are as follows.

1. An application was developed based upon the requirements defined in the Pennsylvania Rules and Regulations. (Sample application shown in figure 1)

2. Each agency was required to complete this application and provide the necessary supporting documentation.

3. The Pennsylvania staff reviewed each agency's submission per a standardized check list. (figure 2)

4. Once all of the data was assembled, the consulting team and the Pennsylvania staff met and developed a standardized interviewing format. (Instruction sheet of guide - figure 3)

5. An interviewing team of state and consultant personnel visited each of the agency's primary offices to interview key personnel identified in the agencies' applications. Visits were made to secondary sites when deemed necessary.

6. Each interviewing team prepared written summaries of their findings, along with the standardized interview format.

7. A meeting of all of the persons was then held at which time all data was reviewed and compared.

8. Each agency that made an application was sent a written critique of their agency's operation, along with recommendations.

9. The agencies that were found acceptable were required to sign a written agreement with the state. This agreement defined the conditions and terms that both parties were expected to adhere to.

The above steps were necessary for the initial approval and a similar process has been used for each year's reapprovals. Presently the process is carried out by state personnel. Figure 4 outlines a typical cycle.

A THIRD PARTY AT WORK

We have discussed the evolution of Pennsylvania's program and its process. At this time a brief review of the work requirements of an agency should be given.

Representing the state, a third party agency has two primary work functions, to evaluate and to inspect. For Pennsylvania, an agency has two primary evaluation activities.

1. Evaluate a manufacturer's product design and all supporting data to insure that it met the building standard requirements.

2. Evaluate a manufacturer's production controls to determine the manufacturer's ability to produce the product as designed.

An agency has two functions to perform through inspection.

1. Inspect a reasonable number of in-production units at the factory to insure that the approved design is being produced.

2. Inspect the production records of the factory for each unit produced. These records should include check-off data as the unit passes through the assembly line.

The agency is required to keep a central record of all the activities defined above with state personnel reviewing the records from time to time.

THE PENNSYLVANIA EXPERIENCE

Before making any suggestions or recommendations as to how other states or federal agencies could use the approval process defined above, I think that some of the findings of the Pennsylvania experience should be discussed.

Looking at some of the more general findings, it was found that:

1. Some of the agencies' written applications drastically differed from the information that was learned during the interviews.

2. Some of the agencies described in their applications how they would like to see their operations run and not how they were actually being run.

3. Some of the agencies used resumes of persons not directly involved in the third party process or activities of the agency.

4. Some of the agencies were not familiar with the requirements of the Pennsylvania program.

While the above comments are somewhat negative, this does not mean that most of the agencies were not trying to do the job to the best of their ability. Most of the problems identified above were the result of a lack of direction being given to the agency by the various states using the agencies, or just basic conflicts in the requirements between the various states. Several agencies made note of the fact that Pennsylvania was the first state that had actually visited their facilities or sat down with them to review the process to be used in carrying out the state's requirements.

Pennsylvania permits the agencies to apply in four different catagories. They were allowed to choose if they would like to be:

1. An Evaluation Agency
    a. Mobile Home
    b. Industrialized Housing

2. An Inspection Agency
    a. Mobile Home
    b. Industrialized Housing

Most agencies elected to be involved in all four areas of third party activities of the state of Pennsylvania.

Eleven applications were made to the state of Pennsylvania for approval as third party agencies. Of these eleven, two agencies were rejected as not meeting the overall requirements of the state. Five of the remaining nine were conditionally approved providing elements of their operations were upgraded during the course of the first year of approval. However, one general limitation was placed on all of the agencies. That is, they were limited to evaluations and inspection to low-rise construction systems. This did not present a major problem since most industrialized housing and mobile homes are single family attached or detached. Some specific problems that surfaced as a result of this review process were:

1. Most agencies did not rely or utilized the manufacturers compliance control program or any of the in-house checks that the manufacturer used to insure that the unit was being built in compliance with the approved design.

2. Agencies did not insist upon the manufacturer maintaining an up-to-date certification package which reflected the current models approved by the agency.

3. Only one agency required that the manufacturer have special trained persons in the design review and inspection process. This agency required that each year a specific designated person from each manufacturing facility that they serviced, attend a training session run by the agency.

4. The frequency of inspection varied from agency to agency. Note Pennsylvania had followed the lead of other states and required that some portion of each major construction area of a unit be inspected during the construction process. This frequency could be varied depending on the degree of inspection performed by the manufacturers themselves. The agencies were asked to make a clear distinction between manufactured facilities where they were required to approve 100% of the production versus those factories which there was only a portion of the units inspected.

5. Most agencies were reviewing the manufacturers' transportation requirements as a part of the design review, but few were conducting an occasional actual check of the transporting process to insure that their approvals or criteria were sufficient to insure that the unit was delivered in a sound condition.

6. Agencies approved manufacturers' erection plans and instructions which showed how a unit was to be installed. However, few were making site visitations to determine if these instructions were feasible, practical or even being carried out.

Other areas of concern by the evaluation team as they reviewed the various agencies was the agency's use of independent consultants and part-time employees in lieu of direct employees of the agency. This was a particular problem with some of the smaller third party agencies.

The major concern was that some of the independent consultants or part-time employees appear to have been involved in the design or inspection process of manufacturers as part of their other businesses. This would present a direct conflict of interest, where they were approving or inspecting products that they themselves had been involved in representing a manufacturer. Another problem of concern was the growth problem of smaller third party agencies. While some of the smaller agencies were doing a very adequate job with a limited number of manufacturers, if the size of their business was to increase drastically, it could greatly effect their ability to perform. It was also a concern that some of the smaller agencies may be effected by the loss of a major client. This could effect their independent judgement with regards to representing a state.

After going through the initial review process of third party agencies, one of Pennsylvania's major concern's was how to measure the performance from year to year of the various agencies. During the review process, a matrix was developed to determine the relative quality of agencies as they compared to each other. This has been utilized in subsequent years to determine improvements or poor performance by agencies. Figure 5 is an outline of this matrix.

The information to be inserted in each block for the respective agencies was developed from an individual sheet which used the same catagories and rated the agency in each catagory from seven points for being perfect and zero points for being hopeless. (See figure 6)

ABOUT THE CONSULTANTS

All through this paper the consultant team has been mentioned as the primary tool of approving the third party agencies used in Pennsylvania. It may be of some concern as to how this consultant group was selected and who were the participants. Because there was no identifiable group with expertise in this area, the consultant team was amalgamated from a number of individuals who had had experience in the industrialized housing regulatory process and with third party agencies. The team was headed by David Falk of a well known law firm in Washington, D.C. Mr. Falk brought not only leadership to the team, but also a vast experience from HUD in industrialized housing, where he had participated in Operation Breakthrough. He was most familiar in the Pennsylvania program since he had been involved in the writing of the rules and regulations for the program and had done extensive research as to what other states had done in this area.

There were two engineers involved in the process, Mr. Charles Hagberg and Mr. John Dunlap. Both of these gentlemen had worked for state agencies involved in industrialized housing regulation. Their activities in these agencies had not been just as engineers but as primary administrators of state's program. After their involvement in two different states as building regulatory officials, both were under contract with the National Bureau of Standards to evaluate various aspects of the industrialized housing regulatory process, including third party agencies. Tyrell Brooke came from a consulting firm based in Washington, D.C. His firm had been involved in a number of building regulatory reviews outside of the industrialized housing arena and he served as a valuable resource for comparison for what was being done in other areas. The state of Pennsylvania was represented by C. Morgan Edwards, who was the Chief Administrator of Industrialized Housing Regulatory Program for the state.

RECOMMENDATIONS

In reviewing the process that was carried by the state of Pennsylvania, one may conclude that the process was rather lengthy and overly involved. But in reaching this conclusion, one must be considered that by the time Pennsylvania entered into the third party regulatory process for industrialized housing, a number of independent engineering firms and other types of agencies were beginning to feel that they could enter the third party business. The more that Pennsylvania investigated the practices in other states, the clearer it became that a precise procedure must be utilized in determining which agencies would qualify and which agencies would not qualify to represent the state in this manner.

In concluding, I would like to make the following recommendations to any state or federal agencies which find themselves in a situation of using third party agencies to carry out the evaluation and/or inspection functions.

1. The ASTM Standard E541-75 should be used as a basic criteria for defining the expectations of an independent agency.

*Note: This is the document discussed earlier in the paper as being in the draft stages when Pennsylvania designed their approval process.

2. A written application should be required, requiring agencies to submit documentation defining their qualifications to participate as a third party agency.

3. Some form of on-sight visitation should be made to verify the application data, as well as observe the agency in operation.

4. A performance system should be designed to determine whether the approved agencies are increasing or decreasing their performance over a given period of time.

5. A re-approval process should be used at least annually to insure that agencies are continuing to carry out performance as originally approved.

DCA 267 (5-74)
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF COMMUNITY AFFAIRS
BUREAU OF HOUSING AND DEVELOPMENT

SUMMARY OF APPLICATION FOR APPROVAL

Date of Application ______

Name and Address of Applicant ______

Branch Office Locations ______

This is an ☐ INITIAL ☐ REAPPROVAL application for:

☐ MOBILE HOMES
☐ Evaluation Agency
☐ Inspection Agency

FEE $ ______

☐ INDUSTRIALIZED HOUSING
☐ Evaluation Agency
☐ Inspection Agency

FEE $ ______

DCA USE ONLY

☐ FEE ENCLOSED TOTAL FEE $

☐ Approved ______ Date

☐ Rejected ______ Date

Application Information is found on page(s):	INFORMATION REQUIRED IN APPLICATION:
	a. the legal character and good standing of the applying person;
	b. the financial strength of the applying person;
	c. the qualifications of the management and technical personnel of the applying person;
	d. the range of salaries and other compensation of the technical personnel (including inspectors) of the applying person, excluding all principals, principal officers, and directors of the applying person;
	e. the policies and procedures of the applying person for the hiring, training and supervision of all technical personnel, including education and training following changes in the codes and standards applicable under these regulations;
	f. the extent, if any, to which the applying person will engage independent consultants and the functions the independent consultants will perform;
	g. the prior experience of the applying person in performing similar or related functions;
	h. the capability, if any, of the applying person to perform testing, including the nature of such testing and the facilities and personnel to perform it, and the identity, facilities, experience, and key personnel of any independent testing agencies with which arrangements have been made for testing services and the nature of such testing services;
	i. the extent, if any, to which the applying person is affiliated with or influenced or controlled by any producer, manufacturer, supplier or vendor of products, supplies or equipment used in industrialized housing or housing components;
	j. the procedures to be used by the applying person in discharging the responsibilities under the regulations of an evaluation agency or inspection agency, as the case may be. An applying person seeking approval as an inspection agency should furnish representative examples of compliance assurance manuals it would use for each type of construction for which is seeks approval, and state its policy with respect to the frequency at which it will conduct inspections of each phase of the manufacture, transportation and installation of industrialized housing, housing components or mobile homes.

FIGURE 1

THIRD PARTY APPLICATION CHECKLIST

FIGURE 2

Agency Name ____________________
Primary Office
Address ____________________
____

Primary Contact
____

Telephone ____________________

ELEMENTS	SUBMITTED	SATISFACTORY
A. Managerial Affiliations		
B. Agency Affiliations		
C. Personnel Affiliations		
D. Personnel Affected by Outside Influence		
A. Articles of Incorporation		
B. By-Laws		
C. Organizational Structure		
D. Stock Ownership		
E. Professional Authority and Liability Responsibility		
F. Staff Qualifications:		
1. Structural		
2. Mechanical		
3. Electrical		
4. Fire Protection		
5. Miscellaneous		
6. Summary of Staff Education		
7. List of Consulting Engineers		
8. Organization Chart		
G. List of Advisory Persons		
H. Evaluation Experience		
I. List of Contracts with Persons Other Than Employees		
A. Description of Evaluation Process		
B. Description of Testing, Analysis, and Recording		
C. Address of Central Records		
D. Two-year Record Maintenance		
E. Methods and Procedures		

INTERVIEW INFORMATION GUIDE FOR INTERVIEWING THIRD-PARTY AGENCIES

APPLYING FOR APPROVAL UNDER PENNSYLVANIA MOBILE HOME

AND INDUSTRIALIZED HOUSING PROGRAMS

Preliminary Instructions:

1. The purpose of the Interview Information Guide is to assure the relevant information is asked of each third-party agency applicant and recorded in an uniform amnner to facilitate comparisons and evaluation. In some instances, I have summarized some of the specific characteristics we are looking for to aid you in your investigation of the agency. Each person participating in the interview should be thoroughly familiar with the agency's written application and with the content of the Interview Information Guide before the interview begins. It will be noted that the information listed in the Interview Information Guide is presented in the order of the listing of the criteria for evaluating third-party agencies in the regulations. However, do not feel that you should restrict your inquiry to matters listed in the Interview Information Guide if other matters seem relevant to the agency's qualifications.

2. At the start of every interview, each third-party agency should be informed that the interview constitutes an integral part of the application and evaluation process. Responses to questions to the agency will become a part of its application and will be placed in the permanent file of the third-party agency maintained by the Department of Community Affairs.

3. After the conclusion of the interview, the interviewer should fill out a new Interview Information Guide which organizes the information gathered during the interview in a more organized manner than is likely to come from notes made during the interview. This should be accomplished as rapidly as possible after the conclusion of the interview while impressions and memories of the conversations remain vivid.

4. A final blank page has been included at the end of each Interview Information Guide. This page may be used to record any additional observations you wish to make about the third-party agency. This page may also be used to record observations if you are able to visit a manufacturer's plant which is serviced by the third-party agency.

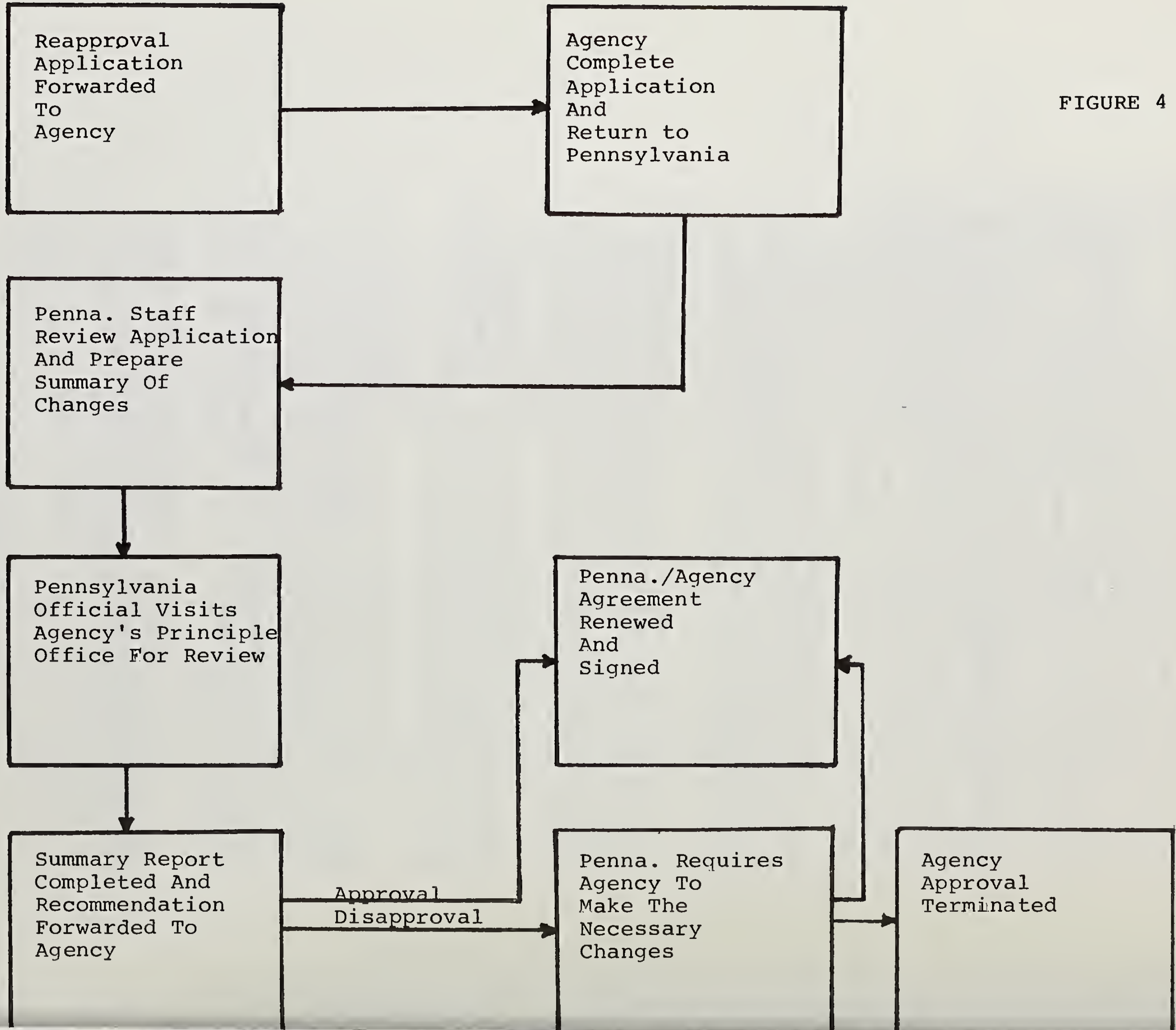
5. Each agency has been asked to furnish, as supplemental information if not included in its earlier application, its latest financial statement, an organizational chart, flow charts, illustrating its procedures in performing as an evaluation and inspection agency, a litigation report and a list of clients representing 20% or more of its gross billings. This information should be made available to you during your interviews, if not previously furnished. The organization chart and flow charts should be particularly helpful to you in gaining an understanding of how the agency is structured and how it operates.

6. Specific numerical references to sections in the regulations are to sections in the regulations for the Industrialized Housing Act. However, a parallel section can be found in the regulations for the Uniform Standards Code for Mobile Homes Act.

July 3, 1974

FIGURE 3

FIGURE 4


Reapproval Application Forwarded To Agency
Agency Complete Application And Return to Pennsylvania
Penna. Staff Review Application And Prepare Summary Of Changes
Pennsylvania Official Visits Agency's Principle Office For Review
Summary Report Completed And Recommendation Forwarded To Agency
Approval
Disapproval
Penna./Agency Agreement Renewed And Signed
Penna. Requires Agency To Make The Necessary Changes
Agency Approval Terminated

THIRD PARTIES - COMPARATIVE RATING

FIGURE 5

Elements of Qualifications	NAMES OF AGENCIES
A. ORGANIZATION CONSIDERATIONS (See Figure 6	
B. EVALUATION AGENCY (See Figure 6	
C. INSPECTION AGENCY (See Figure 6	
TOTAL	
PERCENTAGE	

FIGURE 6

THIRD PARTY RATING

AGENCY NAME:

APPROVED AS:

DATE OF VISIT:

ELEMENTS OF QUALIFICATION	WEIGHTAGE	PERFECT 7	EXCELLENT 6	VERY GOOD 5	GOOD 4	FAIR 3	POOR 2	VERY POOR 1	HOPELESS 0	WEIGHTED SCORE
ORGANIZATION CONSIDERATION										
1. Conflict of Interest										
Manufacturers										
Engineering										
Others										
2. Dependence										
Manufacturers										
Testing Facilities										
Outside Consultants										
3. Litigation										
Direct										
In-Direct										
4. Problem With Other States										
Suspension/Revocation										
Other										
5. Other Considerations										
Consumer Complaints										
Agreement Violation										
Co-operation with Dept.										
EVALUATION AGENCY										
1. Staff										
Manager										
Engineers										
Technicians										
2. Administ. Procedures										
Collection of Data										
Documentation										
Back-Up Services										
Training										
3. Evaluation Review										
Structural										
Electrical										
Mechanical										
Plumbing										
Revisions										
Transport/Instal										
4. Quality Assurance										
Plant Evaluation										
Staff										
Procedures										
Inspection Manual										

FIGURE 6

THIRD PARTY RATING

AGENCY NAME:

APPROVED AS:

DATE OF VISIT:

ELEMENTS OF QUALIFICATION	WEIGHTAGE	PERFECT 7	EXCELLENT 6	VERY GOOD 5	GOOD 4	FAIR 3	POOR 2	VERY FOOR 1	HOPELESS 0	WEIGHTED SCORE
INSPECTION AGENCY										
1. <u>Staff</u>										
Manager										
Supervisors										
Inspectors										
2. <u>Administ. Procedures</u>										
Inspection Reporting										
Analysing										
Testing										
Up-Dating										
Documentation										
Rotation of Staff										
3. <u>Review Inspection Reports</u>										
Check List										
Frequency										
Monitoring										
4. <u>Quality Assurance</u>										
Quality Control Procedures										
Tests/Records										
Site Visits										
5. <u>Seal Controls</u>										
Record Keeping										

STRUCTURAL INSPECTION OF COMPLEX STRUCTURES

by

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Gerald P. Berson, P.E., Chief, Permits and Plan Review, Fairfax County, Va.

This paper provides a look at what a local county government, burdened with the responsibility of inspecting all new construction, has done to insure quality construction, proper inspection and code compliance for large or complex structures, with a minimum of expense to the tax payers.

Key Words: Code enforcement; County Building Code; critical structures program; expense; inspection requirements; pre-construction conference.

INTRODUCTION

On March 2, 1973, a portion of a high rise building under construction collapsed at Bailey's Crossroads, Virginia. Fourteen workmen were killed and forty-three were injured. For two weeks, the national news media focused on the tragedy.

COLLAPSE AT BAILEY'S CROSSROADS, VIRGINIA

COLLAPSE AT BAILEY'S CROSSROADS, VIRGINIA

COLLAPSE AT BAILEY'S CROSSROADS, VIRGINIA

COLLAPSE AT BAILEY'S CROSSROADS, VIRGINIA

During the aftermath, the Fairfax County Government examined its inspection program to determine what could be done to reduce the possibility of future tragedies within the County.

The first alternative open to the County was to write new requirements into the County Building Code and to hire additional inspectors to enforce them. Those who endorsed this alternative advocated at least one inspector full time on every job. The County reviewed this proposal and rejected it because it meant adding too many additional people at a time when the economy was in a recession. And now with the current attention focused on government spending, this decision is still valid. Evaluation of the building codes indicated that they were adequate in their construction and inspection requirements. The County also evaluated the private sector of the architectural and engineering community and found that professionally qualified people were available to perform the required inspection.

The County decided to adopt a mechanism for enforcing the nationally recognized codes to ensure that professionally qualified people were involved during critical construction activities.

The County Board of Supervisors promulgated a policy requiring all critical structural work to be monitored by a professional engineer or registered architect. This could be either the engineer or architect of record or someone acceptable to the County. The Board also stated that these people would control the contractor's activities. This meant that critical activities such as pouring concrete and stripping formwork could not proceed without their approval. Finally, the Board stated that County inspectors would monitor the projects on a random basis to ensure that the operation was satisfactory.

In practice, the procedure works as follows. After the plans have been submitted, the Chief of Plans and Permits reviews them to determine whether or not the design comes within the scope of the critical structures program. If the design does, then the applicant is notified that construction operations must be monitored by a professional engineer or architect.

The scope of the program is defined to include:

- Structures more than six stories or 75 feet in height.
- Structures with unique design features; such as an underground school with radial reinforcing bar patterns.
- Deep foundations, such as drilled piers.
- Large retaining walls.
- Structures with broad expanses of area such as a shopping mall.

After the plan review is complete and the inspection firm has been selected, a pre-construction conference is held. The construction conference includes:

1. The design engineer or architect.

2. The structural superintendent.

3. The general superintendent.

4. The Chief Building Inspector and his personnel, and

5. The engineer or architect responsible for performing the required inspections.

Some of the topics discussed at the pre-construction conference are:

1. Scope of duties for the inspection firm.

2. Rate of testing and the Code requirements involved.

3. The forms that will be used to report and verify progress, and

4. The control features that will be required.

After the conference, the building permit is issued and construction can begin.

During construction the inspection firm submits reports to the design engineer or architect and to the County. For example in reinforced concrete construction, the inspection firm is expected to verify the:

1. Size, number and location of reinforcing bars.

2. The condition of the batch plant.

3. The proportioning of the concrete mix, and

4. The accuracy of form work and shoring.

The inspector is also required to personally observe every concrete pour. The results of this inspection are monitored by a County Inspector who maintains surveillance over 8 to 10 projects to insure everything is progressing satisfactorily.

If an unusual situation arises or if an ambiguity in the plans is discovered, the design engineer or architect of record is called in by the County for a resolution. Once the determination is made, construction resumes.

All reports are required to be certified by the engineer who supervises the inspection and testing effort. At the completion of the critical structures portion of the project, a final report is required. This report must certify that those elements of the building which he inspected have been constructed according to approved plans and all pertinent building codes.

The advantages of the program are obvious:

1. The quality of construction has improved because it has been more closely monitored.

2. The design engineer is more involved in construction. Therefore, he has a better idea of what is happening to his design during construction.

3. Any decisions regarding plan ambiguities are resolved by qualified people, and

4. The inspection agency is backed up by the legal enforcement ability of the County. This insures that any deficiency noted by the inspection agency will be corrected.

Naturally, the program does have costs associated with it, however, they do not appear significant.

Some testing firms have complained because the County allows either the owner or the contractors to contract with them for services. They would like the County to adopt a policy requiring the owner to employ the inspection firm. They feel they have more leverage on the job if the owner hires them. We concur with this thinking but we have not as yet found a way to legally compel such a procedure.

Some designers have been apprehensive about their professional liability if they make inspections. However, several engineering testing firms have willingly entered this arena. The testing laboratories in the Washington area have organized into a self-policing group, (WACEL). A majority of the member firms have worked successfully on large buildings in the County.

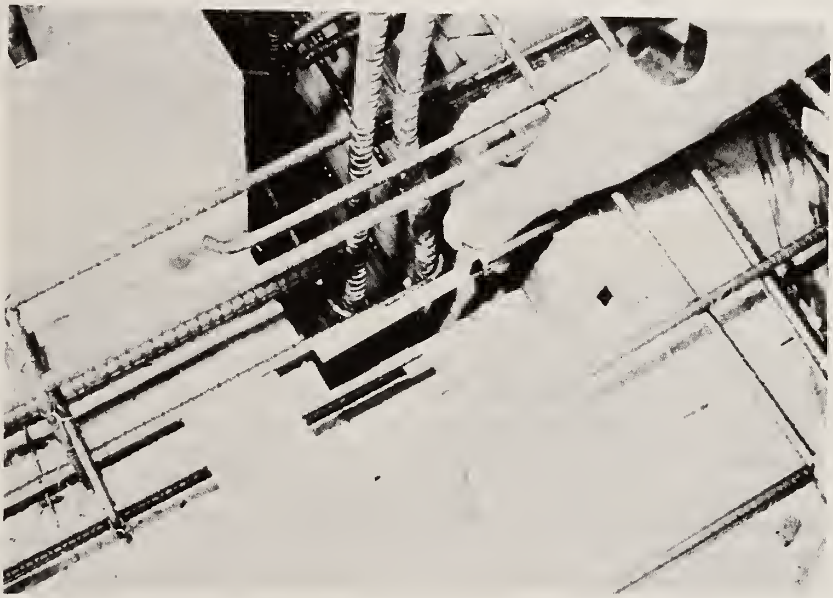
Owners, however, have been quite pleased with this procedure even though it does represent an additional cost for them. For one 10 story condominium apartment building where the average cost of

PRE-CONSTRUCTION CONFERENCE AT THE JOB SITE

A WELL DESIGNED SHORING SYSTEM

TAKING A CORE SAMPLE FROM A CONCRETE SLAB

CHECKING THE SPACING AND
NUMBER OF BARS COULD BE A PROBLEM



CHECKING THE SPACING AND CONCRETE
COVER OVER THE REINFORCEMENT STEEL

a unit was $50,000.00, the cost of complex structures inspection was $50.00 per unit. Another 200 unit apartment building where the average cost of a unit was $78,400.00, the cost of complex structures inspections was $91.00 per unit.

CONCLUSION

Fairfax County's experience indicates that it is possible to insure that Code requirements are satisfied without drastically altering the size of the County staff. This can be done by promulgating procedures that insure professionally qualified people are required to monitor construction and that existing Codes are enforced.

LIGHTING AND BUILDING CODES FOR ENERGY CONSERVATION

by

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and
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The role of lighting within the purpose of building codes is discussed. A review is made of the continuing controversy over the visual performance criteria being used as the basis for IES (Illuminating Engineering Society) recommended levels of illumination. These levels are the present design procedure base levels for the ASHRAE 90-75 and NCSBCS Code for Energy Conservation lighting power budget procedure. The third section of the paper lists the objectives of an energy-conserving building code for lighting and compares the NCSBCS code with a lighting power budget approach recommended for Seattle by the Citizens' Task Force on an Energy-Conserving Building Code, on which the author serves. The final issue discussed is an alternative for the future, a performance standard. Thorough evaluation of lighting alternatives for energy conservation will require detailed analysis, such as computer simulation, that looks at the interaction of the building components and systems. A lighting computer program which has been developed at the University of Washington to predict illumination levels from daylight and from artificial light sources is described briefly, and its inclusion in a larger building performance simulation outlined.

Kay Words: Building codes; building performance simulation; computer applications; energy conservation; illumination standards; lighting distribution simulation; visual performance.

INTRODUCTION

Many states and cities have recently completed, or are in the process of, writing energy-conserving building codes. Due to federal mandate, these standards must match or exceed ASHRAE 90-75 in their potential for saving energy use through building design. In the field of lighting, a controversy has arisen over the proper form that these standards should take. Lowering illumination levels is one of the effective ways to reduce energy consumption for lighting. Since there has been much well-founded criticism of the official Illuminating Engineering Society position that its recommended levels of illumination should be followed, both the background for the setting of these levels and also alternative research approaches are examined. Objectives of a code for energy conservation in lighting are listed, and ASHRAE 90-75 (1) and an approach taken in Seattle (2) are evaluated according to these objectives.

A new approach to building codes is being considered now: a performance code. Some considerations necessary to a performance code for lighting are mentioned. The use of computer programs to simulate building performance and energy use would seem to be necessary to allow use of performance codes and to encourage innovation and accuracy in building design. A computer program, UWLIGHT, which simulates light distribution in rooms from daylight and from artificially-generated light, is described briefly.

BUILDING CODES AND LIGHTING

The stated purpose of building codes is to promote the health, safety, property, and public welfare of the occupants and neighbors of a building. (3) However, it is often difficult to know where to draw the line in assessing health and safety with respect to illumination. It has been stated categorically that no organic damage to the eye or human visual system will result from low levels of illumination. (4) An analogy to hearing is helpful in understanding this concept: we may have to strain to hear a faint noise, but it will not cause damage to our auditory system as loud noises can. Furthermore, with regard to safety, only very low levels of illumination are necessary in order to see well enough to move about safely. An example is a moonlit country scene, where the average illuminance may be around .01 footlamberts, but it is still possible to walk about without aid of a flashlight. In buildings, a minimum level for safety ranges between .5 and 5 footcandles (2,5), although these levels would never be proposed for work areas. In terms of health and safety, then, illumination levels are not a major factor. Design of the building systems to prevent them from collapsing on people or burning needlessly ia an appropriate area of regulation for health and safety of the occupants, as is design for sanitation to prevent the spread of communicable disease.

The performance of the people working or living inside these buildings does not seem to be an appropriate area of regulation for health and safety, however, once the miminum standards have been met. It is well-recognized that illumination levels alone do not account for differences in human visual performance. Factors involved in visual performance beyond illumination level include the quality of the lighting installation; the physical and performance characteristics of the task; the physiology of each person's visual system; and the mental condition of the person with all the many variables that entails. (6,7) Certainly a massive research effort is needed if these variables are to be explored systematically and useful results obtained. Even if such research were to be completed, a word of caution must be entered: lighting is inextricably linked to perception and aesthetic judgment of an environment, and reaction to it is difficult to quantify. Even a brief look at recent buildings will attest to the individuality of design aesthetics. It would be restrictive to legislate lighting in such a way as to narrow available choices within the context of reasonable energy use. It would be helpful to know, however, the physical parameters of "comfortable lighting" just as it is helpful to know ranges of temperature, humidity, and air movement which produce occupant comfort. (8) It is difficult to factor in all of the variables, however. Questions about preferences are now being asked and researched by Prof. John Flynn at the University of Pennsylvania, but it would seem that in the case of lighting this is information for designers, not for codes.

The purpose of energy-conserving building codes is to assure the conservation of energy used in building construction and operation without adversely affecting the health and safety of the occupants. There is ample evidence that the prevalent lighting design practice has resulted in the consumption of proportionately large amounts of a building's energy use, mainly through the provision of high levels of illumination as recommended by the IES. (9,10) These IES recommended levels are the basis for the NCSBCS and ASHRAE 90-75, Section 9 (lighting) energy-conserving codes, which are essentially the same. (1, 11) In effect, all these codes require is that the lighting energy use for all the different parts of a building must be designed using specific tasks for each area and the IES recommended illumination levels for each task. (12,13) Once the design is completed, the projected energy use for that design cannot be exceeded. No energy use limit is actually set; the design procedure could result in an "energy budget" of five watts per square foot for lighting. Although Tao has shown in a recent article (14) that judicious use of ASHRAE 90-75 can result in more energy savings than the energy limits set by North Carolina, Massachusetts, and California codes, he also points out the fact that tasks could be so chosen by the designer to get a higher lighting power budget than needed. Of course we all hope that project designers will follow good practice and not inflate the budget, but the fact is that this method of setting a power budget allows inflation.

VISUAL PERFORMANCE CRITERIA: THE CONTROVERSY OVER ILLUMINATION LEVELS

Major savings in energy use for lighting can be achieved by lowering illumination levels. (2,9,10,15,16) There are many other means, too, such as using efficient light sources and luminaires, dimming, switching, designing for non-uniform lighting levels, and using daylight, all of which have been practiced by some designers for many years. But the relative merits of using these latter measures, versus a combination of these approaches with reduced illumination levels, is a long and continuing controversy. Some of the early and current research work in the area of visual performance and prescribing illumination levels is reviewed here as background for understanding the different approaches and the effect of their results on visual performance and energy consumption for lighting.

There are two opposing schools of thought on the levels of illumination that are necessary for optimal visual performance. One of these schools of thought relies on laboratory tests of human visual performance to obtain data to establish illumination levels. (17,18, 19) The other approach involves testing the total task performance of human subjects in as realistic a work setting as possible. (20,21) In the 1940's, Luckiesh, a proponent of laboratory vision experiments, opposed Tinker, who worked in the other manner. (18,21,22,23) The proposed illumination standards resulting from Tinker's work were lower than those resulting from Luckiesh's, and each criticized the other. Even in the same "school" of visual performance testing, differences in methods lead to different results and implications for establishing lighting standards. For instance, Yonemura et al. (19,24) have set up laboratory experiments investigating parameters of human vision that lead to different conclusions that Blackwell's work (17) which, as the basis for IES recommendations, is explained below. The experiments of Yonemura et al. were conducted at threshold (illumination level at which one can just detect "something") and suprathreshold (range of illumination in which one can definitely see) levels, rather than only at threshold as Blackwell's had been conducted. Their data for threshold visibility corroborated Blackwell's findings, but showed different relationships between task contrast and level of illumination as light levels were raised. In fact, according to Yonemura's work, there seems to be an optimum illumination level for certain types of tasks, and visual performance may even fall off above this level.

There is also a matter of the interpretation of results as well as experimental method. For example, the work of Smith and Rea is sponsored by the Illuminating Engineering Research Institute (IERI) and is cited by them as supporting their recommended illumination levels. (20) This research also forms the basis of Ross and Baruzzini's Federal Energy Administration report which questions the validity of those levels. The situation is complicated. Is the basis for using IES recommended levels of illumination supported and justified by unquestioned evidence solid enough to warrant their use a a prescription for energy-conserving lighting codes at this time? The answer is no. A brief review of the development of current IES recommended levels is given as background for that opinion.

The research work upon which current IES recommendations are based was done by Blackwell and reported in 1959. (17) His work follows the school of thought that bases visual task performance analysis on laboratory experiments. Blackwell investigated visual performance using contrast discrimination as the experimental parameter. The variables that were studied are task luminance, size of the detail to be identified, contrast between task and background, and recognition time. The Blackwell experiments were conducted at threshold visibility and the results extrapolated for application to suprathreshold. The results of Blackwell's work have been presented in the form of a Visibility Level curve relating the task contrast (e.g., the difference in the luminance of the letters on this page to the luminance of the paper) to the luminance of the background of the task material. (25) The "necessary" level of illumination for a certain Visibility Level can be found by figuring the amount of incident illumination needed on the background of known reflectance to achieve the prescribed background luminance. The curve chosen for figuring illumination needed for suprathreshold visibility is the Visual Performance Criterion Function, known as VL8 because it has been displaced up the vertical scale of the graph by a factor of 8 from the curve obtained from experimental data (1.9 to account for conditions of realistic work, 2.78 to account for a moving target, and 1.5 to account for locating the target). (25)

Both the experimental approach and the application of the results have been questioned. Was the design of the experiment really relevant to real-world situations? How much did the isolation of the visual task from other aspects of perception we normally use -- touch, hearing, smell -- affect the visual performance of the subjects? Is the choice of 99% theoretically perfect performance as a parameter a reasonable one, especially in light of the fact that amounts of illumination necessary to raise performance from 95% to 99% accuracy are very large? For example, for a particular task, a 200% increase in illumination would be necessary to achieve a 4% increase in accuracy. Finally, is extrapolation from threshold data to suprathreshold levels by a simple multiplier valid? (24)

The question of the relationship of the Blackwell experimental setup to real-world applications has been investigated by Smith and Rea. (10) The visual task used in Blackwell's experiment was the detection of a luminous disk subtending four minutes of arc to the eye when it was exposed for 1/5 second. Smith and Rea conducted experiments in which subjects were given realistic tasks (reading, check sorting, and proof reading) at levels of illumination ranging from 1 to 450 footcandles. As a result of these experiments and a survey of other research, the FEA report strongly recommends that VL8 be abandoned as the sole indicator for performance with regard to lighting for the following reasons: it is based on visual performance related to only one very difficult task; relating visual performance to the Visibility Level has been shown to vary in ways that are not yet completely understood or predictable (see also 23); results predicted from VL8 do not agree with tests that measure performance; and the use of Visibility Level criteria alone ignores the contribution of other factors such as contrast, size, and performance time, which have been shown to be more effective than raising the level of illumination for improving performance. (29)

Experiments in the area of total task performance are currently being conducted by Smith and Rea. (20,22,26) Their latest work in visual performance as reported by Ross is with numerical recognition, thought to be one of the more difficult visual and cognitive tasks likely to occur in typical office work. Subjects worked at a real task matching columns of numbers under realistic conditions. The conclusions drawn from this experiment are, first, that task performance is improved little, if any, for most office tasks by adding illumination to the task once 20 to 30 footlamberts brightness is achieved. (This brightness is achieved for most tasks in the range of 30 to 50 footcandles incident illumination.) Second, no amount of added illumination to achieve brightnesses in the range of 30 to 150 footlamberts can compensate for task material with poor contrast (such as gray letters, rather than black). Third, performance with poor quality task material such as handwriting (rather than typing) cannot be improved significantly by increasing brightness above 10 footlamberts. And further, no increase above 10 footlamberts can cause significantly improved performance for the older subjects. (22) A recent article by Smith (26) points out that plotting psychophysical data such as the results of these experiments on linear abscissa, as Ross has done, is inaccurate and that the data should be plotted on logarithmic scales for brightness. In either case, analysis of the numbers on the graphs leads to the same conclusion: that above a certain brightness level, inordinately large amounts of additional light (and therefore energy) must be added to achieve very small increments of improvement in visual performance.

Several recent reports have stressed the relationship between illumination levels and productivity with the warning that reduced illumination levels may cause productivity to drop, necessitating longer working hours, and thus more energy expenditure for the same amount of work. But, there are also reports that show no drop-off in measured worker productivity with decreased illumination level. (22) Quantity of light is only one of many factors influencing performance and productivity and may not even be the most effective in improving production. Other approaches can be taken. Improving the quality of the task material (such as using a clean Xerox copy rather than a smudged fifth carbon)has been shown to improve visual performance of a task more effectively than increasing the illumination. (22) Another example comes from China, where people doing embroidery work are required to do eye exercises at certain intervals throughout the day. Several studies conclude that worker productivity is unlikely to fall due to lighting level alone. (22,27)

No agreement has been reached in the professional lighting community regarding the results of the various experimental approaches to establishing illumination guidelines related to human visual performance. There persist several disagreements on means and results. The IES of North America continues extrapolating research results in the line of previous interpretation of Blackwell's work, while reasonable interpretation of the work of Smith and Rea and Yonemura et al. points toward other alternatives. Hopkinson notes (28) that once minimum levels are achieved, the provision of more illumination depends on economics. When we are faced with real problems in the national economy concerning the cost and supply of energy for buildings, lighting included, we may be able to reach an agreement concerning illumination levels and energy use for lighting. A reasonable approach is one suggested by Thornton (29): "The central question before us all in these times is: How little lighting power can be used to illuminate a worker's task without measurably reducing his performance?"

It is difficult to get a true feeling for the elements of the illumination level dabate by reading research results and differing opinions. The most useful information is first-hand experience, and can be acquired very simply by carrying around a light meter for a day to measure the light levels which you experience during a typical day and to compare these measurements with your reaction to the different environments. A simple footcandle meter can probably be borrowed from a local office which deals in lighting products or from a college or university. It is also possible to use a photographic light meter by taking some comparison measurements with it and a footcandle meter and marking a footcandle scale on the photographic light meter. It is important in this exercise to describe first how you respond to the environment you are going to measure: pleasant, unpleasant; cheerful, gloomy; bright, drab; easy to see and work, difficult to see and work; etc. Than take a few measurements. In exercises done by my students, the illumination level in environments rated "good" have varied between 2 footcandles and 8000 footcandles (the latter outdoors). This exercise may convince you better than research results that no unsafe or unhealthy conditions will be forced on the American populace by following codes for lighting which limit energy use and may affect illumination levels. The normal eye adapts well to changing conditions, and the quality of the luminous environment is more important than quantity after minimal needs have been met.

OBJECTIVES OF AN ENERGY-CONSERVING CODE FOR LIGHTING

A reasonable approach to addressing lighting in building codes is one recommended by Ross and Baruzzini, consultants to the Seattle Energy Office, in their work on writing an energy-conserving building code. (2) This approach will be compared with ASHRAE 90-75 in meeting objectives set for this type of code.

Recent work on energy codes for light basically agree on the objectives that lighting standards should meet. These objectives, taken from Ross and Baruzzini's Seattle report, state that lighting codes for energy conservation should:

1. effectively and measurably reduce energy consumption;

2. be simple to understand for both designers and code officials;

3. not restrict the design approach;

4. be equitable and economical for building owners and tenants; and

5. be flexible and amenable to revision.

Each objective will be applied to the NCSBCS approach and to the Seattle approach. Both code methods result in a lighting power budget, the former in watts/square foot of net useable floor area, and the latter expressed in watts/gross square foot of building area.

1. The first objective can be met by simply limiting energy allowable for lighting, making sure that the limit allows good lighting installations. This approach has been used in California, Massachusetts, North Carolina, and Oergon -- with some variation among them -- as well as Seattle. The current California code has lighting power budgets designated for approximately 360 tasks and building types. The North Carolina code uses a single number for all lighting energy limits (3 watts/square foot), Massachusetts sets six use categories (four indoor and two outdoor), and Oregon uses fifteen categories (thirteen indoor and two outdoor).

For the Seattle Energy Code, nine categories of lighting energy use have been identified by Ross and Baruzzini: seven for interior occupancies and two for exterior lighting. Unit Power Budgets for each category have been designated for the most part on the basis of Ross and Baruzzini's studies for the National Bureau of Standards. (See Appendix I, Unit Power Budgets) Their brief survey of Seattle's current energy use for lighting offices and markets showed an average connected lighting load of 5.1 watts/square foot for offices and 6.3 watts/square foot for markets. Obviously the proposed code limits of 1.7 watts/square foot for offices and 2.4 watts/square foot for retail spaces will effectively and measurably reduce energy consumption. As explained in the previous section, the NCSBCS/ASHRAE 90-75 code ensures no such savings. In fact, the lighting section of this code is listed in a recent article as a loophole in the ASHRAE 90-75 code. (30)

2. The second objective, that lighting codes be simple to understand for both designers and code officials, is also met by the Seattle proposal. The lighting power use in a building is simply the total installed watts for lighting divided by the gross floor area. Both figures are calculated as part of standard practice in figuring electrical loads or in figuring building area, making the final calculation check easy. The fact that the lighting energy budget is set by the designer in the NCSBCS approach means that code officials would have to know all the original design assumptions and be able to calculate all the back-up material in order to check out the validity of the budget. Since this back-up material is based on task definition and the entire IES calculation process, code officials would have a lot to learn. In the Seattle and other energy limit approaches, only the numbers need to be verified.

3. The third objective, not to restrict the design process, is addressed by both approaches, but in different ways. The power budget approach of Seattle and others puts no restrictions on design method. Although ASHRAE 90-75 specifies the lighting design process and requires its completion in order to establish the budget, once

established the allowable lighting energy can be used in any way.

4. The fourth objective is that the code be equitable and economical for building owners and tenants. ASHRAE 90-75 fails in this respect due to the wide vicissitudes it allows in setting power budgets. Depending on the design, two buildings of the same size next door to each other with the same operating schedule could easily have lighting energy uses that differ by a ratio of 5 to 1, and the quality of the lower energy-use installation could actually be better. Since owning and operating costs are generally ten times the first costs of a building, cost benefits will continue to accrue where lighting energy use is limited. Although lighting design fees will increase in order to meet fixed power budget limits with good designs, reductions in energy use will return that investment approximately thirty-five times. (2) There will be additional savings through reduced air-conditioning loads since each watt of lighting requires approximately half a watt of air-conditioning. (10) A fixed power budget approach spreads these costs and benefits equally among building owners and tenants. A variable power budget limit, as set by ASHRAE 90-75, does not.

5. The fifth objective, being flexible and amenable to revision, is met easily by the Seattle proposal, since any new definitive research results or other findings can be reviewed by expert consultants, base calculations figured again, and a new unit power budget set. The NCSBCS/ASHRAE 90-75 approach, on the other hand, is based on the entire illuminating engineering process and all its background and assumptions. To alter or revise this procedure would be to change the code. The lighting level recommendation procedure is in fact in the process of revision with the planning of the sixth edition of the Lighting Handbook, scheduled for publication in 1980. This process is necessarily lengthy as it is careful, but it may result in both a new method of recommending lighting standards and higher recommended levels of illumination. The introduction of an energy-conserving code for lighting based on this procedure will not meet the objective of ease of revision. When changes occur in recommended practice, code officials will have to learn the new system in order to review the calculations.

The conclusion to be drawn from this review is that the ASHRAE 90-75 approach meets the third objective while the Seattle approach meets all five objectives. Objectives 2 and 5 are of particular interest to code officials. It seems more economical to pay a recognized expert consultant once to set appropriate and reasonable power budget limits than to have code officials continuously checking lengthy calculations. This checking may even have no bearing on conserving energy since no limits are set by the 90-75 procedure.

The power-limiting approach also serves as an incentive to manufacturers and designers to explore new approaches, since the power budget is set and compliance cannot be avoided by writing one's own budget. In regard to the realistic possibilities of meeting the proposed power budget limits, office and school lighting systems have been installed at 1.5 watts/square foot and .9 watts/square foot, below the recommended 1.7 watts/square foot limit. (2)

ALTERNATIVE FOR THE FUTURE: PERFORMANCE CODE FOR LIGHTING

This report has considered viable code alternatives for immediate implementation. The best alternative for the future, in the author's opinion, is a total building energy budget approach. Also called a performance standard for building design, this approach considers the energy required to provide habitable conditions and occupant comfort within a building in a certain climate zone. Regulations based on this type of criteria would meet all five objectives of an energy-conserving building code for lighting, and it would do it in concert with other building systems. The interface among the various building systems -- building envelope, HVAC, and lighting -- would be most fairly observed under a total energy budget approach, and the most freedom and allowance for innovation would be fostered.

There are currently two national efforts underway to develop codes and standards of this type. One is a HUD-sponsored American Institute of Architects study, and the other is an NBS study. Some preliminary findings of the NBS study have been released (7,31), and it is interesting to consider briefly how the performance approach can be used in building codes for energy conservation in lighting.

Many new factors are added to the usual lighting considerations when they become part of a total building energy budget. The time-dependent nature of use of the lighting system becomes a prominent factor, demanding detailed analysis of duration of use with regard to climate (available daylight), occupancy, and control systems. When considering use of available daylight, large-scale issues such as building orientation must be considered along with building subsystems such as the building envelope. Glazing for daylighting allows added heat loss and heat gain as well as admitting light, so that the thermal balance of the overall building performance must be studied in order to predict the role of that glazing as an overall energy-saver or energy-loser for a particular building. If daylighting can be used to good effect, then the artificial lighting should be designed to supplement it. Interaction of the artificial lighting system with mechanical systems and structural and ceiling systems must also be considered.

This very brief outline serves to give an idea of the inherent complexity in a total building energy budget approach to lighting, its design, and codes about it. The potentials for designing and building truly climate-responsive and energy-conserving buildings is the strength of this approach. However, it will require sophisticated analysis of proposed building designs in order to predict accurately the expected energy-consuming performance of a completed building.

UWLIGHT, a computer program recently developed at the University of Washington by a research team working on energy conservation in building design for the State of Washington, is an example of a resource for analysis of lighting energy use. The program simulates the light distribution in a room resulting from both daylighting and artificial lighting installations. The daylighting component of light distribution in a room is calculated according to the C.I.E. (International Commission on Illumination) concept and definition of the Daylight Factor, which is the ratio of illumination at a given point in a room to that light available outdoors on a horizontal surface from the unobstructed sky. Light from the sky is calculated using two C.I.E. standardized formulas for light distribution, the C.I.E. Standard Overcast Sky and the C.I.E. Standard Clear Sky. Light reflected from obstructions outside the room and reflections among interior room surfaces are also calculated. The artificial lighting component is calculated by a point-by-point method beginning with photometric data about light distribution from the fixture. This data is available from most lighting fixture manufacturers. Interreflections of light within the room from these sources is calculated at the same time as interreflections from daylight sources. Results of the calculations can be expressed in Daylight Factor for daylight sources or in footcandles for both daylight and artificial light sources. (32)

UWLIGHT is intended for use as a design tool, and as such it has been kept separate from a larger building thermal performance simulation program, UWENSOL, developed under the same research project. (8) Use of UWLIGHT in design and building analysis problems is as a preprocessor to UWENSOL. A particular lighting design can be tested and refined by using UWLIGHT. The resulting energy requirements are fed into UWENSOL by adjusting the daily schedule of artificial lighting operation. The effects of daylighting design are evaluated along with the other thermal transfer considerations when the window and skylight data (location, type of glazing, type of shading devices, type of moveable insulation) are entered into the program. The effects of several lighting alternatives and all their details can be analyzed by making runs changing these parameters alone and comparing the resulting total building energy use for a defined period of time.

CONCLUSION

In accordance with the stated purpose of building codes, to promote the health and safety of the populace, it does not seem proper for codes to specify a lighting design procedure as done in ASHRAE 90-75. In view of the facts of the continuing controversy over illumination level and visual performance, it does not seem valid to base energy-conserving codes for lighting on the achievement of lighting levels above 50 footcandles except for special conditions. Evaluating ASHRAE 90-75 and the Seattle approach against objectives for an energy-conserving code for lighting, the Seattle approach is clearly superior. Given the complicated interactions among building subsystems which must be considered in a performance code for energy conservation in lighting, computer simulation seems necessary as a design and analytical tool. A computer simulation program for lighting, UWLIGHT, is described briefly.

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APPENDIX I

LIGHTING POWER BUDGET LIMITS

from

SEATTLE ENERGY CODE (2)

TYPE OF OCCUPANCY	UNIT POWER BUDGET (watts/square foot)[1]
1. Office buildings, libraries, hospitals, clinics, laboratories, police stations, banks, court houses	1.7
2. Retail stores, enclosed shopping areas	2.35
3. School buildings	1.65
4. Museums, art galleries, field houses, gynmasiums, indoor recreational facilities, fire stations, restaurants	1.5
5. Auditoriums, public assembly, passenger terminals, maintenance garages, aircraft hangars	0.5[2]
6. Warehouses, indoor storage	0.7
7. Indoor parking garages	0.2
8. Special Task Requirements: Description	
8a. ____________________	
8b. ____________________	
8c. ____________________	
9. Total Interior Lighting Power Budget (Sum of lines 1 through 8c)	
10. Exterior Power Budget:	
10a. Building perimeter: ___ ft. times 7.5[3]	
10b. Outdoor parking area: ___ ft. times 0.05	
11. Total Building Lighting Power Budget (Sum of lines 9, 10a and 10b)	

(1) Watts, not volt-amperes
(2) Minimum of 1 KW
(3) Include stage lighting or special task lighting in 8.

TAX SHELTER IN CONSTRUCTION: PUBLIC OBJECTIVES AND PRIVATE INCENTIVES

by

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Building as an activity is strongly conditioned by both the taxation system and the building regulatory mechanism. Since both of these systems represent public commitments and funds, it is reasonable to assert that the ensuing consequences should, whenever possible, be mainly in the public interest. The main purpose of the regulatory system is to protect the public by maintaining adequate health and safety standards. An ostensible goal of the incentives as related to building is to further public objectives by encouraging specific activities perceived to be of societal value, which are not adequately covered by a free market situation. It is felt that current tax incentives in building, however, are not always in the public interest, but rather serve private interests instead.

It is felt that some conceptual changes in the building process and pattern of ownership could best combine the intent of the regulatory and taxation systems with public interest objectives. It is suggested that the tax incentives in building could be designed to draw distinctions between those aspects of building which are market-related (and hence in the private interest) and those portions which are health and safety oriented (and hence in the public interest). It is further suggested that tax incentives in building bear a direct relationship to the degree of public utility involved.

The implications of this proposition are examined in the light of increasing economic pressures to produce large quantities of housing efficiently and economically.

The Role of Taxation and Regulatory Systems in the Building Industry

Building is an important segment of the economy: approximately half of all private funds invested each year are placed in construction and real estate projects.

Since construction vies with other forms of investment for capital, some strong incentives are needed to ensure a steady flow of funds into building projects. To attract capital into this segment of the economy the government has increased the actual profitability of investments in the construction sector by a series of tax incentives. These incentives are complemented by a complex regulatory structure or constraint system which controls the activity of building to ensure a modicum of health and safety for the occupants. These incentives and constraints are strongly linked: incentives increase the profitability of investing capital in buildings; constraints increase building costs and consequently reduce profitability. Any new regulations, therefore, have to be associated with the concomitant financial inducements in order not to upset the balance of incentives and constraints.

Incentives

The incentives which account for the huge sums attracted with regularity to construction are closely linked to the American taxation system. Real estate and construction offer one of the prime forms of tax shelter. Investment in these areas allows the investor to take advantage of special tax provisions which, in turn, reduce the total amount of tax liability. These reductions in taxes are, in fact, equivalent to a public subsidy. In 1977, for instance, 10.3 billion dollars were allowed as tax deductions to housing mortgage holders, based on interest payments. This subsidy far exceeds the figure spent yearly on all forms of public housing. In addition, portions of real estate which are non-owner occupied can be depreciated yearly (usually at an even rate over the length of a mortgage). This practice results in further income tax reductions by reverting income tax liability to capital gains tax some time in the future. Not only are capital gains taxes usually lower than income taxes, but it also makes funds available to the owner until such time that the property is sold. The owner, in fact, is borrowing money from the public at no interest. The present high rate of inflation makes this arrangement even more advantageous.

Constraints

Constraints imposed on building take two principal forms: codes and zoning ordinances. Codes regulate the manner in which things are built and tend to be enforced with police power. Their objective is to protect the public from unsafe building practices and to curb excessive uses of energy. Codes maintain basic levels of safety and health by establishing standards that must be met by anything built. Regulations apply, regardless of the purpose of a structure or its public utility. Codes regulate construction in terms of either specified performance levels or prescriptive methods.

Zoning ordinances tend to control what can be built where. They determine the land use, occupancy, bulk, setbacks, height limitations, and land coverage. Any change in either codes or zoning ordinances has a significant impact on the cost and profitability of a building venture. More stringent code requirements usually increase costs, whereas more lenient stipulations reduce initial costs. The introduction of additional code provisions, therefore, tends to be counterbalanced by some financial inducements or tax incentives, in order not to affect the quantity of construction.

The balancing of incentives and constraints in the building industry has become an important aspect of governmental control of the economy. The purposeful channelling of funds into construction through taxation incentives assures a sufficient flow of capital for new projects. The elimination of special tax provisions would siphon off funds into other, more lucrative forms of investment and thus create a necessity for increased public sponsorship of essential building projects, including housing. Under the present scheme, the government's role is restricted to the sponsorship of only those projects which are considered in the public interest and which cannot find private sponsorship. However, many projects, although essential to the functioning of society, are not considered sufficiently profitable by the private sector to warrant private investment without additional inducements. An obvious case in point is the government's sponsorship of various forms of public housing.

THE INCENTIVE SYSTEM: PUBLIC VERSUS PRIVATE INTERESTS

Generally, the regulatory system is not meant to serve as a policy device, either explicitly or implicitly, concerning <u>what</u> is built. Its concern is solely to control <u>how</u> something is built. The role of a policy device for encouraging what is built falls on the shoulders of the taxation system. It is through such mechanisms that building activities perceived to be of some societal value are encouraged.

The taxation and regulatory systems are ostensibly meant to serve the public, however this intention is not always evident in practice. There are inequities in our present incentive system. In the case of housing, the paradoxical nature of tax incentives can be clearly demonstrated. The amount of tax shelter bears a direct relationship to the use of a building: the more the initial price, the more the amount of allowable tax deduction. Thus, two projects of identical size--one designed for the luxury market and one designed for low and moderate income--receive the same degree of financial inducement, despite the fact that the recovery of initial expenditure is faster and more assured in luxury housing. Given a free market situation, the development of luxury housing is incomparably more profitable in terms of return on investment than lower income housing. This situation is further exacerbated by the higher tax incentives associated with the more expensively appointed luxury units. For the same number of units, luxury housing costs considerably more; and this qualifies for a much larger tax deduction. The public is therefore subsidizing a portion of the additional cost required to ensure the market advantage associated with luxury housing. This situation favors not just investment in housing, but investment in luxury housing. Yet, luxury housing is already profitable and does not require the same degree of additional financial inducements as housing built for lower income brackets.

RESTRUCTURING THE INCENTIVE SYSTEM

The basic notion of tax incentives for encouraging activities which are in the public interest, such as the construction of housing, has become an integral part of many basically capitalist economies. It is not the purpose of this paper to broach the subject of the respective merits of political ideologies, but rather to reexamine the present system in terms of its own objectives. It is suggested that improvements within our existing context can be made which further larger societal purposes, by more explicit control of the use of tax incentives. The suggestions to be made are based on the implicit relation that exists between the taxation and regulatory systems as applied to building construction.

Given some of the inequities of the present taxation system, it is suggested that clearer distinctions be made between the aspects of buildings which are safety and health-related and those that are market-related, and that these distinctions be reflected in both the taxation and regulatory mechanisms. Those aspects of a building devoted primarily to health and safety would receive the benefit of continued or even increased governmental incentives, e.g. depreciation allowances or interest deductions, while those responding primarily to the market conditions would either be decreased or eliminated.

Neither the taxation nor regulatory system distinguishes between these widely differing aspects of building, but instead apply incentives blanketly. The end effect is that tax incentives foster the inclusion of items which serve private interests as much as items strictly related to health and safety. The unfortunate consequence is that many building efforts are diverted away from the most socially desirable projects. No distinction is made in the amount of incentive associated with building in relation to the degree of public utility that a structure provides.

In any building some aspects relate directly to assuring the health and safety of building occupants. These aspects include such components as the structure and basic service distribution and subsystems, as well as fire alarms, sprinkler systems, and other safety devices. Most of these components relate to the basic building shell. These components are controlled by building regulations and can be considered to be in the public interest. It can be argued that all other aspects of a building benefit primarily the owner or developer because they respond primarily to market conditions. The appointment of a rentable unit, the facilities, the exterior and interior finishes and the landscaping, all contribute to the profitability of a project and thus ultimately benefit the owner. Generally, the aspects of building that are primarily conditioned by market considerations tend to serve private rather than public interests.

In this context, it seems appropriate to propose two significant differences in the application of tax incentives to building construction. First, it is suggested that only those portions which clearly serve public interests be subject to tax incentives. Market-related aspects of buildings should not benefit from blanket legislation but should instead rely on a reasonable return on investment without governmental inducements. The second notion which is advanced proposes that the degree of public utility and social purpose be reflected in the associated tax incentives. Under this scheme, an attempt would be made to use tax incentives as a compensation mechanism to make up for the lack of profits in some essential, socially desirable building types.

Both these suggestions subscribe to the idea of investment in building for profit. They are, however, critical of the present system which seems inequitable and often not in the best public interest.

METHODS FOR TARGETING TAX INCENTIVES

Having established the principle that a differentiation should be made between those parts of a building dealing with the public interest and those affecting the marketability, a question arises about the feasibility of actually making such distinctions. There appear to be several possible models which can be employed to achieve these ends. Three of the models are briefly outlined below in order to stimulate further discussions about this subject.

The models differ in approach, however they all have the same objective--a more defined targeting of tax incentives. The first model designates a blanket percentage of the building as a function of the building type; the second model is based on the square footage of buildings devoted to health and safety measures; and the third model stipulates a separation by trade of all potentially hazardous and controlled portions of a structure. Obviously the definition of which parts of a building are in the public interest affects the choice of models. Thus, by inference, a description of the model implies a definition of the separation between public and private interests.

Model 1

This approach assumes that the components of a building can be defined to be either mainly market-related, and thus in the private interest, or mainly safety and health-oriented. Proposed buildings would be subjected to an examination of each component for a scientifically determined representative sample of a certain building type. In the case of housing, some initial analyses indicate that approximately sixty percent of construction costs are devoted to components directly or indirectly related to the marketing of the final dwellings. These components make the distinctions in quality between one building and another. The quality of a building, in turn, is reflected in rental and sales levels, thereby directly relating to the interests of the owner. Essentially, the remaining components relating to health and safety are similar for all types of units. Based on information such as this, specific ratios can be established which define the percentage of a building which can typically be considered in the public interest and therefore become the subject of special tax treatment. Thus, for each building type norms would be established which could then be applied to specific building projects for taxation purposes.

The application of this method allots a fixed percentage of the initial construction cost for special tax treatment. As the construction cost varies, so does the proportion of allowable tax deductions.

Model 2

This method is based on a space allowance approach. Space allowances, of course, are an accepted taxation device. In this method analyses are made of different building types with the intent of determining relative square footages of spaces that primarily serve intents of health or safety and those that serve market objectives. Luxury housing, for example, typically has larger space requirements for individual rooms than do low-income units. A space allowance approach would address these market-related differences between various housing types quite directly.

In a typical housing project, corridors, vertical egresses, bathrooms, and kitchens are normally regulated in one way or another by public health and safety measures. It can consequently be argued that they represent the public interest; all other spaces are considered to represent strictly marketing concerns. While somewhat simplistic, distinctions of this type could serve as a feasible basis for establishing space allowances to be used for tax deduction purposes. In a typical housing project, for example, about seventeen percent of the gross square footage of a building is used for corridors and vertical egresses. In addition, minimum space standards are stipulated in standards and regulations for bathroom and kitchen spaces. The combination of both these square footages could be used to arrive at appropriate space allowances.

Since each type of area such as a kitchen, bathroom, or bedroom area costs different amounts per square foot, it would be necessary to make adjustments in order to establish some degree of parity. Since corridors are similar in cost to apartment space, this can be counted as equivalent square footage. The bathroom allowance, because of its higher relative cost, would be counted at, say, four times the rate of normal space. Thus a typical required minimum of 35 square feet for each bathroom becomes a 140 sq. ft. allowance. Similarly, the kitchen areas traditionally cost on the order of three times the amount of non-service space. Thus a 60 sq. ft. kitchen space would be turned into a 180 sq. ft. allowance.

In order to arrive at a total for an apartment building, all of these adjusted allowances would be considered. Thus, typically, for a building consisting of a number of 800 sq. ft. units, approximately 48% could be used for special tax consideration.

The effect of this method is interesting because the allowance tends to be a larger percentage for lower income housing than for luxury housing. It therefore introduces some kind of economic gradient and compensates for higher rentals or sales. The method is also useful, since space figures are far easier to determine than actual construction cost figures.

<u>Model 3</u>

This method is based on an analysis of actual cost breakdowns by trade. The sum of the costs associated with those trades whose activities can directly or indirectly affect the health and well-being of building occupants would form the basis for tax concessions. Thus, typically, the work done on the structure, the plumbing, the electrical and the HVAC can be used for special tax concessions. Actual cost breakdowns into trades varies with each project in direct proportion to the actual cost of a building.

The effect of this type of assessment is to make those portions of a building which typically tend to be controlled by codes and regulations eligible for favored tax treatment. No differentiation is made between buildings built for minimal or luxury standards. For an average housing project, the percentage of health and safety-related portions is approximately 30 percent of the total cost. However, this figure will vary with each building project. The advantage of this model is that allowances are neither set based on averages (see Method 1) nor

Type of Targeting	Assessment	Method	Tax Incentive
Percentage of total building	Fixed proportion of specific building types	Norms assessed according to building types	Percentage of cost
Square footage devoted to health and safety	Variable percentage of gross square footage depending on the deviation from FHA minima	Allowances based on legal minima	Square footage allowance
Differentiation by trade of code determined portions of building	Variable depending on construction cost	Based on cost breakdown by trade	Portion of construction cost

METHODS OF TARGETING TAX INCENTIVES

Type	Benefit	Proposal
Interest deduction	Income tax reduction	no, or only partial, allowance for interest deductions
Depreciation	Transfer of income tax liability to capital gains	Variable rates of depreciation for different portions of a building
Capital gains	Calculated at a fraction of normal income tax	No capital gains tax on public interest portion of buildings

TYPES OF TAX INCENTIVES ASSOCIATED WITH BUILDING legal minimum space requirements (see Method 2), but instead the actual figures for each project provide the basis for assessments.

No matter how assessments are arrived at, they can then be translated into one or several of our present tax shelter possibilities. An amendment of the present interest rate deduction scheme and/or depreciation allowance, as well as a modified capital gains tax formula could be used. The exact method of assessment and the specific translation into non-targeted tax incentives would, of course, have to be worked out in exacting detail and subsequently refined over an extensive period. The choice of methods is therefore not addressed here. Some form of distinction of costs into public and private interests and the adjustment of tax concessions accordingly is indeed possible.

CONCLUSION

The case for a carefully targeted incentive program for stimulating aspects of building, which are deemed in the public interest, has been presented above. The implications of this idea, however, warrant some further observations.

The proposed idea does not question the basic notion of introducing governmental incentives to stimulate private participation in socially desirable ventures. On the contrary, it makes more effective use of public money by directing financial inducements exclusively into areas which correspond to public objectives.

The total level of funding for the public subsidies to building, even after redistribution, may stay at their present level or be adjusted upward or downward. Specific levels of funding are political decisions which are best left in their present arena. However, the specific levels chosen should reflect the need for certain building types which are not adequately addressed by the market.

The most significant implication of a careful implementation of the proposed models is the probability that building activities, which are fully supported by public funds, can be kept to a minimum. Subsidies in terms of tax incentives could make additional building types which are now in the public domain attractive enough for private participation and investment. It thereby discharges a social responsibility by only partial use of public funds by establishing new partnerships between public and private vested interests.

Attracting capital to building, particularly those portions which do not provide competitive returns on investment, is an increasing problem. The choices which present themselves are: an expansion of full public sponsorship, <u>or</u> more carefully targeted incentive programs for private capital. The political and ideological implications of taking either of these alternatives are profound and far-reaching. An expansion of public sponsorship puts an increasing number of buildings in public ownership and thereby saddles society with the ongoing responsibility for the continued maintenance of these projects. Gradually an increasing percentage of buildings will become a public responsibility. This incremental change in the pattern of ownership is compatible with socialist ideologies. A carefully targeted incentive system, on the other hand, reduces public involvement in the production and operation of buildings to an absolute minimum. This will cause an expansion of private ownership rather than a heavier reliance on the public sector. The second option seems to be more in keeping with present national objectives and economic policy.

Inaction or a refusal to enact proposals akin to the models discussed in this paper will gradually increase the amount of public ownership. This seems undesirable unless there is an explicit realignment of economic and ideological objectives. The implementation of a redefined incentive system associated with building therefore becomes a matter of considerable importance and urgency.

RESOURCE ZONING AND LAND USE PLANNING: AN EXAMINATION OF URBAN INFRASTRUCTURES

by

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Buildings cater to the full array of human activities. They are disposed over the landscape in a range of patterns and densities. Each pattern not only designates spatial arrangements of building masses, but also sponsors a series of mostly invisible supply and distribution networks.

Existing infrastructures, particularly in urban areas, tend to be old, badly maintained and often in less than excellent condition. Each network has a maximum carrying capacity which is determined by the type of system and its state of repair. While it is possible to envision far more technologically advanced infrastructure systems than we now possess, the extent of the investment in our current systems is so vast as to mitigate against any radical changes in the forseeable future. Land use policies therefore must more directly begin to face the issue of how best to cope with an infrastructure system of a fixed or even declining quality and capacity.

The capacity of existing infrastructure systems, particularly of water and sewerage, can be a determining factor in imposing density and other land use constraints. Thus, many typical city zoning ordinances are directly or indirectly influenced by the character of the existing infrastructure. Zoning regulations based mainly on these considerations may not, however, be the most socially or economically advantageous.

This paper proposes an approach to land use planning involving the concept of Resource Zoning. This type of zoning draws a clear distinction between ordinances that relate to social goals and those that relate to constraints imposed by the existing infrastructure. It is felt that the idea of Resource Zoning would not only prove valuable in the context of land use planning but could also provide the necessary incentive for the development of innovative practices in the design of service systems for individual buildings.

Introduction

Our society is a highly complex organism. Its fabric is made up of many constituent parts tied together by a plethora of supply and distribution networks. These networks connect disparate parts of our environment into a series of interdependent fabrics. The extent and intricacy of these fabrics tend to bear a direct relationship to the complexity and state of technological advancement of a society. In most of the Western World the connective networks which make up urban infrastructures are of staggering size and complexity. Fuel and water supply, sewage disposal, and other support networks tend to be taken for granted, and are scarcely noticed as separate distribution systems. However, our increasing dependence on centrally organized and controlled systems has reached an unprecedented level during the last few decades.

The addiction of our society to elaborate and complex infrastructures has many consequences. Of particular interest are the effects on current land use patterns and building practices. Conversely, the shifting desirability of land affects the patterns of demand and thus affects the character and location of the networks. The relationship between infrastructure and land use policies has remained surprisingly unexplored by land use planners, building code officials, architects, engineers and others having a professional interest in how the activities of our society are accommodated.

More generally, however, the total reliance of our society on elaborate infrastructures poses some fundamental questions, particularly in view of newly espoused national priorities dealing with the allocation of resources. The physical characteristics of our present infrastructure systems evolved in a context of apparently inexhaustible supplies and resources. All forms of consumption were encouraged, with the result that systems emerged which, by our current standards, often promoted wasteful and thoughtless squandering of limited resources. One of the first serious challenges to the attitude of infinite supplies was posed by the not too distant Arab oil embargo. Ever since, there has been some public awareness of the need for realignment of societal objectives in an age of scarcity. The situation mandates that resource allocation and conservation measures be actively and vigorously pursued. Consequently a systematic examination of infrastructure systems has become an issue of higher priority than ever before.

It is within this general context that this paper begins to critically deal with the relationship between infrastructure, land use patterns and building practices. Suggestions are advanced for land use policies dealing with the problem of how to cope with large, and often deteriorating, infrastructure systems in urban areas. These suggestions are followed by some speculative observations about how resource allocation and management policies might foster innovative practices in the design and construction of individual buildings.

The Historical Development of Infrastructures

Direct public involvement in the establishment of common networks, particularly those that cannot be easily amortized, is a tradition which dates back to the earliest civilizations. Even in Greek and Roman times, elaborate road networks which, parenthetically, often served the dual purpose of channelling sewage, were considered of military importance and therefore in the public domain. Potable water was transported for miles in Roman aqueducts through what appeared to be insurmountable topographical obstacles.

Despite early examples, most important public works and private utility projects are products of the 19th and 20th centuries. In the early 19th century, horse-drawn vehicles still rattled over cobblestoned streets which were strewn with refuse. Sewage was collected in cesspools which were cleaned out at infrequent intervals and therefore added an all-pervading aroma to urban settings. Streets were not lit at night since the only readily available source of lights were individual kerosene and oil lamps. Only water was transported and distributed in coherent networks; and then primarily in a few major urban areas. Water was brought into the houses of the well-to-do; all others had to avail themselves of wells, fountains, and other public water sources.

It was during the same period, however, that the first of a series of key developments occurred which kindled public imagination and made people embrace the development and implementation of particular infrastructure components. The change was brought about primarily by a series of specific inventions coupled with the industrial revolution. The use of coal gas for lighting was shown to work by Lebon around 1800, yet it was not until the construction of a central gas works in London in 1814 that the idea took hold. By mid-century, most English communities sported their own gas works which distributed gas to individual households. The invention and manufacture of gas cooking stoves after 1860 made gas a chief source of domestic power. The technical improvement of gas lights and the reliability of the power supply had a considerable impact on the general pattern of life. Public gas lights illuminated the streets, and thus the sun was no longer the major determinant of waking and sleeping hours.

Water closets, initially invented by Joseph Brainate in 1778, quickly became accepted by the wealthier households. These contraptions emptied into cesspools and, although an improvement over an outhouse, they still produced a considerable stench. It was not until Edwin Chadwick advocated a central sewerage system for London that real improvements could be made. The system, as implemented just over a hundred years ago in London, has remained basically unchanged to this day. Many sections are, in fact, still in operation in their original state. Central sewerage networks soon became accepted in the United States and were systematically installed in all major cities by the turn of the century. Electricity, particularly after Edison's and

Swann's invention of the vacuum light bulb, rapidly gained in popularity. Siemen's invention of the dynamo made the supply of reliable quantities of electricity possible. Soon, electrical power began to supplant gas as the main source of power for lighting. The invention of the telephone and its rapid acceptance towards the end of the 19th century ensnarled households in yet another set of umbilical cords.

The success of steam driven boats spurned the development of the railroads, particularly in the latter half of the 19th century. Travel was made easy, safe, and speedy for masses of travellers; and goods could be reliably transmitted over great distances. The invention of the internal combustion engine made the car a logical replacement for horse and buggy. The industrial production of the motor car soon added another item to the arsenal of things without which present life is unthinkable and impractical. Transportation systems also became an essential part of the distribution chain for supplying heating fuel. Heating systems based on coal and oil developed early and remain popular to this day. These systems tend not to rely on a fixed network, but instead are hauled to their point of usage on waterways, rail and roads in carriers of various sizes.

The rapid development and mass production of machines such as refrigerators, washing machines, dryers, electric irons, and a plethora of appliances and gadgets made our reliance and dependence on centrally run or controlled systems almost complete. At this point, very few of even the most remote rural houses can be considered autonomous, and in cities, even the semi-autonomy of a building is unthinkable and economically unfeasible.

The Demand on Infrastructures

The demands our society places on its infrastructures are staggering. In terms of rough order of magnitude, the average American household now consumes approximately 200,000 gallons of potable water per year, which is used for anything from drinking to flushing toilets. Each household generates an average 160,000 gallons of sewerage per year and discards approximately 8,000 pounds of garbage and solid waste. In addition, a staggering 8,400 KWH of electricity and 1,400 gallons of heating fuel are expended. An average family ingests approximately 4,000 pounds of food, which must be made accessible in nearby shops.

More difficult to measure, but nevertheless present in even the most rudimentary households, is the access to telephone, radio, and television.

Maintaining a constant supply of goods and services to our society is an enormous problem. A temporary breakdown of any one of the systems becomes calamitous even after brief periods, as was amply demonstrated

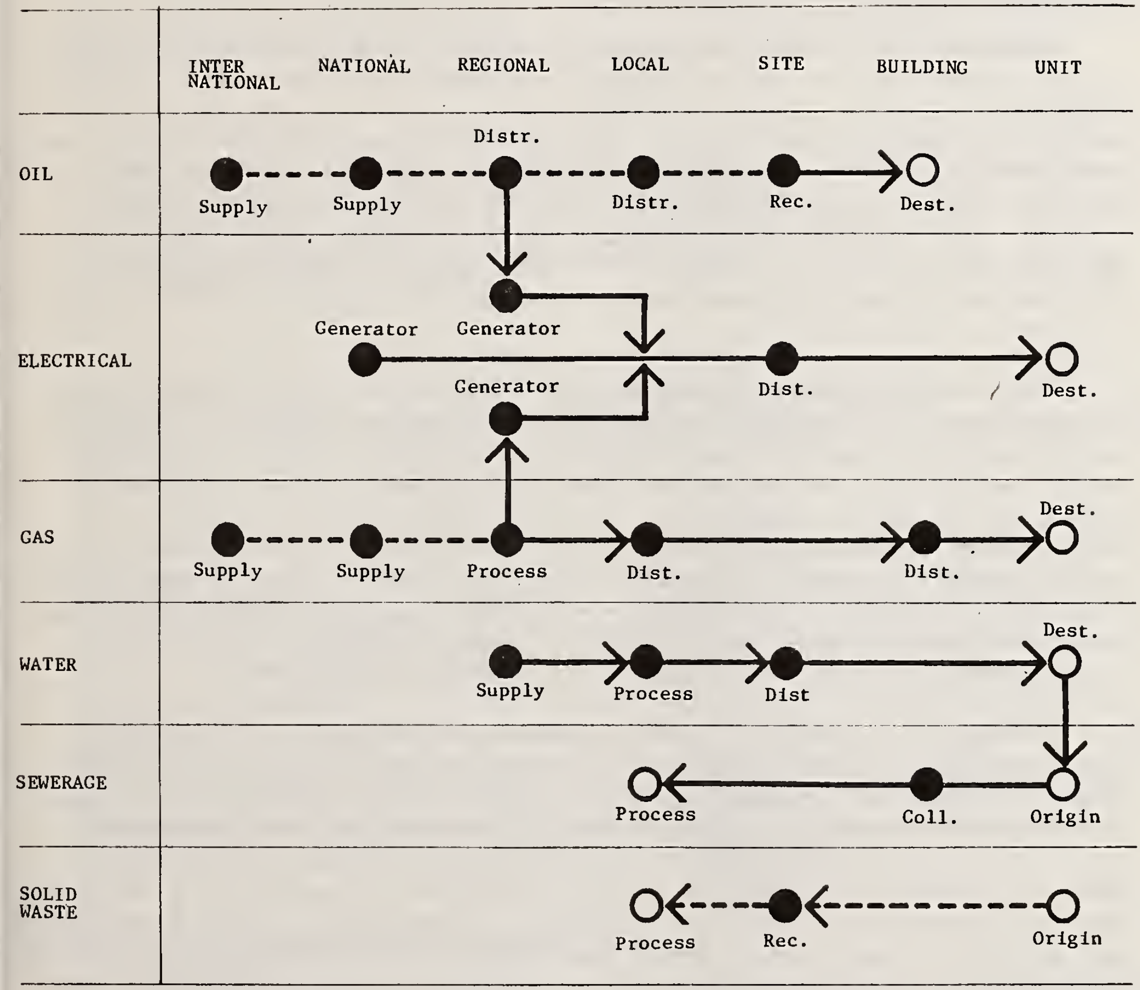

FIGURE 2 SCHEMA OF MAJOR DISTRIBUTION NETWORKS FOR HOUSING.

by the disruptions and civil strife caused by the infamous New York blackouts.

Whether we consciously appreciate the fact, our society and the buildings which house it are completely dependent on the existence and continual functioning of these support systems.

THE STATUS QUO

The Organization of Infrastructures

Generally, metropolitan infrastructures can be divided into three major components with differing characteristics. First there are the distribution systems inside buildings (or intrastructure) which link individual usage points with major public utilities. Thus, in the case of electrical power, regardless of the number and location of power outlets, lights and appliances in a building, all electrical power emanates from a single metered point which, in turn, is connected to the main power supply. Usually, the distribution systems within a building are privately owned and constructed in accordance with applicable codes and regulations.

The second primary infrastructure consists of utility networks or infrastructures which link individual distribution systems with major supply points. There are many interwoven fabrics of this kind which carry commodities such as water, electricity, gas, and telephones to each metering point. Basically these systems consist of a series of interrelated networks which have to be carried over or under the public road network or through easements on private land. These systems tend to be publicly owned, or privately owned but publicly controlled. The sheer size and relative reliability of these systems are one of the unrecognized pillars of our social and economic structure.

The third component of an infrastructure consists of the major central supply or collection points, whether they be power plants, gas works, or sewerage treatment plants. These major facilities also tend to be publicly owned or under publicly controlled private ownership. The size and political clout of these corporations can affect the outcome of political discussions dealing with their operation and control. However, regardless of size or political importance, the major suppliers and producers feed their product into local or regional arterial systems, which through their many capillaries reach every single household (see Figure 1).

A distinguishing feature among the three primary infrastructure components is the relative susceptibility of the different components to change. Of the three components, the local or regional distribution network, which takes utilities from the supplier to each building, is the least susceptible to change. The sheer size of investment in the present systems strongly mitigates against the introduction of new technology which is not directly compatible with the existing networks. New technologies which would demand the replacement of our road networks or existing city-wide sewage disposal networks, for example, are neither practicable nor feasible in existing urban areas.

A further illustration of the importance of investments in this part of the infrastructure is the spectacular financial failure of most American new towns. Much of the failure has been attributed to the inordinately high cost of establishing entire distribution networks from scratch. The staggering costs on a per user basis for new towns gives some indication of what the possible replacement costs for existing infrastructure systems would be.

In contrast, it is evident that at the microscale the distribution system within buildings, or intrastructure, although at present constrained by building codes, could potentially adapt well to technological innovations. Most of the innovations possible in this domain could be incrementally introduced and thus would not require massive investments of public funds.

Similarly, at the macroscale the supply of resources can become subject to technological innovations without affecting the general nature of the infrastructure. The obvious example is electrical power, which can be supplied by any number of generating principles without any impact on the distribution system.

The assertion that some parts of the infrastructure have a built-in resistance to change is further borne out by an examination of present city fabrics. In most cities, the present water distribution and sewerage systems were built around the turn of the century; the basic forms of most electrical distribution systems have remained basically unchanged for half a century; many of the gas lines now in use are of an even earlier vintage; the layout of road networks, except for the interstate highway system, are substantially unchanged since the 19th century; and a preponderance of public transit systems date from the same period as well. Many of these same systems are by now dilapidated or verging on the need of replacement.

The Ownership Patterns of Infrastructures

The ownership of infrastructure components follows an interesting pattern which is dependent on the density and size of projects. In the case of housing, for example, the utility companies tend to deliver to each site or building. Thus comparing typical suburban housing with high density urban housing, interesting differences emerge. In the case of low density suburban housing, the utlity network is brought in close proximity to each dwelling unit; whereas in an urban high-rise structure, the utilities are brought to the site only, leaving the distribution to each individual dwelling unit in private hands.

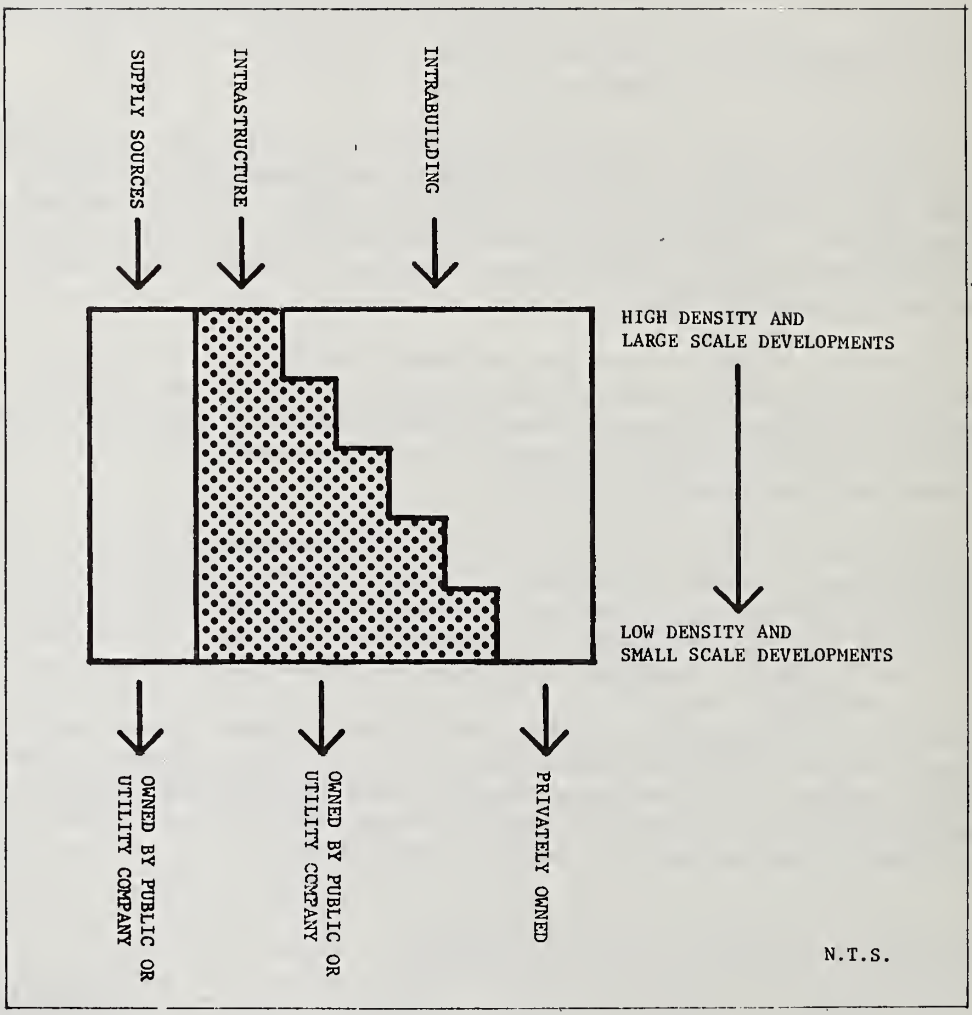

FIGURE 1 OWNERSHIP OF INFRASTRUCTURE IN RELATION TO DENSITY.

In housing of a suburban density, the distribution networks are owned and operated by utility companies. Only the cost of distribution within the unit to each usage point is defrayed by the private owner. The cost of distribution in low density areas is relatively high on a per unit basis, particularly when costs of continual maintenance are considered. In high density urban housing the distribution to each unit within a building is both installed and maintained by the owner, who also bears all costs. The final expenses of the intrabuilding networks are borne by the consumer. There is therefore no parity in the ownership of utility distribution networks at various densities. For higher densities a pattern of ownership emerges which places a relatively larger portion of the distribution networks in private ownership (see Figure 2).

In public or publicly controlled companies, expenditures to expand service or to maintain a network are passed on to the consumer as part of the utility charges. The cost of providing service to a suburban house, both in terms of initial and continued expenditures, obviously far exceeds the costs associated with urban high density housing on a per unit basis. The final effect is an indirect subsidy of public funds for low density privately owned suburban housing. The exact size of the subsidy per unit is dependent on the terrain and building density; however, it often amounts to a sizeable sum, particularly taking into account the ongoing expenses for maintenance.

Since utility costs are assessed on a per unit measure of use, the occupants in high density areas are, in essence, providing a subsidy to occupants in low density areas. This policy is publicly condoned; however, its financial impact is quietly absorbed. The most important aspect of this observation is the decided financial encouragement given to lower densities. If that objective were an explicit piece of a societal restructuring program, then the encouragement and financial inducements for lower density development would be appropriate. In the absence of any specific supporting legislation reflecting agreed upon societal objectives, the unequal distribution of infrastructure installation and maintenance costs is worth pondering about.

It is interesting to note that in some states planned unit developments (P.U.D.'s) are treated much like an apartment complex, i.e. leaving the distribution to each unit in private hands. This reasonable and equitable approach does, however, not extend to all low density suburban areas which are not developed as an entity. The cost of maintaining an extended suburban distribution network far exceeds the costs for similar delivery capacities in high density areas. The continual care and attention demanded by a highly articulated capillary system will become acute when whole distribution systems need to be systematically replaced or significantly overhauled some twenty to fifty years from now. It is likely that these events will usher in a crisis, the porportions of which are hard to contemplate at this point. Not only will the scarcity of resources be a key planning consideration, but the cost and upkeep of the infrastructure system will become equally if not more important.

Infrastructures and Land Use Planning

The symbiotic relationship between the infrastructure and the use of land for construction strongly indicates that the design, installation and management of distribution and delivery systems be an integral part of any land use planning policies. The increasing scarcity of resources and the economic commitment to present channels of distribution strongly favor solutions which make use of the existing infrastructure without overtaxing its capacity. In particular, approaches which are innovative and conserve resources either at the source of production or at the point of usage should be encouraged. The rationale behind most ordinances deals primarily with local objectives. Zoning requirements therefore largely address politically perceived social and economic goals.

Only in rare cases is the capacity of the infrastructure a direct consideration in the development of zoning guidelines. Usually an *ad hoc* approach is taken, in which the effects of each project (in relation to its demands on the infrastructure) are considered on a one-by-one basis. This process does not take adequate account of the additive nature of these incremental changes, with the ensuing result that development patterns emerge which may not be desirable in terms of general societal objectives. As a corollary, vague infrastructure arguments are at times used to dissuade development, without any basis in fact. The ambiguous nature of most analyses of the cumulation effect of zoning changes in relation to the carrying capacity of the infrastructure is a serious impediment to both informed long-term planning and farsighted short-term measures.

RESOURCE ZONING

The Concept

Many of the problems inherent in our current approaches to zoning could potentially be reduced by establishing clearer distinctions between zoning objectives serving social and economic goals and those serving to maintain acceptable demand levels on existing infrastructure systems.

It is therefore suggested that a concept termed Resource Zoning be introduced and become an integral part of zoning procedures. Under this model the quantifiable effects of a project on the infrastructure would become a determinant of the magnitude and type of development. The allowable maxima would be determined in the framework of long-range plans dealing with the conservation or expansion of available resources and with the state of repair and capacity of the infrastructure. Thus, instead of a piecework approach, the effects of the addition or deletion of sources of supply could be properly anticipated and planned. The zoning plan of an area thus would take full account of the necessary infrastructure capacity and monitor the effect of incremental zoning changes to make sure that the existing or proposed systems are properly utilized.

Given a capacity of the infrastructure to deliver services, demands can be balanced through zoning ordinances which increase densities in one area or decrease them in another (and vice versa). Resource zoning measures of this type could be made an explicit part of standard zoning ordinances or form an independent but parallel set of measures to be considered alongside traditional stipulations governed by social and economic considerations. A resource audit of existing infrastructures would by necessity precede the introduction of Resource Zoning. A resource audit would reveal the systems which are critical in determining the overall capacity of the infrastructure to support given densities. Depending on the planning objectives, this audit could give rise to the exploration of new supply sources or act as a limiting factor in determining density levels. The question of whether or not to expand supply sources would be left as a local political decision, as always.

A determination of capacities is an engineering task involving the systematic analysis of each system. The technical limitations, state of repair, and delivery capabilities would have to be taken into account in arriving at optimum operating levels. It should be noted that the optimum operating capacity for some systems is lower than the maximum carrying capacity. The life expectancy and maintenance requirements of systems can be altered drastically by continual intensive use. All these considerations would have to be factored in to determine the separate and joint capacity of the systems which constitute an infrastructure.

Thus the formulation of specific Resource Zoning measures would be preceded by three separate operations: A resource audit, a demand forecast, and a determination of the optimum operating capacities of each system. The critical infrastructure determinants can thus be identified and become the subject of Resource Zoning stipulations. These zoning stipulations would limit the amounts which can be taken out or put into the existing infrastructure in a quantifiable, unambiguous way.

Despite the additional efforts required, planning strategies based on the concept of Resource Zoning would be more apt to avoid unnecessary redundancy and to prevent the precipitation of crippling shortages. The result is more resource-conscious planning and responsible management of the networks which constitute an infrastructure.

An added advantage of this approach is that it necessitates accurate demand forecasting as part of the zoning procedure. This will allow public and private utility companies to prepare in advance for an expansion or rechannelling of supply sources to meet expected demands. In many instances the supply sources do not increase their capacity gradually, but in quantum leaps. Often the construction or exploitation of additional supply sources requires lead time of years, or even decades.

An equally important aspect of Resource Zoning is more subtle in character. Infrastructures consist of many overlapping networks, each responding to its own logic and principles of distribution. Each supplier tends to make separate estimates and projections of need. Rarely do these estimates coincide and almost never do they find an expression in the formulation of zoning mechanisms. Thus different systems within the infrastructure are often designed for varying density levels. Each of these systems is likely to be based on a projected capacity incongruent with the capacities of other systems. As part of a responsible planning effort it seems highly desirable to have all portions of an infrastructure synchronized in terms of their capacity to deliver.

Resource Zoning is potentially most useful if used in parallel with zoning stipulations dealing with social and economic objectives. The primary advantage of Resource Zoning is that critical determinants are made explicit in quantifiable terms which can be understood by building professionals, users, and utility companies alike. It establishes a rational common denominator and provides a framework for the development of enlightened zoning strategies. Obviously, social and economic objectives have to be taken into account as well and in many instances override infrastructure considerations.

Effects on Building Innovation

Resource Zoning, by limiting the demands placed on the infrastructure, would strongly encourage strict conservation measures and technological innovations. The fixed quotas imposed by an infrastructure would not become a finite limitation of building density but instead could encourage the use of systems designed to place less strain on the capacity of central networks. The complete dependence of individual buildings on an infrastructure could give way to partial or even full autonomy of a building or groups of buildings. Thus allowable densities could be increased commensurate with the degree of independence from the infrastructure systems. Allowances for variations in densities and other zoning constraints could thus be made to respond to other social and economic pressures if suitable innovations were introduced to maintain reasonable demands on existing systems.

Technical innovations do exist which substantially extend the use of centrally supplied utilities without imposing any danger to the health and safety of the occupants. One example is the already well-proven Lliliendahl system, which reduces the consumption of fresh water by approximately 40 percent. This device recycles water on the reasonable assumption that the flushing of toilets does not require drinking water. It sets up three parallel systems: one for drinking water (white); one for non-potable water and for flushing, watering, etc. (grey); and unusable waste water (black). By reducing consumption, this idea dramatically increases the utility of a water source without the need for an increased capacity. Similar devices exist for other utility systems and, given sufficient raison d'être, could be mass produced at relatively short notice.

The rewording of codes and other constraining mechanisms could serve as an inducement to innovation without subverting the objectives of safeguarding public interests. The societal and economic costs of not exploring these alternatives seem high, without any apparent benefit other than maintaining the status quo. Given the changing nature of our society and the increasing scarcity of resources, some revisions are becoming inescapable.

Proposed Studies

Further studies are needed to develop the idea of Resource Zoning more fully. To this end a specific country or district could be designated as a study area. A resource audit could be carried out and coupled with a demand forecast and identification of the relative capacities and states-of-repair of each infrastructure system.

Several existing computer-based models could then be used to analyze the network of exisitng systems and their relative demand levels with the objective of determining optimum resource allocation strategies. The TOPAZ* model, for example, is of particular interest. TOPAZ facilitates the manipulation of a variety of interactive functions which are placed in a set of interconnected zones. This model allows the consideration of pattern flow between various zones as determinants in the resource allocation analysis. Given the capability of such a system, various resource zoning strategies could be devised and tested.

Regardless of the mechanism used to determine allocation and distribution of resources, the present condition of infrastructures imposes a state of urgency which requires prompt action at a national and local level. Critical shortages and calamitous breakdowns in key components of our infrastructures, although infrequent now, are likely to increase dramatically over the next decades. Serious studies are therefore called for and can precipitate preventive actions critical to the survival of our civilization.

*TOPAZ is an acronym for Technique for the Optimum Placement of Activities into Zones originally developed by the C.S.I.R.O., Australia.

Summary

Our society is a fragile organism: it is ensnarled in a series of umbilical cords--each essential to its survival. Our dependence on a plethora of systems is a major technological achievement, but it gives rise to some concerns.

An age of scarcity has precipitated some special problems. The access to limited resources and the wisdom with which they are applied become key determinants of societal objectives. The realization of collective aspirations is conditioned by the availability of resources. Therefore, the proper management and use of resources have a critical effect on the standard of living and the prospering of our society.

The magnitude, complexity and age of the systems which constitute an infrastructure make them vulnerable to technical failures. These failures are coupled with an increasing reliance on centrally controlled systems. Thus, we are exposed to the continual threat of major breakdowns and disruption of vital services.

Individual levels of consumption are still steadily rising. The notion of conserving limited resources, although sound in principle, and acceptable as an abstract notion, is far from implementation. The resistance to individual sacrifices has hampered any serious conservation efforts and produced no significant reduction in demand levels.

In this context, some dramatic steps are needed. However, dramatic steps in a democratic society are fraught with difficulty, unless a major crisis can penetrate public apathy and resistance to change.

Resource zoning throws the problem of distribution and allocation of resources into relief at the occasion of each building project. Yet, since Resource Zoning attacks the problem at a local level, it obviates the necessity for stringent national measures. Resource planning and allocation can extend the use of the existing infrastructures without overtaxing present systems. Innovations at the supply and use ends of an infrastructure can reduce the limitations placed on our soceity by finite resources and distribution systems.

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15. SUPPLEMENTARY NOTES

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The third NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process was held in Annapolis, Maryland on September 12, 1978. The proceedings of the Joint Conference include the opening remarks, the Keynote Address and the 24 papers presented at the technical sessions dealing with various aspects of building regulatory research and innovative administrative application of building codes and standards. The eight technical sessions were organized around the following themes:

- o Regulatory Aspects of Fire Safety
- o Standards Development Activities and the Building Regulatory Process
- o Accommodating Provisions for the Elderly and Handicapped in Building Regulations
- o Implementation of Energy Conservation Building Regulations at the State Level
- o Application of Computers and Information Systems for Building Regulation and Construction
- o Energy Conservation, Solar Energy and the Built Environment
- o Issues Concerning the Intent, Formulation and Economic Impact of Regulations
- o Metrication, Industrialized Buildings and Complex Structures

In addition, three other research papers covering Lighting, Tax Shelters, Resource Zoning, and Land Use Planning are also included.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Administrative procedures; buildings; building codes; building regulations; construction; economic impacts; environmental considerations; innovative practices; regulatory research; standards development.

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