building technology publications

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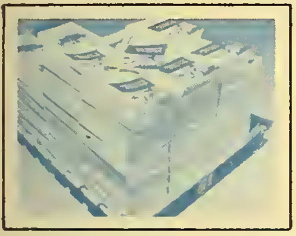
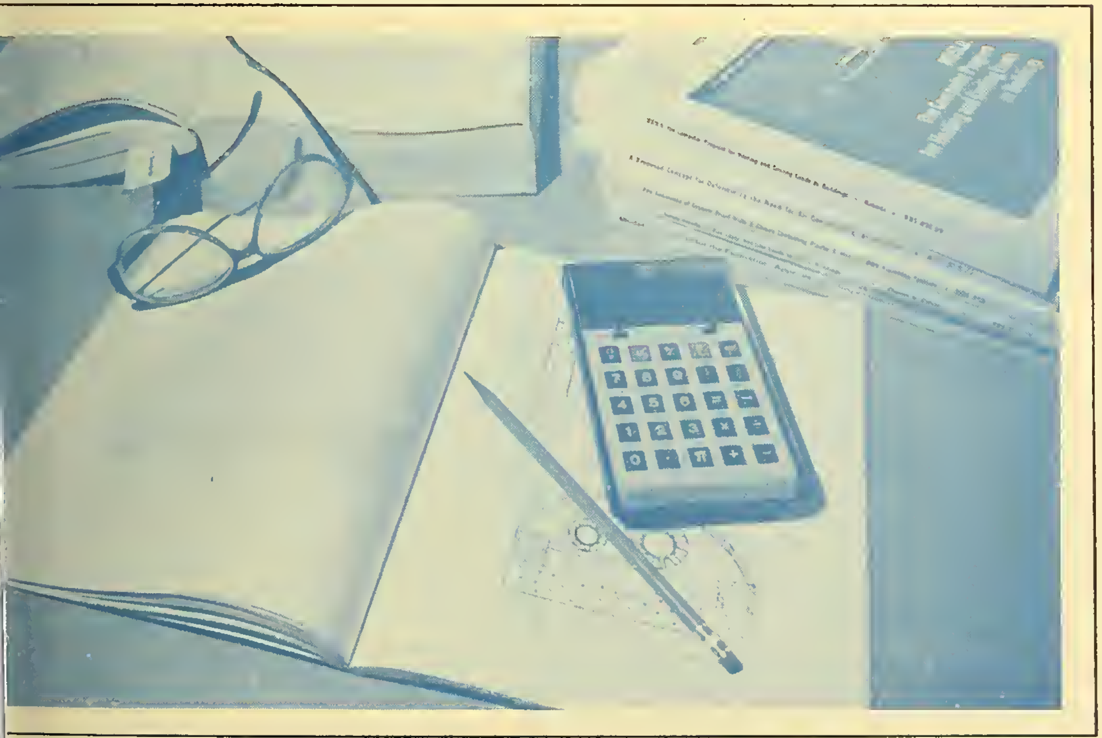
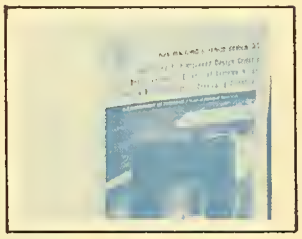
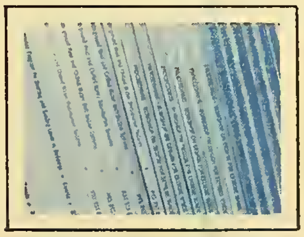
CENTER for BUILDING TECHNOLOGY
Institute for Applied Technology
National Bureau of Standards
Department of Commerce









Introduction

This report presents the National Bureau of Standards' Center for Building Technology (CBT) publications for calendar year 1976. It is the first supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975*, and lists all CBT documents issued during the period from January 1, 1976 to December 31, 1976. It includes titles and abstracts of each NBS publication and papers published in non-NBS media; key word and author indexes; and general information and instructions on how to order CBT publications.

This report provides the means of communicating the results of CBT research to its various technical audiences, as well as to the general public. Publications constitute a major end product of CBT's efforts and, in 1976, appeared in several NBS publication series (Building Science Series, Technical Notes, Special Publications, Handbooks and NBS Interagency Reports) as well as non-NBS published media such as the technical and trade publications. NBS publication abbreviations are:

BSS - Building Science Series

TN - Technical Note

SP - Special Publication

H - Handbook

NBSIR - National Bureau of Standards Interagency Report

This document is divided into three main sections. The first *Titles and Abstracts*, provides report titles, author(s), date of publication, selected key words, and abstracts of NBS technical reports and papers published in outside sources. The *Author Index* cites each CBT author and gives the publication title and/or number of those documents listed in this supplement. The *Key Word Index* is a subject index, listing one-word summaries of the building research topics for each publication and paper. By selecting a main word or subject, which is listed alphabetically, the user is able to locate reports of interest through the subject-related words found in the key word index.

CBT is part of the Institute for Applied Technology, National Bureau of Standards. NBS undertakes basic and applied research in many disciplines other than building technology. Interested readers will find NBS research publications listed in NBS Special Publication 305, *Publications of the National Bureau of Standards* and its supplements, from which parts of this report have been taken.

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Obtaining Publications

Most current CBT publications (excluding *NBS Interagency Reports)* are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Microfiche and paper copies of most CBT publications may be ordered through the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Two other sources are the Department of Commerce field offices and libraries designated to receive government publications. The current price list and availability of publications listed in this report are given in Appendix C.

Department of Commerce Field Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access at the local level, to publications, statistical statements, and surveys. Each Field Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office. These offices make available for local purchase a wide range of Government publications. The reference library maintained by each Field Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

The libraries listed in Appendix A are designated depositories for Government publications and are now receiving selected publication series of the National Bureau of Standards for general reference use. While every Government publication cannot be sent to all depository libraries, certain designated Regional libraries are required to receive and retain one copy of all Government publications made available either in printed or microfiche form. To obtain information on which publications are available, please contact the depository library in your area.

The Photoduplication Service, Library of Congress, Washington, D.C. 20540, makes photoduplicates of material in its collections for research use. National Bureau of Standards publications are on file at the library, so that copies of any Bureau document that is out of print usually can be obtained. Full information concerning this service may be secured by writing to the Library of Congress at the address noted above. In making such inquiry, it is important to give an accurate and complete identification whenever possible (author, title, place of publication, name of series and number, if known) of the document desired.

Contents

Titles and Abstracts

The Center for Building Technology is part of the NBS Campus at Gaithersburg, Maryland. Its 6,500 m² (69,500 ft²) includes office space as well as the Center's unique and specialized laboratories.

Building Science Series reports disseminate technical information developed at the Center on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

BSS69. **NBSLD, the computer program for heating and cooling loads in buildings,** T. Kusuda, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 69*, 398 pages (July 1976) SD Catalog No. C13.29/2:69.

Key words: ASHRAE task group on energy requirements; conduction transfer functions; heating and cooling load; National Bureau of Standards heating and cooling load computer program.

A comprehensive computer program called NBSLD, the National Bureau of Standards Load Determination program, has been developed at NBS to reflect the time change of the many building parameters which are pertinent to accurate estimation of energy usage for heating and cooling. Current status of heating and cooling load techniques is reviewed. Of general interest are unique features of NBSLD which are not available in existing computer programs. A summary of various subroutines of NBSLD is given along with the detailed procedures for them. These subroutines constitute the recommended subroutine algorithms of the ASHRAE Task Group on Energy Requirements. Complete Fortran listing of NBSLD and data preparation forms are given for those who wish to use the program. The NBSLD computation is on the basis of the detailed solution of simultaneous heat balance equations at all the interior surfaces of a room or space. Transient heat conduction through exterior walls and the interior structures is handled by using conduction transfer functions. The use of heat balance equations, although time-consuming in calculation, can avoid the vagueness and uncertainties inherent in the more popularly used weighting factor approach. In addition, it is more accurate for a specific building design.

BSS73. **Structural performance of masonry walls under compression and flexure,** S. G. Fattal and L. E. Cattaneo, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 73*, 65 pages (June 1976) SD Catalog No. C13.29/2:73.

Key words: brick; buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls.

Ninety-five prisms and fifty-six walls of brick, concrete block and composite brick and block masonry construction were tested under various combinations of compressive and transverse loads. Constitutive relations for masonry are developed from test results. By using rational analysis it is shown that prism strength can be predicted on the basis of linear behavior at failure. It is also shown that wall strength can be predicted on the basis of prism strength when an appropriate allowance is made for the effect of wall slenderness on sectional capacity.

BSS76. **Analysis of reinforced concrete beams subjected to fire,** B. Ellingwood and J. R. Shaver, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 76*, 83 pages (July 1976) SD Catalog No. C13.29/2:76.

Key words: creep; fire endurance; fire tests; reinforced concrete; sensitivity analysis; steel; structural mechanics; uncertainty.

Methods for analytically predicting the behavior of simply supported reinforced concrete beams subjected to fire are presented. This is generally a two-step process involving a thermal analysis followed by a stress analysis. This study emphasizes the latter, wherein the determination of moment-curvature-time relationships for the beam cross section incorporates the temperature-dependent strength degradation in the steel and concrete as well as thermal and creep strains. The sensitivity of the predictions to various phases of analytical modeling is investigated to establish the parameters most important for the prediction of beam behavior and to indicate where additional data should be gathered. A comparison of predicted behavior with that observed in fire tests shows excellent agreement when realistic reinforcement temperature histories are used.

BSS80. **Safety during construction of concrete buildings—A status report,** H. S. Lew, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 80*, 56 pages (Jan. 1976) SD Catalog No. C13.29/2:80.

Key words: building; codes; concrete; construction; falsework; formwork; loads; reshoring; safety; shoring; standards.

The current state-of-the-art of safety in concrete building construction is reviewed and summarized. The material presented considers only the technical aspects of the construction safety. Safety of the individual in using equipment and in following construction procedures is not included in this study.

The report presents comparative accident frequencies in concrete construction. Based on reported construction failures, the relative vulnerability of various categories of concrete construction is estimated. The report examines causes of construction failures and reviews major regulatory standards at the federal, state, city and industry level affecting safety in concrete construction.

The factors which affect safety in concrete construction are examined relative to the state-of-the-knowledge and, where appropriate, recommendations are made for areas needing improved standards.

BSS81. **Survey of ground fault circuit interrupter usage for protection against hazardous shock,** R. W. Beausoliel and W. J. Meese, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 81*, 19 pages (Mar. 1976) SD Catalog No. C13.29/2:81.

Key words: branch circuit protection; electrical safety; electric shock; ground fault; leakage current; prevention of electrocution.

The ground fault circuit interrupter (GFCI) is increasingly becoming an integral part of building electrical systems to protect human life. Building researchers, designers, and contractors should have a working knowledge of their purpose and operational characteristics. This report describes the functional principles of GFCIs and relates their performance to effects of electric current on the human body. Information concerning the history, research and testing, installation practices, fire protection aspects, types, manufacturers and costs of GFCIs are included. The trend of requiring installation of GFCIs on more and more electrical circuits by regulatory authorities for safety purposes is outlined. Controversies concerning feasibility, reliability, nuisance tripping and other problems are discussed; laboratory and field investigations addressing these problems should be undertaken.

Permanent installations of GFCIs are being made in new residential and other construction, but very few are being installed in older buildings. The rationale for this needs to be examined. Because of higher leakage currents probable in most older construction, GFCIs manufactured under present standards may not be feasible in older buildings.

BSS82. **A new look at the research basis for lighting level recommendations,** G. T. Yonemura and Y. Kohayakawa, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 82,* 13 pages (Mar. 1976) SD Catalog No. C13.29/2:82.

Key words: gratings; illuminating engineering; lighting; modulation transfer function; suprathreshold visibility; visibility; vision.

The validity of using threshold studies as the basis for lighting level recommendations is questioned. The performance of the eye at suprathreshold levels was investigated with sine- and square-wave gratings. The results of the study indicate that the behavior of the eye is significantly different at suprathreshold levels as opposed to threshold levels. For threshold studies, when contrast is plotted against luminance, the function is a monotonically decreasing function. At suprathreshold levels the function indicates the existence of a definite minimum, luminances greater or less requiring more contrast to appear subjectively equal. It is recommended that lighting levels be based on laboratory studies that appraise visual requirements and performance simulating conditions encountered in real world environments.

BSS83. **Polymer impregnated hardened cement pastes and mortars,** J. R. Clifton, J. E. Fearn, and E. D. Anderson, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 83,* 21 pages (Apr. 1976) SD Catalog No. C13.29/2:83.

Key words: cement; compressive strength; flexural strength; fracture mechanics; polymer impregnated cement; polymer impregnated mortar; porosity; scanning electron microscopy.

Polymer impregnated hardened cement pastes and mortars have been prepared and their properties compared to those of control specimens. Specimens were made by impregnating dried and evacuated precast hardened cement pastes and mortars with methyl methacrylate, under pressure, which was thermally polymerized. The effects of the microstructure of the cement pastes and mortars on the performance of polymer impregnated mortars were determined by preparing specimens with a wide range of porosities by varying the water to cement ratio and the curing times prior to impregnation.

The properties of impregnated and control specimens were investigated by: scanning electron microscopy; porosity determinations; fracture mechanics studies; and strength determinations. The polymer impregnated materials had compressive and flexural strengths, moduli of elasticity, and fracture toughnesses which were substantially higher than unimpregnated materials.

BSS85. **Survey results for fire loads and live loads in office buildings,** C. G. Culver, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 85,* 157 pages (May 1976) SD Catalog No. C13.29/2:85.

Key words: buildings; fire loads; load surveys; occupancy live loads; structural engineering.

Fire load and live load data obtained from a survey of 23 office buildings located in various regions throughout the United States are presented. The survey design is described including the characteristics of the building population used to select the sample. Data are presented on the magnitude and distribution of the loads. Information is also included on the characteristics of office loads such as the type of items (furniture, equipment, etc.) and their properties (material type, dimensions, exposure, etc.). Statistical summaries of the data and a determination of the building and occupancy characteristics affecting these loads are presented. The data do not indicate any significant differences between the loads in private and government buildings. Similarly, geographic location, building height, and building age were not found to have a significant influence on load magnitude. The use of the rooms surveyed, however, did affect load magnitude. A mathematical model developed from a regression analysis of the survey data is presented for calculating fire loads and live loads in offices. The data presented may be used to evaluate current requirements for design loads for buildings.

BSS86. **Engineering aspects of Cyclone Tracy, Darwin, Australia, 1974,** R. D. Marshall, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 86,* 39 pages (June 1976) SD Catalog No. C13.29/2:86.

Key words: buildings; cyclones; disasters; structural engineering; tides; wind.

During the early morning hours of December 25, 1974, the city of Darwin was devastated by the most damaging cyclone ever to strike the Australian Continent. Winds of up to 75 m/s caused extensive damage to housing in particular, requiring the evacuation of approximately half of the 45,000 residents to other major cities in Australia. This report is a result of the author spending several days on temporary assignment with the Department of Housing and Construction – Australian Government to inspect the damage, and to participate in discussions regarding the establishment of new design criteria and construction practices for cyclone areas. The fact that most of the damage was caused by wind forces rather than a combination of wind and storm surge greatly simplified the assessment of damage and structural performance. The experience at Darwin points out the danger in depending too heavily upon past experience and intuition in the design of housing. It also makes clear the need for additional research into the behavior of certain building materials under repeated loads and missile impact, and the racking strength of walls subjected to uplift loads.

BSS87. **Model documents for the evaluation, approval, and inspection of manufactured buildings,** P. W. Cooke, R. D. Dikkers, H. R. Trechsel, H. K. Tejuja, and L. P. Zelenka, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 87,* 296 pages (July 1976) SD Catalog No. C13.29/2:87.

Key words: building codes; certification; compliance assurance; evaluation; inspection; manufactured building; model documents; NCSBCS; standards; state regulation.

To assist the states in developing their building regulatory activities and functions, the Coordinated Evaluation System (CES) Project has defined and developed model informational documentation pertaining to the functional areas of (1) data submission, (2) evaluation, (3) approval, (4) compliance assurance, and (5) installation data.

This report gives the results of the project's investigations and presents sample model documents pertaining to manufactured buildings and building components. The model documentation is based on the Model Rules and Regulations for manufactured buildings developed by a Department of Commerce sponsored working task group, and the results of a comprehensive state-of-the-art study of most state building regulatory programs. The documentation presented covers all functional areas except owner information which is not usually subject to regulation. Emphasis was placed on developing documentation applicable primarily to one and two family detached dwellings.

BSS88. **Energy conservation in buildings – A human factors/systems viewpoint,** A. I. Rubin, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 88,* 19 pages (Nov. 1976) SD Catalog No. C13.29/2:88.

Key words: energy conservation; human factors; people in buildings.

The current emphasis on energy conservation in buildings must be balanced by a careful consideration of how proposed approaches affect building occupants. A head-long rush toward building designs which conserve energy at the expense of the quality of buildings as judged by occupants, would be a very shortsighted approach. There must be a continual awareness and sensitivity of the consequences on people when selecting among alternative "technical" options designed as a result of energy conservation needs. We need an increasing understanding of such factors as thermal comfort and illumination needs in buildings, as decisions likely to influence these requirements are made by designers.

Another area of concern which should not be overlooked is the interactions of people with their environments. "Hardware" approaches to energy conservation problems are often defeated by building occupants. Tight seals around doors and windows are useless if doors and windows are kept open. Building occupants have no choice but to turn all of the lights on or off if these are the only control options available to them. Building managers, operators and occupants have an important, though not well understood role to play in any energy conservation program. This problem deserves serious attention.

BSS89. **The incidence of abnormal loading in residential buildings,** E. V. Leyendecker and E. F. P. Burnett, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 89, 10 pages (Sept. 1976) SD Catalog No. C13.29/2:89.*

Key words: bombs; building codes; design criteria; explosions; gas; hazardous materials; loads; progressive collapse; sonic boom; vehicular collision.

The findings of an analysis of available U.S. statistics concerning the incidence of abnormal loading events in residential buildings are presented. The study evaluates natural gas explosions, bomb explosions, motor vehicle collision, sonic boom aircraft collision, and explosion of hazardous materials.

It is concluded that the gas related explosion, bomb explosion, and vehicular collision are of significance in building design for progressive collapse. Of these, the natural gas explosion is the most significant in terms of incidence. The gas explosion causing severe damage occurs with an annual frequency of 1.6 per million dwelling units and approaches a probability of 1×10^{-3} per apartment building per year.

BSS90. **The structure of building specifications,** S. J. Fenves, K. Rankin, and H. K. Tejuja, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 90,* 83 pages (Sept. 1976) SD Catalog No. C13.29/2:90.

Key words: building code provisions; building codes; building component classification; building specifications; building standards; performance concept.

This paper provides a scientific basis for the formulation and expression of performance standards and specifications and for explicit attention to performance in procedural and prescriptive standards and specifications.

The provisions of the NBS-developed *Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings,* a performance specification, are classified in terms of the physical entities addressed, the attributes of the built environment, and the properties which group together particular physical entities which may be subject to similar dysfunctions. These provisions are also subjected to a linguistic analysis which examines in detail the wording used and formalizes certain key concepts which are realized in the wording.

The provisions of the *Uniform Plumbing Code,* a prescriptive code, are classified in terms of the physical entities addressed and the performance attributes which can be inferred (though they are not explicitly addressed).

Guidelines for the expression of provisions in performance codes and specifications are presented. These guidelines are based on the classification studies and the linguistic analysis mentioned above.

BSS91. **The development of an improved test for evaluating the racking resistance of wall panels,** C. W. C. Yancey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 91,* 75 pages (Nov. 1976) SD Catalog No. C13.29/2:91.

Key words: lateral loads; loading rate; racking; test method; vertical loads; wall panels; walls.

An experimental investigation of the primary factors involved in the laboratory testing of prototype wall panels, under simulated wind-induced racking loads, is reported. The objective of the investigation was to recommend a static racking test method, generally applicable to a variety of wall construction types, that features realistic boundary and loading conditions. Initially, a literature survey was conducted for the purpose of evaluating the test methods which have been, or are being employed in determining the resistance of wall panels to static racking loads. In the experimental program, 17 exploratory tests were conducted on a sample comprised of two types of wall panel construction. The 8 ft by 8 ft steel-frame and wood-frame panels were subjected to a combination of vertical and horizontal loading and their resulting deformation behavior was systematically monitored. Modifications to the testing procedure and to the boundary condition at the top of the panels were introduced as the experiments progressed. Detailed descriptions of the laboratory procedures used are presented. As the tests were developmental in nature and not intended for performance evaluation of the types of construction, selected results are presented. A static racking test method, applicable to traditional and innovative wall construction was derived as a result of the laboratory study and the literature survey. The principal new features of the proposed standard method are: (a) the application of distributed vertical loading, (b) the capability of testing panels of various height-to-width ratios and (c) the provision of top and bottom boundary conditions which do not force unrealistic modes of failure.

BSS92. **The viscosities of roofing asphalts at application temperatures,** W. J. Rossiter, Jr., and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 92,* 44 pages (Nov. 1976) SD Catalog No. C13.29/2:92.

Key words: application temperature; asphalt; built-up roofing; interply thickness; roofing membranes; viscosity.

The optimum range of viscosity over which hot asphalt should be applied in the fabrication of built-up roofing membranes was determined to be 50 to 150 centistokes (mm^2/s). This viscosity range was based on the relationship between interply thickness and application temperature of asphalt obtained from roofing membrane specimens fabricated in the field. Because laboratory measurements showed a wide range of viscosities for roofing asphalts of the same type over their application temperature ranges, it was recommended that asphalts be applied at temperatures based on viscosity and not empirically determined temperature limits. In practice, the viscosity-temperature relationship should be determined for each roofing asphalt for the application temperature range prior to use. Using this relationship and the optimum viscosity range, the temperature range for applying each asphalt can be determined.

TECHNICAL NOTES

Technical Notes present data which are complete in themselves but are not as comprehensive in scope or as definitive in treatment of the subjects as reported in Building Science Series.

TN859. **Literature search: Law enforcement facilities—planning, design, construction,** R. Kapsch and J. Stroik, Eds., *Nat. Bur. Stand. (U.S.), Tech. Note 859*, 221 pages (Nov. 1975) SD Catalog No. C13.46:859.

Key words: architecture; bibliography; building; construction; design; law enforcement facilities.

Citations and abstracts are provided on literature concerning the planning, design, and construction of law enforcement facilities in the United States and in foreign countries. In addition, plans of 21 select law enforcement facilities are included.

TN895. **An overview of floor slip-resistance research with annotated bibliography,** R. J. Brungraber, *Nat. Bur. Stand. (U.S.), Tech. Note 895*, 113 pages (Jan. 1976) SD Catalog No. C13.46:895.

Key words: building safety; floor surface friction; occupancy safety; slip-resistance; slip-resistance testers; walking friction.

Slips and falls in the home as well as in public buildings have reached serious proportions (8,000,000 accidents per year in the home, resulting in 9,600 deaths and 1,600,000 disabling injuries). This paper reviews the literature relating to this problem. Based on studies of kinesiology and anthropometry, the coefficient of friction between foot surfaces and floor surfaces is found to be a significant parameter controlling slips and falls. A review of the general study of friction and a critical appraisal of methods for determining the coefficient of friction on slip-resistance of floors leads to a guide for selection of slip-resistance criteria. The paper concludes with a discussion of the legal aspects of the problem and the present status of slip-resistance specifications.

TN898. **A prototype semi-automated system for measuring air infiltration in buildings using sulfur hexafluoride as a tracer,** C. M. Hunt and S. J. Treado, *Nat. Bur. Stand. (U.S.), Tech. Note 898*, 24 pages (Mar. 1976) SD Catalog No. C13.46:898.

Key words: air infiltration instrumentation; air infiltration measurement; building ventilation rates; sulfur hexafluoride tracer.

A system is described which automatically operates a small gas chromatograph and measures parts per billion concentrations of sulfur hexafluoride (SF_6) in air. It samples air on a 10 minute cycle and records the response on a strip chart recorder. When SF_6 is distributed in the air of a building, data is obtained from which air infiltration rates may be determined.

TN899. **Development of proposed standards for testing solar collectors and thermal storage devices,** J. E. Hill, E. R. Streed, G. E. Kelly, J. C. Geist, and T. Kusuda, *Nat. Bur. Stand. (U.S.), Tech. Note 899*, 265 pages (Feb. 1976) SD Catalog No. C13.46:899.

Key words: solar collector; solar energy; solar radiation; standard; standard test; thermal performance; thermal storage.

A study has been made at the National Bureau of Standards of the different techniques that are or could be used for testing solar collectors and thermal storage devices that are used in solar heating and cooling systems. This report reviews the various testing methods and outlines a recommended test procedure, including apparatus and instrumentation, for both components. The recommended procedures have been written in the format of a standard of the American Society of Heating, Refrigerating, and Air Conditioning Engineers and have been submitted to that organization for consideration.

TN900. **Deflection performance criteria for floors,** R. A. Crist and J. R. Shaver, *Nat. Bur. Stand. (U.S.), Tech. Note 900*, 29 pages (Apr. 1976) SD Catalog No. C13.46:900.

Key words: deflection; dynamic; floor systems; human responses; performance criteria; serviceability; static; vibration.

Serviceability performance criteria for floor systems are discussed in terms of their static and dynamic components. Development of traditional static stiffness criteria is given along with a review of their strengths and weaknesses. Criteria for serviceable floors are presented from a vibration viewpoint and the derivation of an improved criterion is given. A new approach for future vibration criteria is described.

TN904. **Correlation of floor vibration to human response,** J. R. Shaver, *Nat. Bur. Stand. (U.S.), Tech. Note 904*, 29 pages (May 1976) SD Catalog No. C13.46:904.

Key words: analysis; experimental; floor systems; human response; random process; spectral analysis; vibration.

A new approach to the problem of perceptible floor vibrations is presented predicated on the realization that human activity and human response to this activity are random variables. Techniques for data reduction are discussed and a detailed description of one approach is given along with the associated computer program. Data from floor vibrations is compared with current criteria for human response to vibration.

TN909. **Investigation of wind damage in the Metropolitan Washington, D.C. area, April 3-4, 1975,** F. Y. Yokel, C. W. Yancey, L. E. Cattaneo, and R. D. Marshall, *Nat. Bur. Stand. (U.S.), Tech. Note 909*, 65 pages (May 1976) SD Catalog No. C13.46:909.

Key words: building codes; design standards; masonry construction; roofs; siding; structural engineering; wind; wind damage; wind engineering.

A limited investigation was conducted of wind damage that occurred on April 3 and 4, 1975 in the Metropolitan Washington, D.C. area. Meteorological data indicate that the winds were somewhat less severe than those that should be anticipated by designers. Thus, most of the observed damage reflects inadequacies in design or construction. Damage was observed in occupied buildings, as well as in buildings under construction. Damaged elements of occupied buildings included: masonry curtain walls; masonry gable walls; masonry veneer; roofs with overhangs; roofing; and cladding. Damaged elements of buildings under construction included roofs and masonry walls.

TN915. **Metrication problems in the construction codes and standards sector,** C. T. Mahaffey, *Nat. Bur. Stand. (U.S.), Tech. Note 915*, 25 pages (June 1976) SD Catalog No. C13.46:915.

Key words: building regulations; dimensional coordination; metric conversion; planning and scheduling.

This report is a response to a request for an outline of problems to be faced by the building standards development and building regulatory sectors of the American building industry. It includes a discussion of the SI metric units themselves, giving examples of the conventions regarding their use adopted in other countries to illustrate the nature of the decisions that must be made by the U.S. building industry. It discusses the relationship of dimensional coordination to the metric conversion effort, its impact on the U.S. building regulatory system and illustrates some of the decisions these sectors need to make. It also discusses some of the organizational problems required to involve all segments of the industry in this decision-making process, and for implementing these decisions in a coordinated way on a national scale.

TN918. **Survey of building code provisions for historic structures,** M. Green and P. W. Cooke, *Nat. Bur. Stand. (U.S.), Tech. Note 918*, 47 pages (Sept. 1976) SD Catalog No. C13.46:918.

Key words: building codes; cities; health and safety; historic preservation; states.

In order to resolve conflicts between health and safety objectives and historic preservation objectives, a number of states and cities have adopted special building code provisions. A survey was conducted to determine the extent of adoption of such special provisions. The survey included the states, territories and member cities of the Association of Major City Building Officials (AMCBO). The survey responses revealed that sixteen of the forty-seven responding states have special provisions or regulations as do fifteen of the twenty-four responding cities. The majority of states and cities have established a special preservation appeals board. Legislation and special provisions are reviewed in the report. Recommendations for additional research are included.

TN921. **Survey manual for estimating the incidence of lead paint in housing,** W. G. Hall and L. T. Slovic, *Nat. Bur. Stand. (U.S.), Tech. Note 921*, 111 pages (Sept. 1976) SD Catalog No. C13.46:921.

Key words: lead paint; lead paint detection; lead paint programs; lead poisoning; portable x-ray fluorescence; random sampling; x-ray fluorescence.

This manual is intended as a guide for municipal managers in performing a survey to determine the prevalence of lead based paint in their community's dwelling units. There are four parts to the Manual, each is intended for a different audience.

Part I discusses the preliminary considerations for a survey. It is intended for the department head or executive who will initiate plans for the survey. It presents a managerial overview of the processes, the cost determinants, criteria for the establishment of objectives and the resources required.

Part II is intended for the survey manager and the inspector supervisors. It contains more detailed information on the planning, staffing, training, and execution of the data collection phase of the survey.

Part III is for the use of the person responsible for the control and management of the data collected and for the analysis of these data.

The Appendices contain quite detailed information about procedures we have used in previous surveys. These may be used as they are described or may be modified or adapted to meet specific objectives.

TN922. **Economic analysis of experimental lead paint abatement methods: Phase I,** R. E. Chapman, *Nat. Bur. Stand. (U.S.), Tech. Note 922*, 112 pages (Sept. 1976) SD Catalog No. C13.46:922.

Key words: abatement; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.

Public and private concern about the potential for lead poisoning in children due to the ingestion of lead-based paint chips has resulted in a Federally sponsored program to develop technologies by which lead-based paint may be eliminated from the nation's housing. Through this program lead-based paint abatement techniques were tested in field deleading operations conducted in Washington, DC, and Atlanta, GA. The program also focused on the collection of data on the direct costs of labor, materials and special equipment associated with these abatement techniques.

This report provides a statistical analysis by abatement technique and building component (i.e., walls, doors, door frames, windows and frames, and miscellaneous trim) of this direct cost data. Abatement techniques are then ranked according to their relative costs. A cost model is developed for each category (ranking) which identifies the key factors which affect direct cost and provides a framework whereby direct costs may be estimated. Recommendations are made for further refinement of the model; a methodology through which the optimal combination of lead-based paint abatement techniques can be identified is also outlined.

TN923. **Applications of thermography for energy conservation in industry,** C. W. Hurley and K. G. Kreider, *Nat. Bur. Stand. (U.S.), Tech. Note 923*, 31 pages (Oct. 1976) SD Catalog No. C13.46:923.

Key words: energy conservation; energy surveys; infrared; nondestructive evaluation; thermographic surveys; thermography.

Infrared thermography has been developed as a tool to measure the temperature of various types of surfaces. Notable applications include thermal detection of diseases such as cancer and circulatory problems in human beings, aerial land mapping of hot surfaces to detect thermal pollution and geological formations, and remote scanning of buildings to detect heat losses. More recently, infrared scanning has been used to detect defects in high amperage electrical connections, transformers, and steel processing furnaces in industrial environments.

It was the intent of the NBS IR program to build on these technologies to assist energy conservation engineers to assess heat losses in industrial plants. IR teams from the NBS Center for Building Technology had previously used the equipment to survey heat losses in buildings where the IR camera was found to be particularly useful in detecting infiltration problems, missing insulation, and construction defects. Our intent in this project was to survey furnaces and heating systems in addition to electrical and mechanical systems to find areas suggesting energy conserving actions. This qualitative survey has been found to be an excellent method to detect heat losses in unit process equipment and auxiliary systems. This survey method described in this paper was carried out in fifteen industrial plants in order to develop a methodology and examine the feasibility of the approach.

In addition to the qualitative survey quantitative data was gathered by calibrating the temperature of the "hot spots" uncovered in the survey. This information was very useful in developing priorities and estimating the magnitude of the heat loss due to a given defect.

TN932. **Concrete strength during construction,** H. S. Lew, T. W. Reichard, and J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 932*, 56 pages (Dec. 1976) SD Catalog No. C13.46:932.

Key words: compressive strength; concrete; maturity; mechanical properties; nondestructive evaluation; pull-out strength; splitting tensile strength.

The early strength gain characteristics of a concrete at various temperatures was investigated in this study. In addition, the applicability of two widely known nondestructive evaluation methods were examined for the purpose of determining the compressive strength of concrete at early ages.

For destructive evaluation, standard cylinder compression tests, splitting tensile tests and pull-out tests were made on specimens cured at 73 °F (22.8 °C), 55 °F (12.8 °C) and 35 °F (1.7 °C). For nondestructive evaluation, both probe penetration and rebound hammer tests were performed on slabs. Tests were carried out at the age of 1, 2, 3, 5, 7, 14, 28 and 42 days after casting the concrete.

Statistical analyses were made to examine the possibility of using maturity of concrete as a parameter to correlate test results of concrete cured at different temperatures. Rate of gain of the splitting tensile strength, pull-out bond strength and elastic modulus were compared with that of compressive strength.

The results show that when related to maturity, the rate of increase in the splitting tensile strength is about the same as that of the compressive strength, whereas the rate of increase in the pull-out strength and the modulus are slightly greater than that of the compressive strength. The results of nondestructive evaluations revealed that the compressive strength could not be estimated correctly by the probe method using the manufacturer's conversion charts. Because of lower rebound readings, the rebound hammer could not be used to estimate the compressive strength at early ages.

SPECIAL PUBLICATIONS

This series includes proceedings of conferences sponsored by the Center, and other special publications appropriate to this grouping including project summaries, list of publications, wall charts, pocket cards, and bibliographies.

SP403. **Energy conservation through effective energy utilization.** 1973 Engineering Foundation Conference, New England College, Henniker, NH, Aug. 19-24, 1973, J. C. Denton, S. Webber, and J. Moriarty, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 403*, 251 pages (June 1976) SD Catalog No. C13.10:403.

Key words: automobile; break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics.

These proceedings of the 1973 Engineering Foundation Conference focus on effective utilization of thermal energy as a means of energy conservation. It is hoped publication will help stimulate the national dialogue toward a balanced national program for more energy conservation.

The varied professional backgrounds of the participants provided an interdisciplinary approach for action steps to be taken in areas where research is needed and will provide a significant impact. For example, the development of better stack controls was recommended as a specific research task, and the improvement of energy accounting systems and energy use norms was recommended as a useful research area. Broad agreement was reached that there is much left to be accomplished in thermal process technology as used in industrial processes, in industrial equipment, and in heating, ventilating, and air conditioning (H-VAC) equipment for buildings.

A clear conclusion of the conference is that while new technology is important the introduction of much technology that is already available is equally, if not more, important. Institutional barriers relating to economics, management, finance, and national policy keep available technology standing in the wings. The conference papers and discussions show that engineering design, when it can be rigorously applied, does result in striking reductions in energy use in the thermal process technologies. *These proceedings include the following papers (indented):*

Effective utilization of energy and other natural resources, C. A. Berg, *SP403*, pp. 3-12 (June 1976).

Key words: costs; economics; energy; fuel; imports.

An overview of the Nation's energy problems is presented to provide a basis of definition for the term "energy crisis." The term does not represent a crisis of depletion of energy resources but rather refers to energy cost. The dependency of the United States on fuel imports illustrates the problems that questionable reliability and increasing costs of fuel imports pose for American industry. Improving energy use efficiency would reduce energy consumption and, considering rising energy costs, may prove to be economically attractive to industry. A policy of national life-term costing of equipment, which includes energy cost of that equipment, should be promoted rather than the present criterion of justification which is based primarily on first costs. Further, a rational economic method for achieving effective and balanced use of all natural resources, based on total life-term costing, is advocated.

Energy conservation goals and methods, R. E. Shepherd, *SP403*, pp. 13-18 (June 1976).

Key words: conservation; energy; organization.

The goals of the President's energy message of early 1973 and the feasibility of the 1974 goal of a 5 percent energy use reduction nationally are discussed. An overview of the Federal government's organizational structure is presented and discussed with reference to attaining these goals. Voluntary energy conservation measures and a major educational program directed at energy users are urged to help solve the Nation's energy problems.

National benefits of energy conservation, L. R. Glicksman and D. C. White, *SP403*, pp. 21-41 (June 1976).

Key words: correlation; economic; energy; imports; international; petroleum.

Starting from the correlation between a nation's gross national product and its energy consumption per capita, the consequences of economic growth on the world's estimated energy resources is discussed. In the absence of new energy technologies or a reduction of energy consumption in relationship to GNP, sustained high economic growth will be difficult and costly to achieve as our own resource base diminishes. The developing nations of the world will be competing for resources as their own GNP's increase, further exacerbating the resource depletion problem. As the nations of the world compete for scarce resources, there are potential international complications beyond those presently apparent in the effect of petroleum imports on America's transportation sector.

Options for energy conservation, B. Hannon, *SP403*, pp. 43-56 (June 1976).

Key words: economic; energy; input-output model.

An input-output model useful in measuring energy use, efficiency of production processes, and product uses is presented. The model provides estimates of total energy and employment shifts in a variety of processes and products. Several of these demand shifts and their potential impacts are discussed. United States industry, in general, becomes more energy-intensive as it grows. The impacts of demand shifts and changing character of industry as it evolves on consumer cost, employment, and pollution should be thoroughly understood before policy recommendations should be initiated.

Measures of thermal energy utilization, B. B. Hamel and H. L. Brown, *SP403*, pp. 57-64 (June 1976).

Key words: energy; heating systems; model; thermodynamics.

It is necessary to quantify, or structure, the ideas of thermal energy utilization in order to develop an efficiency of energy utilization. Such a quantitative analysis is useful in assessing any modification or change in design of an energy system. A method of analysis useful in assessing modifications in an energy system is presented. The concept of thermodynamic availability is used to determine maximum energy utilization efficiency. The method is illustrated by evaluating the efficiencies of several water heating systems.

Economic and environmental implications of effective utilization of energy, J. C. Denton, *SP403*, pp. 65-74 (June 1976).

Key words: automobile; economic; energy; model; transform analysis.

Technology uses energy, materials, money, people, etc. to produce products and services for society. The resultant products and their impacts on resources, society and the environment exist in a dynamic interrelationship. Technology transform analysis is an analytical model which is proposed to identify and elucidate the interrelationships between these elements and to assess the consequences of their modification. The technology transform analysis is prerequisite to the application of input-output analysis if the interrelationships between energy, environmental, economic, and human factors is to be displayed in a compatible fashion. An abbreviated example analysis of the automobile industry is presented to demonstrate the complexities which must be included and the subtleties which appear. Possible pitfalls of an incomplete analysis are discussed.

Industrial energy analysis and forecasting, D. R. Limaye, J. R. Sharko, and J. H. Kayser, *SP403*, pp. 77-93 (June 1976).

Key words: break-even analysis; economics; energy; industrial.

Although the industrial sector is one of the largest consumers of energy (over 33% of total energy consumption), relatively little is known in detail about the end use characteristics in this sector because of the diversity of processes and practices. Two approaches are discussed: a detailed engineering process analysis, involving an in-depth look at each major product in each industry; and a survey approach employing interviews and questionnaires. Studies are presented on the Chemical and Allied Products industry (SIC 28). A break-even analysis is employed to determine the prices at which two fuels are economically equivalent. An overall methodology is presented for integrating all of the different aspects of industrial energy analysis. The initial steps are the identification of end use characteristics, energy requirements per unit of output, process economics, and qualitative factors affecting energy use. Based on these and on estimates of total industrial output, the total energy requirements can be determined.

Management's role in industrial thermal energy utilization, A. S. Cook, *SP403*, pp. 95-101 (June 1976).

Key words: conservation; costs; economics; energy; thermal.

The industrial sector has a vital role and stake in decisions with respect to utilization of the country's thermal energy resources. Energy management responsibility requires a significant reorientation of the management job toward energy conservation. Industrial management's present dedication is to competitive free enterprise and energy substitution for human toil. The reorientation is toward acceptance of higher energy costs and toward security of energy supply. Discussions are presented on what industrial manufacturing can do and some factors external to industrial process thermal energy utilization. In the former category a new process technology, ultraviolet curing, is presented to exemplify conservation results from application of a new technology. In the latter category, it is emphasized that a given company cannot operate in isolation in its energy conservation efforts without running the risk that the total energy required by the society may increase.

Development of industrial energy management policies, M. C. Noland, *SP403*, pp. 103-111 (June 1976).

Key words: conservation; economic; energy; management; manufacturing.

A systematic approach to energy management at the operational level must be custom-fitted to specific industrial facilities. Preliminary results of attempts to (1) determine the steps being taken by industry in response to changing energy supply conditions and the potential for conservation inherent in that response and (2) develop guidelines for the establishment of plant energy management policies in the manufacturing and process industries are presented. The major incentive for future conservation of energy by industry is cost. The only alternative is regulation and enforcement. The economic incentive involves both direct energy cost and the indirect costs of energy security. The approach to energy problems taken by different firms follows no discernibly systematic pattern, varying from little concern to progressive programs. An outline of steps in the development of industrial energy management policies is presented.

Case histories of effective energy utilization in industry, W. Rudoy, *SP403*, pp. 113-117 (June 1976).

Key words: attitudes; conservation; energy; industrial; systems.

Energy conservation through effective energy utilization falls into three classes: better "housekeeping" or energy management of present systems; application of present off-the-shelf technology to existing systems; and revision of existing systems to provide the same objective with less energy. Three general components enter into any implementation of energy conservation—technology, economics, and people. There is a great deal of off-the-shelf technology that could be employed and case studies are presented showing significant gains in energy conservation in the area of comfort conditioning of the industrial environment. In most cases, the rule-of-thumb economic payback period of two years for revising a system is not met. The decision to move toward more efficient utilization, even when the other two components are favorable, is often influenced by the attitudes of key personnel.

A projection of energy demand by the iron and steel industry, D. Larson, *SP403*, pp. 121-152 (June 1976).

Key words: energy; forecast; industry; iron; steel.

The iron and steel industry is not only one of the larger consumers of energy (7.5% of the total U.S. energy use in 1968), but is also a very complex industry. The interrelationships between projected demand for products and the amounts of fuels needed for manufacturing the products are discussed as well as the trends that could change the amounts of fuels needed per unit of product. Conclusions drawn are that there should be a 65 percent increase in production and a 28 percent increase in energy consumption in the industry between 1971 and 1985. The growth rate of energy consumption decreases with time and should almost level off by 1985. The change in energy requirements per ton of finished product is primarily the result of technological changes. Therefore, trends that phase out obsolete inefficient equipment can accelerate this energy utilization efficiency. Most of the improved efficiency is expected in the iron-making and steel-making processes and very little change is forecast in the reheating and finishing portion of the industry.

Potential energy savings in the forming of paper, T. Speidel and D. Kallmes, *SP403*, pp. 153-161 (June 1976).

Key words: energy; industrial; paper.

The United States produced 59 million tons of paper and paper products in 1972 requiring 320×10^{12} BTU exclusive of the energy required to produce the necessary wood pulp. The conventional paper forming process is described in brief. A new method of forming paper is described having the potential of saving 40 percent of the energy conventionally required to form paper. The new method can make high quality paper utilizing up to 2 percent suspended wood pulp. A helical mixer with a high shear component in the jet permits a 35 percent decrease in the heat required during the process. This process is particularly attractive where fuel oil or fuel gas is used to supply the heat rather than waste bark and black liquor.

Potential for energy conservation in heating, ventilating, and air-conditioning equipment for buildings, G. Kelly, T. Kusuda, and J. Hill, *SP403*, pp. 163-191 (June 1976).

Key words: conservation; cooling; cost; energy; heating.

Approximately one-third of the Nation's energy use is presently used in residential and commercial buildings. Over seventy percent of the energy is being used for heating, cooling, and providing hot water. The potential for energy conservation through proper design and use of heating, ventilating, and air conditioning equipment within or in the proximity of buildings is discussed. The topics presented include a discussion of the positive and negative features of both unitary and central HVAC equipment, a description of typical all-air and air-water HVAC systems, the heat pump and how it can be combined with other equipment to conserve energy, and the recovery of energy from the building exhaust air. A brief description is given of total energy systems, modular integrated utility systems, and the utilization of waste heat from incineration plants. Considerable savings could be obtained from judicious choice of standard equipment based on energy conservation considerations. The use of life cycle costing rather than lowest possible first cost would vastly upgrade the present standards of practice.

ASHRAE and energy conservation, P. E. McNall, Jr., *SP403*, pp. 193-195 (June 1976).

Key words: energy; environment; food.

ASHRAE is concerned with all aspects of environmental control for people, as well as for plants and animals as the latter relate to food production and processing. The ASHRAE Guide is discussed and its excellent treatment on thermal comfort in buildings is emphasized. The need for better energy management and the importance of first cost to the building industry in speculative type investments is discussed. The utility of reheat HVAC systems is emphasized since they are easy to maintain and have low initial costs. ASHRAE has considerable know-how which is not optimally used at present because of inadequate incentive. Labor is no substitute for energy since a man is worth only 10¢ per day in energy expended.

Factors controlling the manufacture and marketing of energy conserving products, J. B. Comly and C. M. Huggins, *SP403*, pp. 199-213 (June 1976).

Key words: costs; energy; heating; manufacturing; marketing.

The complex of factors relating to decisions to manufacture and market new or improved products is discussed, with examples taken from consumer equipment of importance in conservation of energy at the point of utilization. The heat pump and the incandescent light bulb are used as specific examples. Premature marketing of the heat pump as a heating system impaired its degree of acceptance. The tradeoff between energy efficiency and replacement cost of the incandescent light bulb illustrates the optimization of these two factors in a product. Technological development alone does not assure immediate implementation of energy efficient systems. The prospect of commercial success of a product should be evaluated well before that product is brought to market.

Economic, energy, environment trade-offs, P. Swatek, *SP403*, pp. 215-223 (June 1976).

Key words: costs; economics; energy; environment.

The individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in the community but his ethics prompt him also to cooperate. Believing that pecuniary motivation is high on the list of human priorities, freer market mechanisms than presently exist are urged. The market should be unshackled, both removing subsidies to the energy industry (oil depletion allowance) and having the producers internalize the now externalized social and environmental cost of their operations. Such measures are projected to be effective in all energy consuming sectors, await the development of no new technologies, require no legislation of rigid criteria and technical standards, require no bureaucracy, rely on the normal operation of the free market, do not depend on changes in basic motivation of consumers, and will work and produce an efficient allocation of resources.

Regulatory, legal, and tax constraints on energy conservation—Polemic or fact?, C. Warren, *SP403*, pp. 225-235 (June 1976).

Key words: energy; legal; regulatory; standards.

Recognizing the vital role of power in society, an education and voluntary basis for balancing the different mechanisms in the market (such as the adjustment of electric rate structures) is urged. In the last analysis, if this approach is unsuccessful, regulation will be required drawing upon the power of the State. Regulatory enactments should be directed toward behavioral norms in the every day activities of people rather than adjudicating conflicts. The State would set standards for the building industry, controlling lighting and insulation, be prepared to establish allocations of energy, and prescribe levels of operating efficiency. Since the standards proposed are essentially performance criteria rather than product quality criteria, one could enforce conformity at the point of end use.

Financial feasibility of energy conservation, S. Sixfin, *SP403*, pp. 237-241 (June 1976).

Key words: costs; energy; financial; resources; risk.

Energy availability is approached from a purely economic point of view. The technology to be used is determined by the rate of return on the investment. A sample cost feasibility analysis for a 100,000 square foot industrial plant is presented as an example. Besides price, the ultimate criterion for choosing an energy source is its availability. Where critical energy shortages are foreseen, incentives must be provided to encourage the flow of capital in the directions necessary to alleviate the shortages. Private investors should be compensated for the risk that they undertake in the location and development of energy resources.

National context for energy conservation, J. C. Denton, *SP403*, pp. 245-246 (June 1976).

Energy management in industry, R. G. Gatts, *SP403*, pp. 247-250 (June 1976).

Application of thermal process technology, K. G. Kreider, *SP403*, pp. 251-252 (June 1976).

Institutional considerations respecting energy conservation, S. Z. Klausner, *SP403*, pp. 253-254 (June 1976).

SP439. **The Center for Building Technology: A perspective,** M. Olmert, *Nat. Bur. Stand. (U.S.), Spec. Publ. 439*, 30 pages (Jan. 1976) SD Catalog No. C13.10:439.

Key words: building research; criteria; energy; engineering; industry construction; measurement techniques; standards.

The mission of the Center for Building Technology is threefold. They are (1) advance building technology by providing technical and scientific bases for criteria and standards that improve the usefulness, safety, and economy of buildings; (2) facilitate, for the public benefit, the implementation of improved building technology by providing technical assistance to all sectors of the building community; and (3) develop improved techniques by which the end-users in buildings, communities and industrial processes conserve energy. This report presents an overview of the Center for Building Technology's research areas through its accomplishments and ongoing projects.

SP444. **Wind and seismic effects.** Proceedings of the Sixth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, National Bureau of Standards, Gaithersburg, MD, May 15-17 (1974), H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 444*, 462 pages (Apr. 1976) SD Catalog No. C13.10:444.

Key words: bridges; buildings; codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind.

The Sixth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Washington, D.C., on May 15-17, 1974. The proceedings of the Joint Meeting include the opening remarks, the program, the formal resolutions, and the technical papers. The subject matter covered in the papers includes extreme winds in structural design; assessment and experimental techniques for measuring wind loads; dynamics of soil structures and ground response in earthquakes; structural response to wind and earthquakes and design criteria; disaster mitigation against natural hazards; and technological assistance to developing countries. *These proceedings include the following papers (indented):*

On the gust response of long-span suspension bridges, N. Narita and K. Yokoyama, *SP444*, pp. I-1 – I-20 (Apr. 1976).

Key words: bridge; design; field data; gust response; model; specifications; structure; theory; wind.

In the design of above-ground structures it is established practice to consider the effects of wind. For some structures, like long-span suspension bridges, the influence of wind may be the primary design control which will then govern the inherent safety of the structures and the final construction cost.

This paper, therefore, will describe the required changes in design specifications to incorporate the influence of gusts on long-span suspension bridges.

The necessary numerical calculations are illustrated in addition to some long-term observations on the Kanmon Bridge. The importance and necessity of studies on gust response are emphasized.

Extreme winds in hurricanes and possibility of modifying them, R. C. Gentry, *SP444*, pp. I-21 – I-33 (Apr. 1976).

Key words: cloud seeding; frequency distribution; hurricanes; typhoon; wind; wind intensities.

A hurricane (or similar storm called by other names) is the most destructive of nature's phenomena. This is partly because of the extreme winds associated with the storms (ranging up to 320 kilometers per hour), but also because the winds may continue blowing for several hours, and they are accompanied by rising ocean water, strong along-shore currents, and torrential rains.

Discussions will be presented of the frequency of hurricanes of various intensities, the rate at which the wind speeds decrease after the storm crosses the coast and moves inland, the effect of the winds on the storm surge, and the variation of the wind speed with height.

For several years, members of the United States Government have been experimenting to reduce the maximum intensity of the winds of hurricanes. Summaries will be presented of the progress and future prospects for this work.

Extreme winds in the United States, A. R. Hull and P. E. Hughes, *SP444*, pp. I-34 – I-39 (Apr. 1976).

Key words: building code; damage classification; extreme wind; tornado; wind loads.

The highest winds reported in the United States have been associated with tornadoes. Fujita (1971) has developed a tornado windspeed/damage classification system which permits extreme wind estimations without follow-up surveys. Fujita classifications of tornadoes for the 1965, 1971, and 1972 seasons, as well as extreme wind values associated with thunderstorms and extratropical cyclones during 1973 are reviewed as they relate to ANSI building code requirements for design loads. Next, a new observational tool, an acoustic, doppler-shift "sonar" capable of profiling low-level wind regimes at the actual building site, is briefly described. Finally, the proposed NOAA Severe Environmental Storms and Mesoscale Experiment (SESAME) is examined. SESAME is an observational/research effort to identify the processes and controlling parameters of extreme-wind generating severe weather systems such as squall lines, thunderstorms, and possibly tornadoes, and to aid in the development of conceptual and numerical models of these phenomena.

Wind tunnel experiments for studying a local wind, K. Suda, S. Soma, and K. Takeuchi, *SP444*, pp. II-1 – II-20 (Apr. 1976).

Key words: bridge; gust; meteorological data; topographical model; wind load; wind profile; wind tunnel.

In general, the study of the effects of local winds on structures is primarily based on data obtained from wind tunnel experiments. As an example of such studies, an investigation of air flow around Nakatojima Island relative to the wind resistant design of a long suspension bridge has been conducted and will be presented.

However, it is not reasonable to conduct such a study entirely related to wind tunnel experiments, as the similitude rule has not been established. Therefore, field observations have been made in parallel with the wind tunnel experiments and the data obtained by both sources are then compared. Thus, the results obtained from the wind tunnel experiment are more reliable.

A study of wind pressures on a single-family dwelling in model and full scale, R. D. Marshall, *SP444*, pp. II-21 – II-51 (Apr. 1976).

Key words: aerodynamics; boundary layers; buildings; codes and standards; wind loads; wind tunnels.

Wind pressures measured on a single-family dwelling are compared with results obtained from a 1:50 scale model placed in a turbulent boundary layer. It is shown that the fluctuating components of surface pressures far exceed the mean or steady pressures and are well correlated over sizeable roof areas. The consistently low fluctuating pressure coefficients obtained from the wind tunnel model are attributed to improper simulation of the lower portion of the atmospheric boundary layer. Comparisons between actual loads and specified design loads suggest that certain current provisions are marginal for tributary areas and excessive for localized areas such as ridges, eaves and corners. A procedure for expressing loads on both localized and extended roof areas in terms of mean pressure coefficients and a peak factor is described.

Nonlinear calculations of ground response in earthquakes, W. B. Joyner, A. T. F. Chen, and P. C. Doherty, *SP444*, pp. III-1 – III-12 (Apr. 1976).

Key words: elastic medium; engineering seismology; ground layer; numerical solution; shear wave.

The response of soil to strong earthquake motion involves a high degree of nonlinearity. Because of the difficulties in solving the nonlinear problem, most calculations of ground response are currently made by a method – variously characterized as "equivalent linear", "quasi-linear", or "strain-compatible" – that assumes the true solution can be approximated by the response of a linear model whose properties are chosen to accord with the average strain that occurs in the model during excitation. The average strain level is determined by iterative calculation. To solve the nonlinear problem directly, we have developed algorithms by which the hysteretic behavior of an individual soil element can be efficiently modeled in a computer. The algorithms enable us to model any reasonable set of hysteresis loops of the Masing type that laboratory experiments may dictate. We are experimenting with various numerical techniques for integrating the basic nonlinear differential equations, including the method of characteristics as described by Streeter, Wylie, and Richart. A comparison was made between the equivalent linear and the onlinear solution (using the method of characteristics) for a 200-meter section of firm alluvium excited at its base by the N21E component of the Taft accelerogram multiplied by four. This excitation produced peak strains of several tenths of a percent. The nonlinear solution showed substantially higher spectral levels of response at five percent damping for periods between 0.1 and 0.6 seconds.

Observation and analysis of ground response in earthquakes, S. Hayashi and H. Tsuchida, *SP444*, pp. III-13 – III-23 (Apr. 1976).

Key words: earthquake; field data; ground response; seismic waves; seismometer; soil-structure interaction.

In the field of port and harbor engineering, the ground response due to earthquakes is generally considered. However, there are many problems at present in idealization of the surface layer, input ground motions, and nonlinear behavior of the soil. In order to provide some design data in these areas, research has been conducted using six downhole seismometer arrays established in port areas in Japan. Typical observed acceleration time histories have been obtained and are shown and compared with those calculated by the multiple reflection theory. In order to investigate ground response relative to structures of large length, such as a tunnel, a two-dimensional seismometer array has been established. Examples of the considerations of the ground response required in practice are seen in microzonation in the earthquake proof design of a subaqueous tunnel.

Research study on liquefaction, W. F. Marcuson, III, *SP444*, pp. III-24 – III-37 (Apr. 1976).

Key words: earthfill dams; earthquakes; ground shaking; liquefaction; soil density; stability.

A research program is being undertaken by the U.S. Army Corps of Engineers to evaluate the liquefaction phenomena relative to earthquake response of earth-filled dams. Present and future studies are summarized.

Estimation of liquefaction potential by means of explosion test, K. Yamamura and Y. Koga, *SP444*, pp. III-38 – III-51 (Apr. 1976).

Key words: earthquake; explosion test; ground strength; ground vibration; liquefaction; pore-water pressure.

A series of field vibration experiments were performed in order to estimate the liquefaction potential of sandy soil during earthquakes. Bore hole explosions were used as a vibration sourcc. A significant relation was found between the ground stiffness and the pore-water pressure as caused by the explosion. A proposed method has been developed for estimation of the liquefaction potential.

Landslide incidence and mechanisms during earthquakes, G. E. Ericksen, *SP444*, pp. III-52 – III-71 (Apr. 1976).

Key words: avalanches; earthquakes; falls; flows; landslides; mechanisms; slides.

Strong earthquakes affecting mountainous terrain are generally accompanied by hundreds or even thousands of large potentially destructive landslides of certain types; earthquakes affecting areas of low relief cause fewer and generally different types of landslides, which, however, may be equally destructive to works of man. On steep slopes, among the many types of landslides that may occur, falls, slides, and avalanches of rock and soil are most frequent during earthquakes. These landslides take place where slides are commonly part of normal mass-wasting processes that affect hillslopes; the earthquake causes the reactivation of old slides as well as the formation of new slides. Surface movement on faults may also cause landslides by the formation of scarps that change slope stability although landslides of this type are relatively rare. In terrain of low relief, failures by rotational slump, translatory sliding, and lateral spreading are frequent causes of destruction in towns and cities that have been constructed on unstable, generally water-saturated soil or unconsolidated sediment.

Landslides, with the exception of those classified as falls, result from failure of earth materials under shear stress. Earthquake accelerations trigger landslides by causing a transitory increase in shear stress in earth materials at the site of the slide, and by causing a dec ease in the shear strength of certain materials, such as water-saturated soil. Most slide failure takes place along one or more planes of weakness, except for flow or landspreading, wherein a given mass fails by loss of coherence. Among the most spectacular or earthquake-triggered landslides are large high-speed debris avalanches that move over a cushion of entrapped compressed air.

Stress condition effects on dynamic properties of soils, E. Kuribayashi and T. Iwasaki, *SP444*, pp. III-72 – III-83 (Apr. 1976).

Key words: damping; damping coefficients; shear modulus; soil; tests; torsional excitation.

In the engineering field, the evaluation of the dynamic characteristics of soils and foundation subgrades has been required in the course of studying vibrational problems and especially problems associated with earthquake engineering. The dynamic characteristics of soils have, therefore, been obtained by laboratory tests, using a resonant column method. These tests were conducted to evaluate the shear modulus and the damping characteristics in dry and saturated specimens of various soils in Japan.

The hollow cylindrical samples tested were 25 cm in height, 10 cm outside diameter, and 6 cm inside diameter. This arrangement permitted a more uniform deformation of the sample cross-section. The specimens were fixed at the bottom, and at the top of the specimens oscillators were fastened to a rigid mass, which supply a torsional vibrational force to the system. A confining pressure, which was applied equally to the outside and inside of the test sample, was supplied by air pressure. An axial load was also applied, and was independent of the confining pressure in order to produce an anisotropic stress condition.

After the sample was prepared and all proper alignments and forces imposed, the frequency of the torsional excitation was introduced and then varied until the oscillator specimen system resonated. The resonant frequency varied from 40 cps to 100 cps, depending upon the dimensions and density of the sample and the applied stress condition and the shearing strain amplitude. The strain amplitude varied from 5×10^{-6} to 5×10^{-4} for these tests. The shear moduli were calculated from the resonant frequencies and the other parameters, as given above. The damping characteristics were obtained by using the amplitude-time decay response curves of the free vibrations.

In the triaxial state of stress, the mean principal stress, p, is defined by $(\sigma_a+2\sigma_r)/3$ and the deviator stress, q, is given by $\sigma_a-\sigma_r$ are the axial and radial stresses, respectively. The test results indicate the following trends for the dynamic properties of soils;

(1) Under constant values of the other parameters, the shear moduli vary with 1/2 power of p and decreases with an increase in the void ratio and shearing strain amplitude. Furthermore, the damping capacity decreases with an increase in p and also increases with an increase of strain amplitude. However, the damping capacity remains constant irrespective of the change in the void ratio, when the other parameters remain constant.

(2) When the value of p is kept constant, the shear moduli are nearly constant irrespective of the value of q until the stress ratio, q/p, reaches a value of about 1.0. However, beyond this value of q/p, the shear moduli begin to decrease with an increase in q/p. This phenomenon is due to the anisotropic stress condition and the corresponding anisotropy in the inner structure of specimens.

Prediction of maximum earthquake intensities for the San Francisco Bay Region, R. D. Borcherdt and J. F. Gibbs, *SP444*, pp. III-84—III-94 (Apr. 1976).

Key words: earthquake; empirical relation; Franciscan Formation; geological character; ground shaking; intensity.

The intensity data for the California earthquake of April 18, 1906, are strongly dependent on distance from the zone of surface faulting and the geological character of the ground. Considering only those sites (approximately one square city block in size) for which there is good evidence for the degree of ascribed intensity, the empirical relation derived between 1906 intensities and distance for 761 sites underlain by rocks of the Franciscan Formation is

$$\text{Intensity} = 2.30 - 1.90 \log(\text{Distance}).$$

For sites on other geologic units intensity increments, derived with respect to this empirical relation, correlate strongly with the Average Horizontal Spectral Amplifications (AHSA) determined from 99 three-component recordings of ground motion generated by nuclear explosions in Nevada. The resulting empirical relation is

$$\text{Intensity Increment} = 0.27 + 2.70 \log(\text{ASHA}).$$

Resulting average intensity increments for various geologic units are −0.29 for granite, 0.19 for Franciscan Formation, 0.64 for other pre-Tertiary, Tertiary bedrock, 0.82 for Santa Clara Formation, 1.34 for Older Bay sediments, 2.43 for Younger Bay mud. These empirical relations have been used to delineate areas in the San Francisco Bay region of potentially high intensity from future earthquakes on either the San Andreas fault or the Hayward fault.

A statistical approach to loading and failure of structures, R. G. Merritt, *SP444*, pp. IV-1 – IV-15 (Apr. 1976).

Key words: failure; probability theory; random process; safety; statistical analysis; structural engineering.

A fundamental problem of structural engineering is the examination and selection of loading criteria. It is imperative that any solution to the problem center around a rationale that relates information available on loading to selected criteria. Such available information is generally in the form of data. It is the purpose of this brief paper to abstract the problem and outline preliminary work on a rationale for addressing the problem.

The paper begins by defining the general nature of the problem. Solution to the problem is related to consideration of available information in the form of data. The next three sections of the paper discuss the initial stages of a rationale for consistent examination and selection of loading criteria. The first of the sections examines available information on structural load and the second examines available information on instances of structural failure. Classes of statistical methods are discussed in the third section. This section also includes discussion of a proposed method for assessing the overall information content of the available data. Finally, several illustrative examples of application of statistical methods to load and failure data are presented and the paper concludes with a discussion of future extension to this preliminary work.

Synthetic experimental research on the ductility of short reinforced concrete columns under large deflection, K. Nakano and M. Hirosawa, *SP444*, pp. IV-16 – IV-36 (Apr. 1976).

Key words: column; ductility; earthquake; reinforced concrete; shear tests; structural engineering; web reinforcement.

In general, short reinforced concrete columns will fail in a brittle manner. In order to create and establish better ductility in such columns, a synthetic research experimental program has been conducted. This program consisted of the testing of 125 short column specimens, subjected to multicycles of flexure-shear loadings. The result from these tests indicate the following:

1) The ductility of structural members is influenced by shear, bond, and buckling of the compression bars.

2) To prevent buckling of compression reinforcement, under small curvature, the spacing of the web reinforcement must be controlled.

3) In order to prevent a shear failure of structural members within reasonable ductility, an effective set of restrictions on the combination of axial force, tensile reinforcement ratio, and shear span ratio are required.

4) The bond failures which were observed in the test members, where deformed bars were used as axial reinforcement, consisted of bond-splitting of the cover concrete. The conventional method, which uses bond strength as an index to verify bond failure, is not effective for the bond-splitting failure mode. It is, therefore, necessary to restrict the tensile reinforcement ratio in order to prevent this type of bond failure.

Nonlinear analysis of a guyed tower, S. K. Takahashi and W. A. Shaw, *SP444*, pp. IV-37 – IV-54 (Apr. 1976).

Key words: finite element; guyed tower; structural analysis; structural engineering; vibration analysis; wind load.

The Civil Engineering Laboratory has performed an analysis of a tower at a Naval communication facility. The tower is about 600 feet high and is guyed at three levels. The upper guy level contains twelve wires; the middle and lower guy levels have three wires each. The guy wires had numerous large electrical insulators attached, each weighing 510 pounds.

A nonlinear finite element analysis of the guyed tower was conducted. Separate finite elements were used for portions of the tower and the guy wires were modeled with a truss element. Deflections, forces, and stresses in the tower and guy wires were determined from dead load and an equivalent static wind load corresponding to 90 miles per hour.

Eigenvalue solutions were obtained for the first five mode shapes and natural frequencies of one of the top guy wires; the guy wire had concentrated masses at five different locations and was initially prestressed.

A standard for the structural integrity of prefabricated dwellings, K. Nakano, M. Hirosawa, and T. Murota, *SP444*, pp. IV-55 – IV-69 (Apr. 1976).

Key words: earthquake; housing; performance specification; prefabricated dwelling; standards; structural design.

In 1973, the Ministry of Construction of Japan presented a standard for the performance of prefabricated housing. The purpose of this standard was to provide consumers with an index for selecting their dwellings. The standards are related to fire, heat, sound, durability, and structural safety against earthquakes, winds, snow, etc.

The criteria for evaluating structural properties are outlined in this paper, as well as the history and present status of prefabricated dwellings in Japan. A typical prefabricated structural system is shown in the last section.

An analytical model for determining energy dissipation in dynamically loaded structures, J. F. McNamara and S. K. Sharma, *SP444*, pp. IV-70 – IV-89 (Apr. 1976).

Key words: analytical model; dynamic analysis; dynamic laoding; earthquake; energy dissipation; finite element; seismic response; structural engineering.

An analytical procedure is developed which predicts nonlinear cyclic structural response under large reversals of plastic strains. The structure is discretized by means of the finite element approximation, and the material behavior is simulated by a refined analytical model which describes the realistic hysteretic stress-strain curves of A36 steel under arbitrary cycles of load. In order to test the validity of this material model, some comparisons are made with experimental values of the inelastic response of a simply supported beam under cyclic bending. The model is subsequently used in the dynamic analysis of a portal frame subjected to a selected portion of the El Centro NS earthquake acceleration record. The improved cyclic response with the current approach is illustrated by comparing results with those obtained using a simple bilinear kinematic hardening material approximation. Comparisons are also made with values obtained using a commercially available nonlinear frame analysis computer program. Some final comments are made regarding the rate of solution convergence with integration time step size for two different temporal integration operators used in this analysis.

Design of pile foundations subjected to lateral loads, M. Nagao, T. Okubo, K. Komada, and A. Yamakawa, *SP444*, pp. IV-90 – IV-112 (Apr. 1976).

Key words: design; earthquake; highway bridges; lateral loads; pile head; piles; structural engineering.

This report presents a number of basic items relative to the design of pile foundations subjected to lateral loads, and deals with the present design status of highway bridges in Japan. Also presented are items to be further studied for the design standardization of pile foundations subjected to lateral loads. Such problems as the deformation mechanism of group-pile structures are examined.

This report presents the method by reinforcement of the pile-head.

Comprehensive seismic design provisions for buildings, C. G. Culver, *SP444*, pp. IV-113 – IV-126 (Apr. 1976).

Key words: building codes; buildings; design; earthquakes; structural engineering.

A review of the development of earthquake design provisions for U.S. building codes is presented. Suggested revisions to the current provisions are noted. A cooperative project directed toward developing comprehensive seismic design provisions is described. The organizational structure for the project including a breakdown of the Task Committees required to develop the provisions and work statements for each Task Committee are included.

Wind loading and modern building codes, E. Simiu and R. D. Marshall, *SP444*, pp. IV-127 – IV-144 (Apr. 1976).

Key words: building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind loads.

The differences between the dynamic alongwind response, the gust factors, and the total alongwind response obtained using various current procedures may in certain cases be as high as 200, 100, and 60 percent, respectively. The purpose of this paper is to investigate the causes of such differences. To provide a framework for this investigation, the paper presents an overview of the questions involved in determining alongwind structural response, and a critical description of the basic features of procedures currently in use. A comparison is made between alongwind deflections of typical buildings selected as case studies, calculated by both new and traditional procedures, some of which are described in various building codes. The reasons for the differences between the respective results are pointed out. The procedures were evaluated on the basis of a recently developed method which utilizes a logarithmic variation of wind speed with height above ground, a height-dependent expression for the spectrum of the longitudinal wind speed fluctuations. The method also allows for realistic cross-correlations between pressures on the windward and leeward building faces.

Seismic retrofitting of existing highway bridges, J. D. Cooper, R. R. Robinson, and A. Longinow, *SP444*, pp. V-1 – V-24 (Apr. 1976).

Key words: design; earthquakes; highway bridges; retrofitting; soil-structure interaction; structural engineering.

The retrofitting of existing highway bridges, to provide an added measure of protection against collapse due to earthquake ground motion, is of great importance. This interest heightened in the United States following the San Fernando earthquake of 1971, which caused extensive damage to a number of modern freeway structures.

Some of the specific concepts for retrofitting to be explored include: (1) widening of bearing supports, (2) motion restrainers across hinges, (3) ties across expansion joints, (4) the elimination of expansion joints, and (5) adding ties or reinforcing to existing columns.

The monetary savings, resulting from an effective retrofit program in preventing collapse of structures, would far exceed the cost of the research involved in generating feasible and practical retrofit details.

This is a progress report on research which will result in mathematical techniques to identify the seismically vulnerable bridge details and a catalog of retrofit techniques. Such techniques will permit strengthening of such weak links, in the total structure integrity.

Dynamic tests of structures using a large scale shake table, S. Inaba, *SP444*, pp. V-25 – V-34 (Apr. 1976).

Key words: dynamic tests; earthquake simulator; shake table; structural engineering; tests.

Since 1970, a large scale shake table located at the National Research Center for Disaster Prevention (NRDP) has been widely used for the dynamic testing of structures. This paper presents the results of some of those dynamic earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural hazard conditions and to estimate the amount of expected damage. Damage to structural building components resulting from the extreme environments encountered in earthquakes, hurricanes, and tornadoes is considered. The methodology has the capability of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. Three independent but related sets of procedures for estimating damage for each of the natural hazards are included in the methodology. The first set of procedures provides a means for qualitatively determining the damage level on the basis of data collected in field surveys of the building. The second set utilizes a structural analysis of the building to determine the damage level as a function of the behavior of critical elements. The third set is based on a computer analysis of the entire structure. All three sets of procedures are based on the current state-of-the-art. The procedures are presented in a format which allows up-dating and refining.

Experimental research on the aseismic characteristic of spherical steel tank for liquid petroleium gas, K. Nakano and M. Watabe, *SP444*, pp. V-50 – V-62 (Apr. 1976).

Key words: dynamic analysis; earthquake; seismic design; seismic response; spherical tanks; structural design.

The results of static and dynamic tests on a spherical steel tank are given in detail. A theoretical technique to explain the "sloshing" effect is presented. A proposal for a safer design procedure to replace the present aseismic design practice is presented.

Research on minimizing earthquake structural damage to single-family dwellings, W. J. Werner, *SP444*, pp. V-63 – V-65 (Apr. 1976).

Key words: building codes; construction practices; damage; earthquake; houses; residential dwelling.

This paper discusses proposed research work to be carried out by the Applied Technology Council of the Structural Engineers Association of California under the sponsorship of the Department of Housing and Urban Development. The objective of the project is to develop a manual of recommended construction practice for earthquake resistive dwellings, for use primarily by builders, building officials, field inspectors, plan checkers, and designers.

The manual is intended to explain the structural behavior of single-family dwellings and townhouses subjected to forces produced by earthquake shocks, illustrate the HUD Minimum Property Standards, building code earthquake requirements and sound practical construction methods and details for the reduction of single family dwelling damage. The paper discusses the need for this research, the various tasks the contractor will perform, and the final products expected to be achieved by the research program.

Earthquake engineering research supported by the National Science Foundation, C. C. Thiel, *SP444*, pp. V-66 – V-79 (Apr. 1976).

Key words: earthquake engineering; grant; RANN; sponsorship; structural engineering.

A summary of earthquake engineering research work conducted by various researchers throughout the United States under the sponsorship of the National Science Foundation is presented.

The wind engineering program, M. P. Gaus, *SP444*, pp. V-80 – V-82 (Apr. 1976).

Key words: research programs; sponsorship; wind engineering.

A summary of wind engineering research work conducted by various researchers under the sponsorship of the National Science Foundation is presented.

Preliminary report on present status and development project of volcanological observation and research in Indonesia, A. Suwa, *SP444*, pp. VI-1 – VI-15 (Apr. 1976).

Key words: field observation; Indonesia; Japan; technical aid; volcanoes.

Indonesia has about 130 active volcanoes and their eruptions are characterized by dangerous violent explosions, nuee ardente, and volcanic mud-flows. The Geological Survey of Indonesia (GSI), Ministry of Mines, has, therefore, been carrying out observations and surveillances of volcanic activities throughout the country.

The Government of Japan, in response to a request from the Government of Indonesia, has decided to give assistance in this field of science in the framework of the Colombo Plan. The Overseas Technical Cooperation Agency (OTCA), the executing agency for the Government of Japan, has, therefore, dispatched a preliminary survey mission, headed by the author of this report, Akira Suwa, of the Japan Meteorological Agency to Indonesia in 1972.

The mission stayed in Java and Bali from November 22 to December 23, 1972, and visited the Ministry of Mines at Djakarta, the GSI at Bandung, and eight active volcanoes (eleven observatories) in order to study the possible scope of cooperation in Volcanology between Japan and Indonesia. The mission recognized two serious problems in Indonesia: deficiency of experts in volcanology, and shortage of up-to-date volcanological instruments.

Therefore, the recommendation by the preliminary survey mission to both governments was as follows:

1. Dispatch for several years the following Japanese experts to Indonesia: a. Instrumental seismologist, b. Volcano physicist; c. Volcanological geologist/petrologist.
2. Train junior volcanologists of the GSI in Japan.
3. Provide Indonesia with the following instruments; a. Seismographs for permanent and temporary observations; b. Instruments for petrological and mineralogical laboratory.

Use of stabilized adobe block and cane in construction of low-cost housing in Peru, S. G. Fattal, *SP444*, pp. VI-16 – VI-24 (Apr. 1976).

Key words: adobe; cane; earthquake; housing; Peru; technical aid.

A description of the use of adobe block and cane for construction of low-cost housing in seismic areas of Peru is described.

A comment on the technological aid to developing countries, M. Nagao and T. Okubo, *SP444*, pp. VI-25 – VI-31 (Apr. 1976).

Key words: earthquake; Japan; natural disaster; storm; structural engineering; technological aid.

This paper describes the technological aid required in developing countries, after a natural disaster, as observed by the writer during surveys of storm and earthquake disasters in these developing countries.

The writer classifies the aid required after a natural disaster into three categories, that is, emergency aid, technological aid, and economic aid. The problems related to the scientific and technological areas in the developing countries after a natural disaster are discussed.

The technological aid is classified into short and long term aid.

Finally, the problems related to the required technological aid are discussed and then the necessary Governmental policy which has been prepared for implementation of a low-cost and disaster resistant housing system is described.

SP446. **Building technology project summaries,** M. Olmert, *Nat. Bur. Stand. (U.S.), Spec. Publ. 446*, 108 pages (May 1976) SD Catalog No. C13.10:446.

Key words: building research; building technology; codes; criteria; project summaries; standards; technical bases.

The Center for Building Technology provides the technical and scientific bases for criteria and standards that improve the usefulness, safety, and economy of buildings while conserving building materials and energy. The Center's activities support the building technology program of the Federal, State and local government; assists design professions, building officials and the research community by developing design criteria that improve buildings; and assists manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarizes the Center's projects for calendar year 1975. It enables individuals to get a clear impression of CBT research activities.

SP457. **Building technology publications 1965-1975,** J. R. Debelius, S. G. Weber, and K. N. DeCorte, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457*, 107 pages (Dec. 1976) SD Catalog No. C13.10:457.

Key words: abstracts; Center for Building Technology; key words; publications.

This report presents the National Bureau of Standard's (NBS) Center for Building Technology (CBT) publications of the past decade. Publications constitute a major end product of CBT's efforts. They appear in several publication series (Building Science Series, Technical Note, NBS Report, NBS Interagency Report, Handbook, Special Publication, the Journal of Research, and the Consumer Information Series).

HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

H115. Supplement 1. **Energy conservation program guide for industry and commerce (EPIC),** R. G. Massey, Ed. *Nat. Bur. Stand. (U.S.), Handb. 115, Suppl. 1*, 212 pages (Dec. 1975) SD Catalog No. C13.11:115/Suppl. 1.

Key words: energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

The Energy Conservation Program Guide for Industry and Commerce (EPIC) is a handbook to assist business firms to establish an on-going conservation program. Supplement contains simplified management program, additional conservation opportunities, case studies, and sources of information.

H120. **Energy management guide for light industry and commerce,** W. J. Kelnhofer and L. A. Wood, *Nat. Bur. Stand. (U.S.), Handb. 120*, 28 pages (Dec. 1976) SD Catalog No. C13.11:120.

Key words: energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

The Energy Management Guide for Light Industry and Commerce is a training tool to assist small industrial and commercial organizations in an energy conservation program. It is part of a planned series, starting with NBS HB-115 (EPIC), of guides and training aids to assist industry in making the most efficient use of the energy supply.

While much of the information in the Light Industry Guide has been published in EPIC, the material has been edited and rewritten in shortened form for use by the large number of small organizations with a limited supply of technical manpower. The energy conservation case studies (Cost Saving Opportunities) have been written with this target audience in mind.

NBS INTERAGENCY REPORTS

The Interagency Reports are a special series of interim or final reports on work generally performed by NBS for outside sponsors (both government and non-government). When released by the National Bureau of Standards and the Sponsor, initial distribution is handled by the Sponsor. Public availability is by the National Technical Information Service (NTIS), Springfield, Va. 22161. This series must be ordered from NTIS by the order number listed at the end of each entry.

NBSIR 75-974. **The demonstration of experimental lead paint hazard abatement in Atlanta, Georgia,** T. H. Boone, H. W. Berger, A. P. Cramp, and H. A. Jackson, 121 pages (Dec. 1975). Order from NTIS as PB249777.

Key words: abatement; barrier materials; building materials; children; housing; lead-based paint; lead poisoning; paint removal.

This report describes the second stage of an experimental lead paint hazard abatement program carried out in 80 dwelling units in Atlanta, Georgia. The entire program will ultimately involve the abatement of lead paint hazards in a total of approximately 250 dwelling units distributed over three or more cities.

The procedures demonstrated in this field testing program were: paint removal using chemical solvents; paint removal using three heat producing devices; the replacement of components such as windows, doors, and wood trim and the installation of flexible sheet materials, rigid boards, plaster products and aggregate filled coatings, over existing lead paint on walls. Also evaluated was the covering of deteriorated, lead paint coated floors with plywood.

The report includes procedures for inspecting and selecting dwellings for lead paint hazard abatement, evaluations of the suitability and implementation characteristics of the abatement methods, and recommendations for their use.

Subsequent reports will present the results of comparable programs in additional cities and a final report will compare the cost-effectiveness of the alternative abatement methods.

NBSIR 76-982. **Data processing and data analysis procedures for fire load and live load survey program,** R. M. McCabe, C. Culver, L. T. Lee, and J. G. Hirschberg, 344 pages (Dec. 1975). Order from NTIS as PB248699.

Key words: buildings; computers; data processing; fire loads; load surveys.

Data collection and data processing procedures utilized in connection with a nationwide fire load and live load survey program are described. The techniques developed for transferring the field survey data to a form suitable for computer processing are discussed. Procedures adopted for data analysis are included. Documentation of the computer programs developed for this purpose is also presented.

NBSIR 76-986. **Building energy authority and regulations survey: State activity,** R. M. Eisenhard, 52 pages (Jan. 1976). Order from NTIS as PB250858.

Key words: authority; building; energy; legislation; regulations; state.

This report provides the status of State authority to regulate energy use in new buildings and the status of bills creating such authority that were pending in the 1975 legislative session. Regulations that have been developed are identified and described. Legislation relating to solar energy, retrofitting, insulation and other building energy matters, is identified and the status indicated.

NBSIR 76-987. **Effect of insulation on the surface temperature of roof membranes,** W. J. Rossiter, Jr. and R. G. Mathey, 20 pages (Feb. 1976). Order from NTIS as PB250857.

Key words: built-up roofing; insulation; performance; radiative cooling; roofing; solar heating; surface temperature.

The surface temperatures of black, gray and white roofs were calculated for various thicknesses of insulation located between the membrane and roof deck. The calculations were performed using a steady-state heat balance equation to illustrate the increase in roof surface temperatures due to solar radiation.

The calculations indicate that the first increment, about 1 inch (25 mm), of insulation causes a significant rise in the roof surface temperature due to solar radiation. Increasing the amount of insulation above this first increment to greater thicknesses does not appreciably increase the roof surface temperature.

NBSIR 76-1003. **Thermal conductivity and electrical resistivity of six copper-base alloys,** M. C. I. Siu, W. L. Carroll, and T. W. Watson, 22 pages (Mar. 1976). Order from NTIS as PB251211.

Key words: copper-base alloy properties; electrical resistivity; Smith-Palmer equation; thermal conductivity.

Measurements of the thermal conductivity, λ, and electrical resistivity, ρ, of oxygen free copper and six copper-base alloys in the temperature range 298 to 924 K are presented. Except for copper, the λ and ρ values of copper alloys having the same chemical composition as those given in this paper have not been previously reported. The measured values of $\lambda(W\cdot m^{-1}\cdot K^{-1})$ and $\rho(\Omega\cdot m)$ were found to conform, within 10 percent, to the predictions of the Smith-Palmer equation, $\lambda=2.39\times10^{-8}\ T/\rho+7.50$ $[W\cdot m^{-1}\cdot K^{-1}]$, where T is the thermodynamic temperature expressed in kelvins.

NBSIR 76-1008. **Energy conservation through the facilitation of increased blended cement use,** P. W. Brown, J. R. Clifton, and G. Frohnsdorff, 28 pages (Feb. 1976). Order from NTIS as PB251218.

Key words: blast furnace slag; blended cements; energy conservation; fly ash.

About 95 percent of the cement produced in the United States is portland cement and its manufacture requires about 2 percent of the energy consumed annually in the nation's industrial processes. The production of blended cements containing substantial amounts of fly ash or blast furnace slag and their substitution for portland cement appears attractive from the standpoint of energy conservation. While production and utilization of blended cements in other industrialized countries is extensive, blended cements account for less than 1 percent of the total cement production in the U.S. The reasons for the small U.S. production of blended cements are discussed in the contexts of standards revision and the need for the development of additional data as a basis for this revision.

NBSIR 76-1011. **Exploratory study of glowing electrical connections,** W. J. Meese and R. W. Beausoliel, 30 pages (Oct. 1976). Order from NTIS as PB259641.

Key words: arcing/sparking; branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections.

This report describes and characterizes with quantifiable electrical and thermal measures the extent to which loose electrical connections in residential-type branch circuits have overheated in the laboratory. With loose electrical connections, which conceivably could be inadvertently duplicated in field installations, but with otherwise normal installation and operating conditions, visible glows have been observed under laboratory test conditions in nominal 120-volt, 15 and 20 ampere branch circuits with both copper and aluminum wire. Characteristics of the glow condition are differentiated from arcing/sparking as sometimes observed in making or breaking electric circuits.

Glowing electrical connections may dissipate as much as 35 watts of power with a current of 15 amps in the circuit and as much as 5 watts with a current of 0.8 amp in the circuit. Temperatures over 750 °F were measured on the "break-off tab" of receptacles. Metal outlet boxes housing glowing connections in an insulated wall test set-up representative of a common type of residential construction attained temperatures in excess of 450 °F. In laboratory tests under repetitive, intermittent and periodic cycles, a connection on a steel wire-binding screw of a receptacle open to the air had sustained glow conditions maintained for over 100 hours. Glowing connections will not perceptibly affect the electrical performance function of lights, appliances or other electrical loads, and will not "blow" fuses, trip circuit breakers or operate ground fault circuit interrupters.

NBSIR 76-1020. **Guide criteria for laboratory evaluation of backflow prevention devices for protection of potable water supplies,** G. C. Sherlin, R. W. Beausoliel, and L. S. Galowin, 44 pages (Mar. 1976). Order from NTIS as PB258256.

Key words: backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; potable water protection; plumbing guide criteria.

This report describes laboratory evaluation procedures which could be required for the approval of backflow prevention devices used to protect potable water supplies against contamination. Performance-based requirements, criteria, and general evaluation considerations that administrative authorities should require for approval of devices are presented. Recommendations for the development of tracer tests are submitted for further consideration. This document results from an investigation undertaken for the Environmental Protection Agency (EPA).

NBSIR 76-1024. **Statistical analysis of blood lead levels of children surveyed in Pittsburgh, Pennsylvania: Analytical methodology and summary results,** W. D. Urban, 75 pages (Apr. 1976). Order from NTIS as PB255876.

Key words: blood; blood lead; children; housing; lead paint; lead poisoning; surveys.

A survey was conducted in Pittsburgh, Pennsylvania to estimate the incidence of lead paint in housing and to develop a survey methodology that could be used in other metropolitan communities for that purpose. A secondary objective of the survey was to determine whether a causal relationship could be found between blood lead levels of children aged 7 years or less, living in the surveyed dwellings and the presence of lead paint in those dwellings. This report deals with the latter objective. For the children tested in Pittsburgh, the incidence of elevated blood lead levels defined as 40 micrograms of lead per 100 milliliters of blood or greater, was found to be less than 1 percent, too low to permit the establishment of a causal relationship. There was a significant correlation between the blood lead levels of the children living in the older homes and the fraction of contaminated surfaces within the dwellings. In addition, there was a significant correlation between the blood lead levels and the age of the dwellings in which the children resided. This correlation appeared to be independent of the lead paint levels in the dwellings. This report presents a summary of the survey procedures, the blood lead measurement process and associated problems and the more significant results of the analysis of the housing/blood lead data obtained in Pittsburgh.

NBSIR 76-1025. **Air-mobility rigid shelter systems,** T. W. Reichard and L. F. Skoda, 99 pages (Nov. 1975). Order from NTIS as PB251753.

Key words: durability; field inspection; foam and beam; honeycomb; impact; lightweight structures; military; reliability; sandwich panel; shelter.

This interim report covers the first portion of a long-range investigation dealing with the design and durability of lightweight, rigid structures (shelters) used by the military as combination shipping containers and housing for tactical and life-support services. This report covers the results of field and laboratory studies intended to correlate functional and structural problems with in-service conditions. It was found that water leakage into the shelters and into the sandwich panels was probably the basic problem area although many shelters appeared to have been defective at the time of delivery. It was found that, under adverse conditions, a polyamid paper honeycomb core would be significantly better for the sandwich panels than is the draft paper core now used. Major delaminations of the sandwich panels could not be correlated with impact damage such as would be caused by forklift bumps.

Subsequent reports will present the results from a structural analysis of and field test on shelters subjected to typical dynamic and static loading conditions.

NBSIR 76-1029. **Unitary heat pump specification for military family housing,** C. W. Phillips, B. A. Peavy, and W. J. Mulroy, 30 pages (Aug. 1976). Order from NTIS as PB261199.

Key words: heating and cooling; military family housing; specification; unitary heat pump.

The purpose of this report is to establish, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability and reliability for system and components; and conformance conditions. This report is intended for guidance in military procurement and applies to hermetic electrically-driven vapor-compression unitary heat pumps of the remote (split) and packages (integral) types, the air-to-air and water-to-air classes, and sizes from 17,000 to 84,000 Btu/hr for both heating and cooling functions.

NBSIR 76-1043. **An economic analysis of residential abandonment and rehabilitation,** P. F. Colwell, 111 pages (May 1976). Order from NTIS as PB254347.

Key words: housing; housing demand, supply, needs; housing rehabilitation; land economics; market adjustments; optimization and feasibility; rehabilitation, conservation.

This paper is an analysis of market and governmental factors which lead to socially inefficient rehabilitation and abandonment decisions. Its purpose is to abstract from complex problems related to the rehabilitation and abandonment of residential buildings by identifying the essential characteristics of the problems and the role some past and existing social programs have had on aggravating or mitigating these problems. Alternative programs are analyzed for their potential effects on these problems, however policy recommendations are not made.

NBSIR 76-1046. **Improved building design through the psychology of perception: Perceptual selectivity applied to livability and safety with sample performance requirements,** N. Starnes, R. Wehrli, and R. Cormack, 103 pages (July 1976). Order from NTIS as PB256476.

Key words: architectural psychology; architectural research; building research; building safety; perception; stair safety research.

For over a decade, architects have been calling for applications from social science which would contribute to building design better suited to the building's users. This report provides such applications relying upon the state-of-the-art knowledge of the psychology of perception, showing how human perception operates in the everyday use of buildings, and then drawing upon this rationale to present building requirements to guide the design and construction of safer stairs in future buildings. The building safety "requirements" have been written in the format and style of the *Guide Criteria for the Design and Evaluation of Innovative Housing Systems,* a housing performance specification written by NBS for HUD's large housing experiment, Operation Breakthrough. The report is directed toward both building designers (who could consider the use of the stair safety requirements for their own building projects) and architectural psychology researchers (who could take the proposed requirements as a set of hypotheses in further research and experimentation).

NBSIR 76-1050. **Tornado-borne missile speeds,** E. Simiu and M. Cordes, 63 pages (Apr. 1976). Order from NTIS as PB253111.

Key words: missiles; nuclear engineering; structural engineering; tornadoes; wind.

At the request of the U.S. Nuclear Regulatory Commission (NRC) the National Bureau of Standards (NBS) has carried out an independent investigation into the question of tornado-borne missile speeds, with a view to assisting NRC in identifying pertinent areas of uncertainty and in estimating credible tornado-borne missile speeds—within the limitations inherent in the present state of the art. The investigation consists of two parts: 1) a study, covered in this report, in which a rational model for the missile motion is proposed, and numerical experiments are carried out corresponding to various assumptions on the initial conditions of the missile motion, the structure of the tornado flow, and the aerodynamic properties of the missile; 2) a theoretical and experimental study of tornado-borne missile aerodynamics, conducted by Colorado State Univ. (CSU) under contract with NBS, to be covered in a separate report by CSU. In the present report, the factors affecting missile motion, and their influence upon such motion, are examined. Information is provided on a computer program developed for calculating missile speeds. Maximum speeds for a number of specified potential tornado-borne missiles are presented, corresponding to a set of assumptions believed by the writers to be reasonable for design purposes. It is pointed out that higher speeds are conceivable if it is assumed that certain circumstances, examined in the body of the report, will obtain. It is the judgment of the writers that the probabilities of occurrence of such higher speeds for any given tornado strike are low. More than qualitative estimates of such probabilities, are however, beyond the scope of this investigation.

NBSIR 76-1056. **Analysis of solar energy system for the GSA demonstration office building at Manchester, New Hampshire,** T. Kusuda, S. T. Liu, J. W. Bean, and J. P. Barnett, 35 pages (Mar. 1, 1976). Order from NTIS as PB254179.

Key words: energy conservation; GSA/Manchester building; solar collector; solar heating and cooling; thermal storage.

The energy conservation demonstration building of the General Services Administration to be built in Manchester, New Hampshire, has been planned to be partially heated and cooled by solar energy. Presented in this report are results of a study made at the National Bureau of Standards to determine the effect of solar collector sizes and the amount of storage on the overall energy consumption of the building. It was found that the fuel savings attainable by the use of solar energy for heating and cooling of the building will be less significant as the size of the collector and the amount of storage are increased beyond certain limits.

NBSIR 76-1058. **Performance of mobile homes—Summary report,** J. H. Pielert, W. E. Greene, Jr., L. F. Skoda, and W. G. Street, 143 pages (Apr. 1976). Order from NTIS as PB262097.

Key words: computer techniques; construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards.

This project was funded at the National Bureau of Standards by the Department of Housing and Urban Development with the objective of documenting mobile home performance problems and relating them to possible inadequacies in the ANSI A119.1 Standard for Mobile Homes and the mobile home enforcement process. Additionally, the durability of mobile home components was a study objective for potential use in mortgage insurance evaluation. Mobile home performance data were obtained for 4,105 mobile homes, categorized and related to the project objectives. This summary report is the last of a series of four project reports. It documents the project approach, results of the various tasks, and presents conclusions and recommendations. This was a problem-oriented study and did not attempt to document the many areas of satisfactory mobile home performance.

NBSIR 76-1059. **Intermediate minimum property standards for solar heating and domestic hot water systems,** Solar Energy Program Team, Center for Building Technology, 171 pages (Apr. 1976). Order from NTIS as PB257086.

Key words: solar buildings; solar collectors; solar domestic hot water systems; solar heating; standards; thermal storage.

This report presents standards for the use of solar heating and domestic hot water systems in residential applications. The standards have been developed for application in numerous housing programs of the Department of Housing and Urban Development and are a companion document to be used in conjunction with the HUD "Minimum Property Standards for One and Two Family Dwellings," 4900 and "Minimum Property Standards for Multifamily Housing," 4910. To the greatest extent possible, these standards are based on current state-of-the-art practice and on nationally recognized standards including the MPS and the HUD "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings."

NBSIR 76-1063. **Air leakage measurements in a mobile home,** C. M. Hunt, S. J. Treado, and B. A. Peavy, 27 pages (Aug. 1976). Order from NTIS as PB257102.

Key words: air infiltration measurement; air leakage measurement; mobile home tightness; sulfur hexafluoride tracer measurement.

Air leakage measurements were made in a mobile home using sulfur hexafluoride (SF_6) as a tracer gas. The home was located in an environmental chamber where it was possible to measure and control the temperature outside the home. The effect on infiltration rate of a number of variables was determined. These included inside-outside temperature difference, simulated wind, installation of storm windows, opening of doors, and operation of the furnace fan. Experiments were also performed in which a fan was sealed to an opening in the house and inside-outside pressure difference measured as the fan blew air into or out of the structure at measured rates.

NBSIR 76-1064. **Existing architectural information indexing systems,** R. J. Kapsch, 68 pages (Mar. 1976). Order from NTIS as PB254181.

Key words: architectural indexing systems; architecture; building; construction; design; information; information retrieval system.

Architectural indexing systems are those mechanisms which we use to organize information concerning how and what to build. Architectural indexing systems are a means of organizing available information in a manner that can readily be grasped by the user. As such, architectural indexing systems are an important component part of architectural information systems. This report reviews and summarizes existing architectural indexing systems presently used in the United States and overseas. Indexing systems reviewed are classified into (1) one way divisions, (2) two way divisions, (3) thesauri and other indexing systems.

NBSIR 76-1070. **Evaluation of backflow prevention devices: A state-of-the-art report,** G. C. Sherlin and R. W. Beausoliel, 142 pages (June 1976). Order from NTIS as PB260913.

Key words: backflow; backflow preventers; back pressure; back-siphonage; cross connections; health hazard; potable water; vacuum breaker; water supply.

A significant potential for potable water supply contamination exists within all water supply systems due to backflow and cross connections. Surveillance of the water supplies to protect from such hazards requires continuing vigilance by the administrators of cross-connection control programs, and continuing upgrading of technical criteria and methods of evaluation.

The Environmental Protection Agency assists local (usually municipal) authorities, through the State water supply agency, in establishing and operating cross-connection control programs. Essential to these programs are (1) information on the suitability of commercially available devices for use in potentially high-hazard locations, and (2) practical and effective standardized test methods for evaluation of devices. The National Bureau of Standards investigation reported herein addresses the two needs identified.

This study includes a systematic review of the literature, together with consultations and visits with water purveyors, plumbing officials, laboratory officials and researchers in this field. Emphasis has been placed on those devices, test methods, and laboratory practices considered most essential to an effective assessment of the state-of-the-art. Also, test development needs were identified in a few areas of greatest concern.

NBSIR 76-1082. **A survey of State legislation relating to solar energy,** R. M. Eisenhard, 166 pages (Apr. 1976). Order from NTIS as PB258235.

Key words: architecture; buildings; design; energy; legislation; solar; State.

This report reviews enacted State legislation dealing with solar energy. Acts involving tax incentives, reduced property assessments, research and development, solar easements and solar energy promotion are identified and abstracted. The responsible State agency and official are listed. Acts and supporting forms and other information are included as appendices.

NBSIR 76-1098. **Daylighting of buildings. A compendium and study of its introduction and control,** J. K. Holton, 39 pages (Oct. 1976). Order from NTIS as PB259523.

Key words: daylight gathering; daylighting of buildings; energy conservation; lenses; light conduits; light control; reflectors; skylights; windows.

We can no longer ignore daylight as a valuable natural resource for building illumination. Significant reductions in the energy consumption of buildings are possible by decreasing the dependence on artificial illumination and decreasing air conditioning loads by employing methods which bring in cool light. In order to design buildings utilizing daylight effectively there must be an understanding of the design principles of daylighting. This requires a knowledge of illumination to meet the needs of the building users, an understanding of characteristics of daylight at the location of the building, and imagination in developing ways to introduce and control daylight. This paper is directed toward the identification of innovative techniques for the introduction and control of daylight. It is arranged in three sections: a Compendium, a Study section, and a Reference section. The Compendium presents a number of state-of-the-art methods to assist the designer in successfully employing daylight more extensively. The Study section provides more detailed information on these methods so an increased understanding can be developed of those which appear to have suitability in a given situation. Finally, the References provide background for further investigation.

The Study organizes daylighting methods as they relate to three zones of a building, the perimeter, the intermediate and the deep zone. Each has different characteristics and is suited to daylighting by different methods.

NBSIR 76-1109. **Architectural glazing safety standard: Survey of codes and standards,** S. C. Adler, 65 pages (Aug. 1976). Order from NTIS as PB257194.

Key words: architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law.

The report describes 34 test procedures extracted from 97 codes and standards identified in an extensive library search of English language codes and standards relating to architectural glazing. The report also contains summaries of existing state laws relating to safety glazing. Test descriptions include procedures, kinetic energy levels, purpose of tests, and acceptance/rejection criteria. Test methods, codes and standards, and sources are cross-referenced.

NBSIR 76-1131. **A model performance standard for guardrails,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 31 pages (July 1976). Order from NTIS as PB259242.

Key words: design; dynamic loads; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; static loads; stiffness; structural safety.

A model performance standard and design illustrations are presented for the design, construction and evaluation of guardrail systems, which will be used for the protection of employees against occupational hazards. The standard stipulates both structural and nonstructural safety requirements. Each criterion includes a commentary section describing the rationale used in its formulation. This rationale is for the most part, based on independent experimental and analytical research investigations conducted at NBS in behalf of OSHA.

NBSIR 76-1132. **Personnel guardrails for the prevention of occupational accidents,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 80 pages (July 1976). Order from NTIS as PB260363.

Key words: anthropometric measurements; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; structural safety.

Existing information is compiled which would assist in determining structural and nonstructural safety requirements for guardrails used for the protection of employees against occupational hazards. Critical aspects of guardrail safety are identified through exploratory studies consisting of field surveys of prototypical installations, reviews of existing standards and industrial accident records, and compilation of relevant anthropometric data. These exploratory studies will be utilized to design an experimental program which will consist of structural tests to determine design loads and nonstructural tests to determine geometric requirements for guardrail safety.

NBSIR 76-1137. **Thermal data requirements and performance evaluation procedures for the national solar heating and cooling demonstration program,** E. Streed, M. McCabe, D. Waksman, J. Hebrank, and T. Richtmyer, 86 pages (Aug. 1976). Order from NTIS as PB257770.

Key words: data requirements; measurement uncertainty; solar energy systems evaluation; thermal performance.

This report presents the results of a study to determine the data requirements and performance evaluation factors to be used in the National Solar Heating and Cooling Demonstration Program. Solar energy systems used for heating hot water, space heating, and space cooling have been considered and specific measurements and analytical procedures have been recommended to determine the thermal effectiveness for daily, monthly, seasonal, or annual operating periods. The sensor accuracy and sampling rate effects on measurement uncertainty for several performance factors is presented. Application of the individual performance factors for the comparison of subsystem and system thermal performance as a function of building type and climatic region is discussed.

NBSIR 76-1140. **Standards referenced in selected building codes,** B. M. Vogel, 447 pages (Oct. 1976). Order from NTIS as PB259626.

Key words: building codes; building regulations; building regulatory system; standards.

This publication provides a compilation of the standards that are referenced in the building codes promulgated by: (1) the three model building code organizations; i.e., Building Officials and Code Administrators International, Inc. (BOCA); International Conference of Building Officials (ICBO); and the Southern Building Code Congress International, Inc. (SBCC); (2) the twenty States that have either mandatory or voluntary building codes; and (3) the thirty largest U.S. cities. In addition to identifying each standard referenced in the above named codes, this publication lists the current date of the standard, its current title, the codes referencing it, the date of the code, the locations within the code where the standard is referenced, and the date of the standard referenced in the code. This publication is intended to provide a base for assisting the building community in updating, utilizing and maintaining the standards referenced in building codes.

NBSIR 76-1142. **Considerations and standards for visual inspection techniques,** G. T. Yonemura, 17 pages (Oct. 1976). Order from NTIS as PB263099.

Key words: nondestructive testing; modulation transfer function; vision; visual acuity; visual capacities.

When we look at the capacity of the human visual system we see that it has many capacities depending on the circumstances under which it is used. The sensory data show that man can adjust to a wide variety of operating conditions. But, unless we have detailed information of the conditions for which these processes are to be optimized and quantitative descriptions of the tasks to be performed, the advantages to be obtained by visual science applications cannot be optimally utilized. Physical correlates of the response should be quantified, followed by a systematic scaling of the physical correlates for application to nondestructive testing. The Modulation Transfer Function widely used in optical imaging assessments would be an evaluation technique applicable to hardware, processing and image description.

NBSIR 76-1143. **Plan for the development and implementation of standards for solar heating and cooling applications,** D. Waksman, J. H. Pielert, R. D. Dikkers, and E. R. Streed, 55 pages (Aug. 1976). Order from NTIS as PB257769.

Key words: buildings; solar energy; standards.

A plan is presented concerning the need, implementation and general scope of standards which may be required for solar heating and cooling applications. Overviews of the building regulatory system in the United States are given along with a listing of the various standards which will be required for the various solar systems, subsystems, components and materials. These include Test Method Standards, Recommended Practice Standards and Specification Standards. Activities relative to standards implementation include laboratory accreditation, certification, training and manuals of accepted practice. The development of standards for solar applications by the Federal Government are outlined, as well as the potential interface and utilization of the existing consensus standards generating organizations.

NBSIR 76-1162. **FY 1975-1976 international building research activities, Center for Building Technology,** S. G. Webber, 67 pages (Nov. 1976). Order from NTIS as PB260879.

Key words: building research; cooperative programs; information exchange; international building research; international organization memberships; special foreign currency programs.

This report documents international building research activities of the Center for Building Technology (CBT) during Fiscal Year 1975 and 1976 (July 1, 1974-June 30, 1976). CBT carries out extensive interactions with foreign and international research organizations to exchange building research efforts. This report presents a summary of CBT's cooperative programs in building technology, international organization memberships, exchange programs, information exchanges, and foreign visits to NBS.

NBSIR 76-1187. **Interim performance criteria for solar heating and cooling systems in commercial buildings,** 100 pages (Nov. 1976). Order from NTIS as PB262114.

Key words: buildings; cooling; heating; hot water; performance criteria; solar energy; standards.

Public Law 93-409, the Solar Heating and Cooling Demonstration Act of 1974, provides for "demonstration within a three-year period of the practical use of solar heating technology, and .... the development and demonstration within a five-year period of the practical use of combined heating and cooling technology." Under the provisions of the Act, in February 1975, the NASA developed a first edition of this document containing interim performance criteria for the design and evaluation of solar heating and cooling systems to be demonstrated in commercial buildings. Since that time, responsibility for further development of the document has been assumed by the NBS. This second edition of the "commercial criteria" represents the first revision to the NASA document. It is expected that this document will be updated periodically as data and information are gained from the demonstration program.

Reprints from the journals listed in this section may often be obtained from the authors. Each entry has been assigned a five-digit number for NBS identification and listing purposes.

15712. Kelly, G. E., Didion, D. A., **A laboratory test of the modular concept as applied to gas-fired boilers,** (Proc. Conf. on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings, Oct. 7-8, 1974), Paper in *Proceedings of Conference on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings,* D. A. Didion and V. Goldschmidt, Eds., pp. 18-30 (Purdue Research Foundation, Lafayette, IN, Oct. 1974).

Key words: boiler oversizing; efficiency vs. heating load; modular boilers; modular concept; seasonal efficiency.

The modular concept of boiler operation was examined in a laboratory test of five gas-fired, cast iron, hydronic boilers. Four of the boilers, each having an input rating of 85,000 Btu per hour, were arranged so that they could either be operated like a single boiler (i.e., all of the boilers either on or off) or as a modular installation in which the boilers are sequentially fired to match the number in operation with the heating load. The fifth boiler had an input rating of 300,000 Btu per hour and was operated as a single boiler installation. Efficiency vs. heating load curves were obtained for the single boiler installation, the four small boilers run like a single boiler and the modular installation operated with and without water flowing through the "idle" modules. These efficiency curves were then used to theoretically predict the effect of the modular concept and boiler oversizing on the seasonal efficiency of gas-fired heating plants.

15713. Achenbach, P. R., **Status of energy standards for heating, ventilating and air-conditioning systems in buildings,** (Addendum to Proc. of Conf. on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings, Oct. 7-8, 1974), Paper in *Addendum to Proceedings of Conference on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings,* P. Newman, Ed., pp. A134-A142 (Purdue Research Foundation, Lafayette, IN, 1975).

Key words: energy conservation; energy standards for mechanical systems; heating and air-conditioning systems; state energy regulations.

The circumstances in energy supply are described which caused the National Conference of States on Building Codes and Standards to request the National Bureau of Standards in 1973 to develop an interim standard for energy conservation in new buildings. The progress in development of such a standard by NBS and the American Society of Heating, Refrigerating and Air-Conditioning Engineers is chronicled to October 1974. The principal policy issues raised by the preparation of an energy conservation standard which could become the basis for State and local regulations are discussed. The components of heating and air-conditioning systems which are at issue between the NBS and ASHRAE documents for inclusion in the energy conservation standard are identified. The long-range objectives of the Federal Energy Administration in developing energy conservation requirements for buildings are summarized.

15741. Powell, F. J., **The Manchester, NH, experimental energy office building,** (Proc. Seminar on Energy Conservation by Design, Orlando, FL, March 20-21, 1974), Paper in *Proceedings Energy Conservation—By Design, Section 14, 1-14 (Harry Phipps, Energy Systems Consultants, St. Petersburg, FL, 1974).*

Key words: energy conservation; energy consumption prediction; experimental office building.

A brief background of the experimental 7-story Federal Energy Demonstration Office Building to be constructed at Manchester, N.H. is given. A summary of the results of a predesign energy analysis done at NBS is presented as a comparison of normal General Services Administration practice in 1972 with changes made for a new energy conservation design approach. A similar comparison is made for the same building if the location were changed to Orlando, Fla. The results indicate annual energy savings of 52 percent for Manchester and 39 percent for Orlando are possible by using additional thermal insulation in the roof, walls and floor, reducing the window area, reducing the quantity of ventilation and lighting power, and using energy efficient heating, ventilating and air-conditioning systems.

15756. Hahn, M. H., Robinson, H. E., Flynn, D. R., **Robinson line-heat-source guarded hot plate apparatus,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 544,* pp. 167-192 (1974).

Key words: conduction; energy conservation; heat transfer; insulation; thermal conductivity; thermal insulation.

This paper presents a description of the line-heat-source guarded hot plate apparatus conceived by the late H. E. Robinson, the results of mathematical analyses of potential sources of uncertainty, and the design of an apparatus of this type being constructed at the National Bureau of Standards. This design utilizes a line source heater, from which heat diffuses laterally in the plate. Such a design does not produce a wholly uniform plate temperature, but does enable calculation of average plate surface, and edge, temperatures utilizing only a few temperature sensors.

15762. Burch, D. M., Peavy, B. A., Powell, F. J., **Comparison between measured and computer-predicted hourly heating and cooling energy requirements for an instrumented wood framed townhouse,** *ASHRAE Trans.* **81,** Part II, Paper No. 2363, 70-88 (1975).

Key words: building heat transfer; computer programs; dynamic thermal performance; heat flow analysis; heating and cooling loads; thermal analysis; transient heat flows.

A sophisticated computer program called NBSLD was validated for predicting the hourly heating and cooling loads of a residence. An instrumented four-bedroom townhouse was exposed to simulated winter and summer conditions inside a large environmental laboratory. During the tests, the activities of a six member family were simulated, and the inside temperature of the test house was maintained at approximately 75 °F (23.9 °C). Hourly heating and cooling input energy was measured and compared with corresponding computer-predicted values. The NBSLD computer program predicted maximum heating and cooling input loads within 9.2 percent, and energy requirements within 8.2 percent.

15782. Mathey, R. G., Clifton, J. R., **Bond of coated reinforcing bars in concrete,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST1, 215-229 (Jan. 1976).

Key words: bond strength; coated reinforcing bars; evaluation; organic coatings; pullout tests.

The bond strengths were determined for 23 epoxy-coated (10 different epoxy coatings), six polyvinyl chloride-coated (three different coating materials), and five uncoated reinforcing bars. The length of embedment of the reinforcing bar in the concrete was 12 in (305 mm). The loads or bond stresses corresponding to a loaded-end slip of 0.01 in (0.25 mm) or a free-end slip of 0.002 in (0.051 mm) were considered as critical values in determining the bond strength, depending on which of these values of slip developed first. For coating film thicknesses ranging from 0.001 in to 0.011 in, the epoxy-coated bars developed bond strengths essentially equal to the bond strengths for uncoated bars. Experimental values were higher than minimum acceptable values in building code and highway bridge requirements. Bond strengths of the polyvinyl chloride-coated bars and bars with thick epoxy coatings were unacceptable.

15810. Marshall, H. E., Ruegg, R. T., **Cost sharing to induce efficient techniques of abating wastewater pollution,** *J. Environ. Econ. Manage.* **2,** 107-119 (1975).

Key words: cost sharing; efficiency; environment; financing; grants; pollution abatement; wastewater; water pollution; water resources.

This paper analyzes existing cost-sharing rules for wastewater pollution grants administered by the Environmental Protection Agency under the 1972 Amendments to the Federal Water Pollution Control Act. It identifies and measures biases in the existing cost-sharing rules that encourage nonfederal interests to select particular techniques (e.g., capital-intensive techniques) over others even when the selected techniques are not the least costly to the nation. The paper develops theoretically a cost-sharing condition – that the same percentage cost share be applied to all abatement techniques – that would eliminate the cost-sharing bias. Alternative cost-sharing approaches are evaluated in terms of their biasing effects and their absolute dollar costs for federal and nonfederal project participants.

15871. Simiu, E., **Equivalent static wind loads for tall building design,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** ST4, 719-737 (Apr. 1976).

Key words: accelerations; building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind engineering; wind loads.

Certain shortcomings of current procedures for computing alongwind structural response have beeen shown to result in unrealistic estimates of tall building behavior under the action of strong winds. Differences between predictions of fluctuating response based on various such procedures have been shown to be in certain cases as high as 200 percent. The purpose of the present work is to present a procedure for calculating alongwind response, including deflections and accelerations, which incorporates these advances. The meteorological and aerodynamic models on which the procedure is based are described in brief. The practical use of the procedure is illustrated in a numerical example. Estimates are provided of errors inherent in the models employed. The range of applicability of the procedure is defined, and it is indicated that for structures with unusual modal shapes or for which the influence of higher vibration modes is significant, a recently developed computer program should be employed in lieu of the procedure presented herein.

15882. Achenbach, P. R., **Government activities and regulations for buildings on energy saving standards. A look at what various agencies have done and intend to do for energy conservation,** *Heat./Piping/Air Cond.* **47,** No. 13, 41-46 (Dec. 1975).

Key words: energy consumption in NYC schools; energy-saving opportunities; incentives – educational, persuasive, financial, regulatory; modular boiler study; NBS-campus energy retrofit; retrofitting existing buildings.

The major near-term opportunity for energy conservation in buildings occurs in the existing building inventory, which includes some 70-million residential and several million commercial and institutional buildings, constructed before energy conservation was a recognized national need. This paper identifies 1) existing documents relating to retrofit, and 2) documents in development for both new and extant buildings with potential impact on regulations, standards, and codes, if the energy shortage persists.

Federal and State government incentives for building owners or operators to work for energy conservation are broadly classified as *educational* – seminars, conferences, publications with wide dissemination for use as guidelines; *persuasive* – exhortation by government and community leaders, and commercial sales efforts toward modification of present buildings or inclusion of energy-efficient components in new buildings; *regulatory* – standards, specifications, regulations and codes – voluntary and mandatory; and *financial* – tax breaks, low-interest loans, direct subsidy, etc. The paper lists documents now available and some in progress, and cites ongoing studies with potential large impact on the Nation's energy conservation effort. The latter include a retrofit of selected NBS laboratories for energy conservation and comparison; a study of existing New York City school buildings for energy consumption; a demonstration of energy savings in a 20-yr-old frame house by sealing leaks, installing storm windows and insulation; and a study of modular boilers which indicates that using several equal-capacity boilers to service a load in lieu of a single large boiler enables operators to match the load under varying weather conditions, and could lead to an approximate 10 percent saving during a typical winter heating season.

15890. Achenbach, P. R., **Government participation in safety standards for refrigerating and air conditioning equipment,** (Proc. Symp. on Domestic Refrigerator and Room Air Conditioners – Safety Standards and Service, Lake Placid, NY, June 24-26, 1968), *ASHRAE Special Bull.* **LP 68-3,** 8-12 (1968).

Key words: Government participation; refrigeration safety standards; safety of appliances; standards for safety.

Consumer protection against equipment hazards can be broadly categorized into three areas: hazard to health, hazard to life, and hazard to property. The principal instrumentalities through which safety requirements are brought into general use are: 1) state, municipal and model national codes, 2) national, international, mandatory and association standards, and 3) procurement specifications. The manufacturers of refrigerators, freezers, and air conditioners have, in general, provided the organizational leadership in preparing, sponsoring, and revising safety standards in the United States. However, agencies of the Federal Government are active in most national standards organizations concerned with equipment safety, and frequently conduct research on materials, systems, and equipment to develop technical information on safety for use in codes, standards, and specifications. Several specific investigations of refrigerators, freezers, and water coolers are described briefly to illustrate the kinds of hazards that may occur from choice of materials, design of a system, or manner of use by the owner.

15899. Simiu, E., Patel, V. C., Nash, J. F., **Mean speed profiles of hurricane winds,** *J. Eng. Mech. Div. Proc. Am. Soc. Civil Eng.* **102,** EM2, 265-273 (Apr. 1976).

Key words: boundary layer; hurricanes; loads (forces); natural analysis; tall buildings; wind profiles.

A numerical solution of the hurricane boundary layer problem is presented in which the hurricane is modeled as a steady, axisymmetric, neutrally stratified flow. The turbulence effects in the flow are accounted for by the phenomenological relations proposed by Bradshaw et al., and Nash, which provide a considerably more realistic picture of the actual flow than the pseudolaminar model used in previous solutions of the boundary layer problem. The results of the calculations obtained on the basis of the model just described suggest that: (1) in the height range of interest to the structural designer, say up to a height of 400 m above ground, it is permissible to use the logarithmic law to represent the mean velocity profile of hurricane winds and (2) if the relation between wind speeds in different roughness regimes which obtains in extratropical storms is applied to hurricane winds, the speeds over built-up terrain, calculated as functions of speed over open terrain, may be underestimated by about 10 percent and 10-20 percent in suburban and in urban exposure, respectively. The corresponding mean loads are then underestimated by about 15 and 30 percent, respectively.

15992. Gutschick, K. A., Clifton, J. R., **Durability study of 14-year old masonry wallettes,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 589, Masonry: Past and Present,* 76-95 (Aug. 1975).

Key words: lime (dolomitic); masonry; mortars (materials); portland cement; testing; walls.

A series of brick wallettes originally built to study the effect of five variables, particularly dolomitic lime, on dimensional stability were analyzed as to their durability performance after 14 years of outdoor exposure. Durability performance was assessed in terms of cracking (bond separation), mortar erosion, and efflorescence, with the influencing factors including type of lime, mortar, and brick, loading, climate, and exposure.

Generally, most walls performed well, considering that they in essence were "parapet" walls, unprotected from the elements on all sides. The greatest incidence of cracking occurred in walls built with the dense, low absorptive white brick and mortar made with high expansive lime; frost action was undoubtedly a contributing factor. Mortar erosion was most prevalent on the south faces of walls, particularly in walls built with the high absorptive red brick and mortar made with high expansive lime; thermal expansion was undoubtedly a contributing factor. Efflorescence was only slight. The study points to the importance of using compatible mortar-brick combinations to get the best performance.

16008. Yonemura, G. T., Kohayakawa, Y., **A new look at the research basis for lighting level recommendations,** *Proc. Symp. on The Basis for Effective Management of Lighting Energy, Washington, DC, Oct. 29-30, 1975,* pp. 151-183 (Federal Energy Administration, Washington, DC, 1976).

Key words: gratings; illuminating engineering; lighting; modulation transfer function; suprathreshold visibility; visibility; vision.

The validity of using threshold studies as the basis for lighting level recommendations is questioned. The performance of the eye at suprathreshold levels was investigated with sine- and square-wave gratings. The results indicate that the behavior of the eye is significantly different at suprathreshold levels as opposed to threshold levels. For threshold studies contrast is a monotonically decreasing function with respect to luminance. At suprathreshold levels the contrast function has a definite minimum, luminances greater or less requiring more contrast to appear subjectively equal. It is recommended that lighting levels be based on laboratory studies that appraise visual requirements and performance simulating conditions encountered in real world environments.

16020. Wehrli, R., Bryan, J., **Assemblage: A process-oriented teaching method,** *AIA J.,* pp. 75-77 (May 1976).

Key words: architectural-design teaching; assemblage; design critiques; feedback; teaching method.

Architecture for the future—with material shortages, environmental protection, and new technological possibilities—cannot be accommodated by traditional methods of design education. A new teaching method called assemblage, with feedback advantages, allows students to assemble special blocks to create designs while their instructor, using a scorecard, evaluates progress against fixed criteria which the student understands. Because design problems are increasingly complex with multiple criteria to satisfy, at early stages of design, the assemblage method is needed. It allows students to take multiple fixed criteria into consideration and the instructor to keep track of all design criteria while giving students immediate, analytical feedback on how well they are doing. With assemblage's design blocks and analytical scorecards, an instructor can assign simulation of real-world design problems, supply feedback from an analytical scorecard to encourage future improvement in design in less than an hour for each trial scheme. A 1968 experiment in assemblage demonstrated students learned perceptibly during six trials when given feedback (critiques), but learning was marginal when feedback was withheld.

16059. Marshall, H. E., **Efficiency impacts of cost sharing on shoreline management,** *Coastal Zone Manage. J.* **2,** No. 4, 369-382 (1976).

Key words: beach erosion control; Corps of Engineers; cost sharing; efficiency; hurricane protection; shoreline management; shoreline protection.

The nation's shorelines are being eroded by high winds and waves. Nonfederal interests have traditionally received federal help in the form of cost sharing for protective structures. This article describes, compares, and evaluates existing and alternative cost-sharing rules for shoreline protection on the basis of economic efficiency. Both engineering and management techniques are examined for beach erosion, hurricane, and emergency coastal flood protection. The present cost-sharing systees.

16072. Culver, C., **Fire loads and live loads in buildings,** *Proc. Int. Conf. on Performance of Building Structures, Glasgow, Scotland, Mar. 31-Apr. 1, 1976,* **1,** 111-119 (Pentech Press Ltd., London, England, 1976).

Key words: buildings; fire loads; load surveys; occupancy live loads; structural engineering.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program and the type of data collected are included. Preliminary survey results obtained from the NBS Administration building are described.

16083. Snell, J. E., **Comments on drainage system performance,** *Proc. CIB Commission W62 Symp. on Drainage Services in Buildings, National Swedish Institute for Building Research, Stockholm, Sweden, Sept. 24-25, 1973,* pp. 1:1-1:11 (Swedish Council for Building Research, Stockholm, Sweden, 1974).

Key words: gravity drainage evaluation; plumbing research.

A number of changes are taking place in plumbing system technology that may lead to significant departures from traditional dependence on gravity drainage. These factors include new designs and materials and the need to conserve water. A major concern in facilitating introduction of new technology is overcoming traditional roadblocks to innovation in this field. This paper describes an approach being pursued by the National Bureau of Standards and others to assure that performance of new systems is demonstrated in terms meaningful to local enforcement authorities.

16084. Siu, M. C. I., **Analysis of edge-heat-loss of a guarded-hot-plate apparatus,** *Proc. 14th Int. Conf. on Thermal Conductivity, Storrs, CT, June 2-4, 1975,* P. G. Klemans and T. K. Chu, Eds., pp. 413-422 (Plenum Press, NY, 1976).

Key words: ambient temperature index; edge-heat-loss; errors; guarded-hot-plate apparatus; line-heat-source; thermal conductivity.

Analysis on the error in measured specimen thermal conductivity arising from edge-heat-loss at the periphery of any guarded-hot-plate apparatus is presented. It is shown that the error due to edge-heat-loss varies linearly with respect to the deviation of the ambient temperature from mean specimen temperature. Explicit expressions are presented for the line-heat-source guarded-hot-plate apparatus being constructed at the National Bureau of Standards.

16087. Culver, C. G., **Comprehensive survey program for fire and live loads in buildings,** *Proc. Public Buildings Service International Conf. on Firesafety in High-Rise Buildings, Seattle, WA, Nov. 18, 1974,* pp. 1-30 (1974).

Key words: buildings; fires; loads; safety; surveys.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program, the type of data collected and data processing procedures as well as a brief description of the data analysis are included.

16091. Margulis, S. T., **The ICET testing program for the certification of engineering technicians,** *Prof. Eng.,* pp. 30-31 (Mar. 1976).

Key words: criteria; decision making; human systems; measuring instruments; research assistants; test device evaluation.

The Institute for the Certification of Engineering Technicians (ICET) certifies engineering technicians nationally. New criteria for voluntary certification have been instituted recently. Central to the approach is a new testing program to determine the technical competence of candidates. Those applying for Associate Engineering Technician or Engineering Technician status are required to pass a written examination; those applying for Senior Engineering Technician status must prepare a 5000-word technical essay.

The testing program is described and evaluated and special uses for the written examinations, which ICET proposes, are reviewed. Overall, the testing program suggests careful test development and a desire for continuing development. Tests appear to be technically sound. Plans for test evaluation, by ICET, will more clearly establish the strengths and weaknesses of the tests. Special uses for the tests—for assessing technical obsolescence as part of a continuing professional development program, and for helping candidates prepare for the written examination by completing a short version of the test, are commendable additions to the testing program.

16092. Burch, D. M., Peavy, B. A., Powell, F. J., **Experimental validation of the NBS load and indoor temperature prediction model,** *ASHRAE Trans.* **80,** Part 2, 291-310 (1974).

Key words: dynamic model; environmental chamber experiment; heating and cooling load computer program; heating load; masonry building.

Measurements of the dynamic heat transfer in an experimental masonry building were made in a large environmental chamber to explore the validity of a computer program developed at NBS for computing heating and cooling loads, and indoor air temperatures. The experimental structure was a one-room house 20 ft long, 20 ft wide, and 10 ft high with walls of solid concrete blocks and a flat roof made of reinforced precasts concrete slabs. The building was exposed to a diurnal temperature cycle for a series of tests where changes were made in fenestration, the amount and location of insulation, and the amount of indoor mass. The NBS computer program predicted both indoor air temperatures and heating loads that were in close agreement with the experimental data.

16101. Beausoliel, R. W., Phillips, C. W., Snell, J. E., **Field investigation of natural gas pipeline accident, Canterbury Woods, Annandale, VA,** *Fire J.* **68,** No. 3, 77-84 (May 1974).

Key words: Annandale; field test; gas explosion; leak detection.

On the morning of March 24, 1972, in Annandale, Virginia, two homes were destroyed and a third home damaged by gas explosions and fires resulting from a construction accident that caused the gas main leak. The National Transportation Safety Board was responsible for investigating this accident and requested that the National Bureau of Standards assist them with their investigation by conducting a field test at the accident site.

The objective of the test was to determine how the natural gas entered the homes and the paths the gas followed from the leak to the homes. The premise of the NBS test was that if an air-tracer mixture could be detected at locations where natural gas was known to have escaped, then the original underground gas paths may still exist. A detailed test plan was developed to determine gas escape locations and paths. This plan included a simulation of the underground gas movement, excavation of various utility trenches, soil tests, and dismantling of the foundation wall of one of the destroyed homes. The equipment used to introduce the tracer into the ground near the original leak consisted of an air compressor, a tracer source3refrigerant R-12), air flow measuring, piping and control valves. Electronic catalytic leak detectors were used to detect the tracer in homes and elsewhere on the test site. The test results substantiated the basic test premise, and tracer was detected in the basements of the two destroyed homes and the damaged home, but not in the undamaged homes. From the results, it is concluded that gas traveled through rock rubble on the site and used as backfill in utility trenches containing the individual water and sewer lines to the destroyed/damaged homes and entered the homes through leaks in their concrete block foundations.

16117. Judd, D. B., Nickerson, D., **Relation between Munsell and Swedish Natural Color System scales,** *J. Opt. Soc. Am.* **65,** No. 1, 85-90 (Jan. 1975).

Key words: color; colorimetry.

The degree to which Munsell hue, value, chroma and the Swedish Natural Color System variables of blackness, whiteness, redness, yellowness, greenness, blueness describe the same color space is shown by simple formulas.

16118. Kusuda, T., **NBSLD-National Bureau of Standards heating and cooling load determination program,** *APEC J.* **VIII,** No. 6, 4-11 (Winter 1973-1974).

Key words: computer program for buildings; conduction transfer functions; heating and cooling load; National Bureau of Standards load determination procedure.

A comprehensive treatment of building heat transfer processes has been incorporated into a computer program called NBSLD in order to study the effect of various building parameters upon the resulting heating and cooling load. The basis of the computation in the program is the detailed solution of simultaneous heat balance equations at all of the interior surfaces of a room or space. Transient heat conduction through the exterior walls and in the interior structures is handled by using ASHRAE type conduction transfer functions. The use of heat balance equations, although more time consuming for the calculation, avoids uncertainties inherent in a weighting factor approach. Thus, precision is improved for a specific building design. Described in this paper are some of the salient features of NBSLD and results of sample calculations which demonstrate the capability of this computer program.

16120. Powell, F. J., **Research on energy conservation in building at the National Bureau of Standards,** (Proc. Conf. on Buildings and the Environment, Cary Arboretum of New York Botanical Garden, Millbrook, NY, Nov. 1974), Chapter 6 in *Buildings and the Environment,* R. Goodland, Ed., pp. 114-140 (Cary Arboretum, Millbrook, NY, 1976).

Key words: buildings energy; energy conservation; NBS programs.

Selected topics of the National Bureau of Standards energy conservation program related to buildings are discussed. Topics included are the National Bureau of Standards Load Determination Computer Program (NBSLD) for estimating building energy consumption, the experimental results of tests on a masonry and a woodframe house, the status of an experiment on a mobile home, the study to retrofit an existing house on the NBS grounds to save energy, the experiment to retrofit a townhouse with solar collectors and storage systems to supply 75 percent of the annual energy needs of the townhouse, the energy conservation demonstrtation office building at Manchester, New Hampshire, and a new energy conservation school in New York City. Other energy conservation efforts are named by title only.

16129. Snell, J. E., Achenbach, P. R., Petersen, S. R., **Energy conservation in new housing design,** *Science* **192,** No. 4246, 1305-1311 (June 25, 1976).

Key words: energy conservation; energy efficient design; life-cycle cost models; new housing.

The combined influences of rising fuel prices and a national goal of energy independence are providing strong impetus to the consideration of energy conservation in design features in housing. This paper examines the potential implications of these influences to new housing design over the balance of this century. A life-cycle cost model is presented and used to estimate the influence of conservation and fuel price increase on a number of major housing design parameters. These parameters include housing type and size, thermal resistance, location, heating and cooling system capacity and efficiency. Next, the technological realities of achieving such changes are examined and the anticipated impacts of energy conservation on new housing design are summarized. It is felt that the principal emphasis will be on smaller more efficient dwellings, mechanical systems, and equipment with essentially improved overall performance utilizing technology readily available to the building industry.

16152. Powell, F. J., Kusuda, T., Hill, J. E., **Occupant comfort as a decision-making concept for air conditioning of buildings,** (Proc. CIB Commission W45 (Human Requirements) Symp. on Thermal Comfort and Moderate Heat Stress, Watford, England, Sept. 13-15, 1972), Paper in *Thermal Comfort and Moderate Heat Stress,* pp. 191-215 (Her Majesty's Stationery Office, London ECIV 3RN, England, 1973).

Key words: air conditioning criteria; human comfort; physiological indices; predicted indoor habitability index (PIHI); weather building human systems.

A rationale for improving air-conditioning criteria is given. A new research approach and concept are presented. The concept is to include in criteria the effect of the building envelope and the response of humans to the resultant indoor temperature and relative humididty in addition to weather data which are normally used to make decisions concerning air conditioning for buildings. The concept involves generation of a "Predicted Indoor Habitability Index" (PIHI) as a means to evaluate the response of occupants to short-term as well as long-term exposure in non-air-conditioned housing. The work completed thus far is described.

The results of a pilot study for two locations, Jersey City, New Jersey and Macon, Georgia, are presented to demonstrate the feasibility of the concept. The indoor temperature and humidity were determined by calculation using a computerized simulation technique which follows a detailed heat transfer analysis of the weather/building/human-body systems. The calculated results were used to compute the value of several available physiological indices to reveal the extent and duration of undesirable indoor conditions when the apartment was not air conditioned. Statistical correlations between indoor and outdoor conditions were prepared as a means to reduce the amount of computation for establishing criteria.

16153. Schaefgen, J. R., **Integrating community utilities for resource conservation,** *Proc. Third National Conf. on Complete Water Reuse: Symbiosis as a Means of Abatement for Multi-Media Pollution, Cincinnati, OH, June 27-30, 1976,* pp. 53-59 (1976).

Key words: community services; cooling; electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse.

A Modular Integrated Utility System (MIUS) provides the utility services of electrical power, space heating and cooling, potable water heating, solid waste processing, sanitary sewage treatment, potable water treatment, and the site distribution, collection, and disposal functions attendant thereto. MIUS facilities are constructed on a community scale to achieve the maximum symbiotic effects from process integration. The MIUS approach to utility services can conserve energy, reduce environmental degradation, and permit greater flexibility in intensive land development at a competitive cost. A demonstration design is being initiated to quantify the performance and evaluate the synergistic benefits of multi-service facilities.

16189. Clifton, J. R., **Protection of reinforcing bars with organic coatings,** *Mater. Perform.* **15,** No. 5, 14-17 (May 1976).

Key words: bridge decks; chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars.

Results of a program aimed at identifying organic coatings suitable for steel reinforcing bars in concrete are given. Resistances of candidate coatings to abrasion, solutions of calcium chloride, hydroxide, sulfate, and fresh cement paste, and surface preparation of steel, resistance of coated bars to electrical currents, and concrete-to-coating bonding are discussed. Tests were made on liquid and powdered epoxy, polyvinylchloride liquid, polypropylene powder, phenolic nitrile liquid, and zinc rich liquid coatings.

16220. Kusuda, T., Tsuchiya, T., Powell, F. J., **Prediction of indoor temperature by using equivalent thermal mass response factors,** (Proc. 5th Symp. on Temperature, Washington, DC, June 21-24, 1971), Paper in *Temperature, Its Measurement and Control in Science and Industry,* L. G. Rubin, A. C. Anderson, J. E. Janssen, and R. D. Cutkosky, Eds., Part 2, **4,** 1345-1355 (Instrument Society of America, Pittsburgh, PA, 1972).

Key words: on-line simulation of temperature controls; thermal response factors.

Several methods are explored for computing room temperature and room thermal load from outdoor conditions. An analytical method based upon rigorous heat transfer analysis of the building system requires a sophisticated computer program and a large computer. A stochastic time series method based upon experimental data of a limited time duration is attractive because it does not rely upon a complex heat transfer mathematics simulation. The stochastic processing of the experimental data, however, leads to the response factors which are physically inconsistent. A semiempirical method, based upon a finite difference solution of a differential equation modeling the equivalent thermal mass system, produced consistent and accurate results. Although this approach has only been verified using experimental data of very simple boundary conditions (without solar radiation effect and the internal heat generation), the results are very promising and encourage further study. Applications are mentioned, such as a simplified on-line computerized linear function temperature control system and, a means of predicting energy requirements for buildings.

16226. Snell, J. E., **Summary Review—Evaluation factors, design requirements and needed research,** (Proc. Symp. CIB (Conseil Internationale du Batiment) Commission W62 on Water Supply and Drainage Inside Buildings, Watford, England, Sept. 19-20, 1972), Paper in *Water Demand in Buildings,* pp. 117-126 (Dept. of the Environment, Watford, England, Nov. 1973).

Key words: plumbing; plumbing research; water demand in buildings; water distributing systems.

This paper presents a framework for evaluation of water demands in buildings, which was used to review and summarize the papers presented at the Building Research Establishment Symposium on Water Demand in Buildings. This symposium was held in conjunction with the first meeting of CIB Commission W62 on Water Supply and Drainage.

This framework identifies prinicpal uses of water in buildings, the determinants of water demands, and the basic issues which must be addressed in developing improved predictive models and water supply and distributing system design procedures. Significant contributions in the symposium papers are noted, in particular experimental methodology and theoretical models.

The paper concludes by identifying important and relevant issues not addressed in the symposium papers and by summarizing needed research. Meaningful data on observed patterns of water use remain a major research need. Other needs include a more accurate and workable methodology for predicting future water demands and for design of water supply and distribution systems.

16315. Pierman, B. C., Bryson, J. O., **Building safety research at the National Bureau of Standards,** *Prof. Safety Mag.*, pp. 13-16 (Sept. 1976).

Key words: accidents; buildings; construction; maintenance; research accidents; safety.

This article summarizes the work that is accomplished in the Center for Building Technology to enhance the inherent safety of buildings in the United States. Aspects of user as well as worker safety resulting from building construction, use, maintenance, repair and retrofit are discussed. Research goals and methods, resulting in the greatest impact on overall safety in buildings are enumerated. Specific research projects are summarized.

16336. Powell, F. J., **Trends in heating, ventilating and air-conditioning,** *Proc. 5th CIB Congress on Research into Practice. The Challenge of Application, Paris, France, June 1971*, pp. 646-648 (1971).

Key words: air-conditioning; heating.

The rapid growth of science and technology in recent years has improved the means by which man can control his environment, but it has also created a rising tide of expectations on his part for a better quality of environment. The merging of the means and the desire for better environment is one of the strong current trends with respect to the equipment and systems used for heating and cooling of buildings. This paper describes some of the current efforts and future needs, with special emphasis on the use of a dynamic approach and computers, for promoting this convergence of potential and desire, as a response to the prepared papers on New Trends in Heating and Ventilation for the 5th Congress of CIB.

16338. Garbern, D., Kelly, G. E., **Dynamic efficiency of a gas-fired boiler,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II*, Paper C.1, pp. 330-335 (Purdue Res. Foundation, Lafayette, IN, 1976).

Key words: dynamic boiler efficiency; efficiency vs cycling rate; efficiency vs heating load; gas-fired boiler.

The effect of cycling rate and part-load operation on the efficiency of a gas-fired, cast iron, hydronic boiler was examined in the laboratory. The boiler studied has an input rating of 300,000 BTU/hr (316,500 KJ/hr). Experimental curves are presented which show how the measured efficiency varied with the rate of cycling at several different heating loads. It was found that the cycling rate had only a slight effect on the part-load efficiency of the gas-fired boiler.

16342. Kelnhofer, W. J., Hunt, C. M., Didion, D. A., **Determination of combined air exfiltration and ventilation rates in a nine-story office building,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II*, Paper B.4, pp. 322-328 (Purdue Res. Foundation, Lafayette, IN, 1976).

Key words: air infiltration; energy conservation; measurement techniques; ventilation of office buildings.

The sulfur hexaflouride tracer-gas technique, which has been used previously for determining air infiltration rates in residential buildings, was applied to a nine-story office building of modern design. The building has sealed windows with openings only on the first level and on the roof, and is mechanically ventilated with a variable air volume system. Tests were run during the cooling season by introducing the tracer gas into the main trunk of the air supply system and measuring the concentration decay rate in the return air. Infiltration rates were determined with outside air vents open and closed. To check the results, a second independent method was used, which involved direct measurement and calculation of infiltration rates.

16347. Chi, J., **Computer simulation of fossil-fuel-fired boilers,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II, Paper C.2*, pp. 336-346 (Purdue Res. Foundation, Lafayette, IN, 1976).

Key words: boilers; computer simulation; DEPAB (Design and Performance Analysis of Boilers); energy saving measures; performance at part load; seasonal efficiency.

After an analytical boiler model is established, which is both an adequate representation of the physical system and capable of reasonably simple mathematical description, governing equations based upon this model are derived. A computer program DEPAB (Design and Performance Analysis of Boilers) is then developed to simulate boiler operations. DEPAB is designed to predict the performance of both the gas-fired and oil-fired hydronic boilers. Accuracy of results from computer simulation has been verified by the experimental data on a gas-fired boiler. Verification for the oil-fired boiler will be made in the future, when experimental data become available to the author. Examples are given to illustrate applications of the program to examine quantitatively the effects of design and operating variables on performance and seasonal fuel economy of heating boilers for buildings. It was found that considerable seasonal savings in fuel can often be achieved by performing certain modifications to the existing boilers.

16349. Clifton, J., Frohnsdorff, G., **Polymer-impregnated concretes,** Chapter 12. Special Review in *Cements Research Progress 1975*, pp. 173-196 (American Ceramic Society, Columbus, OH, 1976).

Key words: concrete; concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete.

This is a comprehensive literature review on developments in the science and technology of polymer-impregnated concretes, up to December 1975. Altogether 116 references have been reviewed.

16360. Evans, A. G., Clifton, J. R., Anderson, E., **The fracture mechanics of mortars,** *Cement Concrete Res.* **6,** No. 4, 535-547 (1976).

Key words: acoustical emission; fracture mechanics; mortars; polymer impregnated mortars; slow crack growth.

A fracture mechanics study of plain and polymer impregnated mortars has shown that the (slow and rapid) macrocrack propagation resistance of these materials is not significantly affected by mortar processing variables, such as water/cement ratio and curing time, but is strongly enhanced by polymer impregnation. Acoustic emission measurements have indicated the important role of microcracking in the fracture of both plain and impregnated mortars; with the susceptibility to microcracking being substantially retarded by polymer impregnation.

16408. Brown, P. W., Clifton, J. R., Frohnsdorff, G., Berger, R. L., **The utilization of industrial by-products in blended cements,** (Proc. 5th Mineral Waste Utilization Symposium, Chicago, IL, Apr. 13-14, 1976), Paper in *Proceedings of the Fifth Mineral Waste Utilization Symp.*, pp. 278-284 (ITT Research Institute, Chicago, IL, 1976).

Key words: blast furnace slag; blended cement; fly ash; materials and energy conservation.

Approximately 85 million tons of portland cement are produced annually in the United States. However, less than one million tons of blended cement containing suitable waste or by-product materials, such as fly ash or blast furnace slag, are produced. In view of the potential for by-product utilization and raw materials and energy conservation, the advantages of increased use of blended cement should be considered. The potential for blended cement production and utilization and the advantages and limitations of utilization are discussed. The limitations imposed on the use of blended cements by standards and other factors are discussed. The technical benefits from the use of blended cements are considered.

16412. MacGregor, J. G., Breen, J. E., Pfrang, E. O., **Design of slender concrete columns,** *ACI J.*, pp. 6-28 (Jan. 1970).

Key words: bending moments; building codes; column (supports); frames; long columns; reinforced concrete; slenderness ratio; strength; structural analysis; structural design; ultimate strength.

Offers a proposal for revising the slender column design procedures of the 1963 ACI Code. Proposes the use of a rational second-order structural analysis wherever possible or practical. In place of such an analysis, an approximate design method based on a moment magnifier principle and similar to the procedure used under the AISC Specifications is proposed. An outline of the normal range of variables in column design and a lower limit of applicability is proposed which will eliminate over 90 percent of columns in braced frames and almost half of columns in unbraced frames from consideration as slender columns. Through a series of comparisons with analytical and test results, the accuracy of the approximate design procedure is established.

16416. Post, M. A., Iverson, W. P., Campbell, P. G., **Evaluating non-mercurial fungicides,** *Mod. Paint Coat.* **66**, No. 9, 31-38 (Sept. 1976).

Key words: accelerated testing; alkyd paints; environmental chamber; exterior exposure; latex paints; nonmercurial fungicides.

Nonmercurial fungicides were evaluated for effectiveness in an exterior acrylic latex and in an exterior long oil alkyd paint. Exterior exposure tests were of six months, one year and two years duration at the National Bureau of Standards exposure site. Exterior exposure tests were also carried out at the U.S. Naval Station, Roosevelt Roads, Puerto Rico. Accelerated fungus exposure testing was performed for four and eight weeks in an environmental chamber (a) without prior exterior exposure, (b) after six months, one year and two years exterior exposure, and (c) after exposure in a xenon arc accelerated weathering apparatus. Of the eight nonmercurial fungicides tested for latex paint protection, only one afforded complete fungicidal protection after two years exterior exposure. Two of the six nonmercurial fungicides tested for alkyd paint protection were excellent. One was superior and the other equal to the mercurial fungicide. The mercurial fungicide afforded much better protection for alkyd than latex paints.

16446. Powell, F. J., **A fresh look at fundamental design parameters,** *Proc. Energy Crisis Regional Conf., Chicago, IL, Sept. 19-21, 1973*, pp. 24-1–24-8 (Capital Development Board, Springfield, IL, 1973).

Key words: buildings; energy conservation; heat transfer.

Two fundamental equations of heat energy transfer in buildings are examined and related to practical design decisions that are made by architects and engineers. Available modern technology that represents an improvement over the simplified fundamental approach is described. An example of the use of modern technology is given together with suggested ways to save energy in heating and cooling applications. Some of the problems of implementation of energy conservation measures in buildings are discussed.

16535. Yokel, F. Y., **A performance standard for foundations and excavations,** *Civil Eng.* **47**, No. 10, 80-81 (Oct. 1976).

Key words: buildings (codes); excavation; foundations; geotechnical engineering; standards.

Work is now in progress on the preparation of a national standard for foundations and excavations under the ASCE-COS "Committee for Foundation and Excavation Standards," (CFES).

16544. Simiu, E., **Wind climate and failure risks,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102**, No. ST9, 1703-1707 (Sept. 1976).

Key words: buildings (codes); failure; probability distribution functions; reliability; structural engineering; wind (meteorology); wind pressure.

The relation is examined between risk of failure, degree of wind sensitivity, type of wind climate, and mean recurrence interval used in design. The results presented are based on the assumption, used in the ANSI A58.1 Standard, that the probabilistic behavior of extreme wind speeds is adequately modeled by distribution functions of the largest values, the parameters of which are estimated from the data consisting of the largest yearly wind speed for every year of record. These results show that a strong correlation exists between probability of failure and type of wind climate, as defined quantitatively by the parameters of the extreme wind distribution. All other relevant factors being equal, including the degree of sensitivity to wind, it was found that the probability of failure of a member may increase considerably as a function of type of wind climate. It is suggested that the effect of the type of climate, as defined in the paper, be taken into account in design.

16545. Simiu, E., Filliben, J. J., **Probability distributions of extreme wind speeds,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102**, No. ST9, 1861-1877 (Sept. 1976).

Key words: buildings (codes); hurricanes; probability distribution functions; reliability; risk; statistical analysis; storms; structural engineering; wind pressure; wind speed.

An automated technique is presented for determining an appropriate distributional model for the largest yearly wind speeds. With a view to assessing the validity of current probabilistic approaches to the definition of design wind speeds, this technique was used in a study of extreme wind speeds based on records taken at 20 U.S. weather stations. The following results were obtained: (1) At 83 percent of the stations not susceptible to experiencing hurricane-force winds, the series of the largest annual wind speeds were well fit by Type I probability distributions of the largest values; (2) the assumption that Type II distributions with $\gamma = 9$ are generally representative of such stations was not confirmed; (3) type I probability distributions do not appear to describe correctly the behavior of extreme winds in regions subjected to special winds, e.g., hurricanes; and (4) in such regions, 20-yr data samples may provide a misleading picture of extreme wind behavior.

16547. Snell, J. E., Kusuda, T., Didion, D. A., **Energy conservation in office buildings: Some United States examples,** *Proc. International CIB Symp. on Energy Conservation in the Built Environment, Watford, England, Apr. 6-8, 1976,* pp. 1-34 (International Council for Building Research, Studies and Documentation, Rotterdam, The Netherlands, 1976).

Key words: commercial buildings; energy conservation; energy consumption; Manchester office building; National Bureau of Standards; New York State offices; office buildings.

The purpose of this paper is to describe recent experience in the United States and, in particular, the National Bureau of Standards (NBS) with energy conservation in office buildings. The NBS, working in cooperation with the Energy Research and Development Administration (ERDA) and the General Services Administration (GSA), is evaluating the energy efficiency of a demonstration office building in Manchester, New Hampshire. NBS utilized its thermal performance computer program (NBSLD) to evaluate a variety of energy conservation design alternatives for this building. These results are described and the current status of the project is reported. The NBS has conducted studies of energy conservation potentials in its own buildings at the Gaithersburg, Maryland, site. These measures include operational as well as retrofit actions. The results of actual tests and computer evaluations of predicted performance are discussed. Overall savings in energy use (fuel oil, fuel gas, and purchased electricity) of 20 percent have been achieved. An additional 20 percent reduction in energy use is expected from planned retrofit, including use of computerized HVAC controls. The NBS also has been working with an ad hoc industry group, representing owners and managers of commercial buildings, toward the development of self-help guidelines these managers can use in achieving energy conservation retrofit cost-effectively in their own buildings. Data collected to date and current status of these activities are reported. Many post-war office buildings were designed and constructed which are inimical to present energy conserving criteria. The excessive use of glass and illumination prevailed, as well as inefficient, although first-cost inexpensive, HVAC systems. Controls for building illumination and space conditioning were often inadequate for energy conservation operations. Therefore, these areas represent major opportunities for energy conservation in existing, as well as new, office buildings in the U.S., and are the target of a major effort by NBS and the Federal Government in general.

16550. Kusuda, T., **Control of ventilation to conserve energy while maintaining acceptable indoor air quality,** (Proc. ASHRAE Symp. on Ventilation Control, Semiannual Meeting, Dallas, TX, Feb. 1-5, 1976), *ASHRAE Trans.* **82,** Part 1, 1169-1182 (American Society of Heating, Refrigerating and Air Conditioning Engineers, New York, NY, 1976).

Key words: air quality; intermittent operation; maximum allowable concentration of CO_2; New York City schools; ventilation.

Basic requirements of ventilation with respect to the undesirable increase of building air contaminants are discussed. A mathematical model for determining the increase of contaminants concentration with time was developed and verified by applying it to the observed CO_2 increases in the New York City School experiment. Equations, tables and graphs were developed for estimating the CO_2 buildup and possible energy saving obtainable by using intermittent operation of ventilation systems. It is concluded that, if properly implemented, intermittent operation of ventilation systems could reduce the energy requirement for heating the ventilating air by as much as 40 percent under typical design conditions.

16556. Mahaffey, C. T., **Metrication problems in the construction codes and standards sector,** *Constr. Specifier,* pp. 25-28, 30-32, 34-37 (June 1976).

Key words: building regulations; dimensional coordination; metric conversion; planning and scheduling.

This report is a response to a request for an outline of the problems to be faced by the building standards development and building regulatory sectors of the American building industry. It includes a discussion of the SI metric units themselves, giving examples of the conventions regarding their use adopted in other countries to illustrate the nature of the decisions that must be made by the U.S. building industry. It discusses the relationship of dimensional coordination to the metric conversion effort, its impact on the U.S. building regulatory system and illustrates some of the decisions these sectors need to make. It also discusses some of the organizational problems required to involve all segments of the industry in this decision-making process, and for implementing these decisions in a coordinated way on a national scale.

16564. Marshall, H. E., Ruegg, R. T., **Efficiency problems from user fees in municipal wastewater treatment,** *Water Resour. Bull.* **12,** No. 5, 903-917 (Oct. 1976).

Key words: cost sharing; economic efficiency; environment; equity; financing; grants; pollution abatement; user fees; wastewater; water pollution; water resources.

The Environmental Protection Agency administers a construction grant program to encourage abatement of wastewater pollution by sharing with municipalities the costs of wastewater treatment facilities. The enabling legislation (P.L. 92-500) specifies that EPA's cost share will be 75 percent of construction costs. It further requires municipalities to collect user fees from industrial users of the facilities to repay that part of the federal grant allocable to the treatment of industrial wastewater. The municipality must return half of the user fees collected to the U.S. Treasury; the municipality is allowed to retain the remaining half. Retention by municipalities of these user fees lowers their effective cost shares and results in the following consequences: (1) a bias for municipalities to select certain kinds of abatement techniques regardless of whether or not they are the least-cost techniques from the national perspective; (2) a bias for municipalities to select larger-than-optimal scales of abatement facilities; (3) a hidden federal subsidy to industry; and (4) grants that favor industrial communities. This article examines the legislative and regulatory requirements for user charges, derives the algebraic expressions for calculating the real federal, municipal, and industrial cost shares with user fees; computes municipal cost shares for selected values of the determinant factors; evaluates efficiency and other consequences of current user fee arrangements; and concludes that the efficiency distortions brought about by the impacts of user fees on cost sharing could be eliminated by requiring that all user fees collected from industry against the federal cost share be returned to the U.S. Treasury.

16654. Wyly, R. S., Galowin, L. S., **An approach to performance evaluation for water supply and drainage for buildings,** *Proc. CIB Commission W62 Symp., 1975, Drainage and Water Supply for Buildings, University of Glasgow, Glasgow, Scotland, Sept. 30-Oct. 1, 1975,* pp. 12/1-12/31 (1975).

Key words: acceptance protocol; performance approach; performance-based plumbing standard; performance statement; plumbing performance criteria; plumbing performance evaluation; plumbing performance.

The performance concept is reviewed as it relates to water supply and drainage for buildings.

An approach is described that is being utilized in connection with the development of a performance standard for plumbing as a complement to an updated specification-type (model) code of practice (National Plumbing Code) under the procedures of the American National Standards Institute.

The recommendation is made that the work in connection with the National Plumbing Code program include first a comprehensive review of existing information to identify existing performance statements, both those actually stated and those merely implied. Several examples are developed illustrating this concept.

It is concluded that the needs in further development and implementation of the performance approach include education, acceptance protocol and new research. The new research would be needed to establish definitive performance criteria, reproducible test procedures or predictive models, and systematic inspection procedures. During the period of transition to performance evaluation methodology, continued reliance will need to be placed on specification-oriented acceptance protocol, expert judgment and experience.

NBS PATENTS

Patents are legal documents which fully describe inventions in return for the right for 17 years to exclude others from making, using or selling the inventions. Patents for CBT inventions during 1976 are listed below. Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, D.C. 20231 for 50 cents each.

U.S. Patent 3,950,995. **Ambient pressure probe,** R. D. Marshall, (Apr. 20, 1976).

Key words: ambient pressure probe; omnidirectional pressure probe; pressure probe shroud; static pressure; weatherproof pressure probe; wind field pressure measurements.

Ambient or static pressure in a fluid stream is sensed with a hollow circular cylinder placed normal to the fluid stream. A shroud is mounted on the cylinder for adjustment over a ring of ports provided in the cylinder. In this manner, the relationship between the internal pressure in the cylinder and the ambient pressure is controllable. Ideally, the internal and ambient pressures are exactly equal. Further, extension of the cylinder above and below the shroud provides symmetry for positive and negative angles of attack.

U.S. Patent 3,975,940. **Portable tester for measuring the static coefficient of friction between a floor surface or the like and a shoe sole or heel material or the like,** R. J. Brungraber, (Aug. 24, 1976).

Key words: floor slipperiness; slipperiness tester; static coefficient of friction measurement.

A portable testing device for determining the static coefficient of friction between a floor surface and a shoe sole or heel material includes an upper, weighted strut movable within a vertical plane and a lower strut pivotably secured to the bottom portion of the upper strut. The upper strut is mounted within a bearing block which is translatably movable within a horizontal plane, and the lower strut has secured to the bottom portion thereof a yoke within which a metal shoe carrying a representative shoe sole or heel material to be tested is pivotably secured. The yoke and shoe project through the base of the device framework so as to rest upon the flooring material being tested, and a trigger is disposed near the shoe so as to be actuated thereby upon the occurrence of slip between the shoe and flooring materials. The trigger is in turn connected to a friction clutch which controls the movement of a graduated rod, which is coupled to the bearing block so as to monitor the movement thereof and upon which the static coefficient of friction data is indicated, and upon the occurrence of slip, the movement of the rod is arrested by the clutch mechanism whereby the friction coefficient may be read directly from the rod.

Author Index

AUTHOR INDEX

Key word Index

KEY WORD INDEX

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C

Computers; data processing; fire loads; load surveys; buildings; *NBSIR 76-982*.

Concrete; concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete; *16349*.

Concrete; construction; falsework; formwork; loads; reshoring; safety; shoring; standards; building; codes; *BSS80*.

Concrete; maturity; mechanical properties; nondestructive evaluation; pull-out strength; splitting tensile strength; compressive strength; *TN932*.

Concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; *BSS73*.

Concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete; concrete; *16349*.

Conduction; energy conservation; heat transfer; insulation; thermal conductivity; thermal insulation; *15756*.

Conduction transfer functions; heating and cooling load; National Bureau of Standards heating and cooling load computer program; ASHRAE task group on energy requirements; *BSS69*.

Conduction transfer functions; heating and cooling load; National Bureau of Standards load determination procedure; computer program for buildings; *16118*.

Conservation; cooling; cost; energy; heating; *SP403*, pp. 163-191 (June 1976).

Conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics; automobile; break-even analysis; *SP403*.

Conservation; costs; economics; energy; thermal; *SP403*, pp. 95-101 (June 1976).

Conservation; economic; energy; management; manufacturing; *SP403*, pp. 103-111 (June 1976).

Conservation; energy; industrial; systems; attitudes; *SP403*, pp. 113-117 (June 1976).

Conservation; energy; organization; *SP403*, pp. 13-18 (June 1976).

Constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; concrete block; *BSS73*.

Construction; design; information; information retrieval system; architectural indexing systems; architecture; building; *NBSIR 76-1064*.

Construction; design; law enforcement facilities; architecture; bibliography; building; *TN859*.

Construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards; computer techniques; *NBSIR 76-1058*.

Construction; falsework; formwork; loads; reshoring; safety; shoring; standards; building; codes; concrete; *BSS80*.

Construction; maintenance; research accidents; safety; accidents; buildings; *16315*.

Construction practices; damage; earthquake; houses; residential dwelling; building codes; *SP444*, pp. V-63 – V-65 (Apr. 1976).

Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law; architectural glazing; codes; *NBSIR 76-1109*.

Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law; architectural glazing; codes; Consumer Product Safety Committee; *NBSIR 76-1109*.

Contact resistance; electrical connections; fire hazard; glowing electrical connections; arcing/sparking; branch circuit; *NBSIR 76-1011*.

Cooling; cost; energy; heating; conservation; *SP403*, pp. 163-191 (June 1976).

Cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics; automobile; break-even analysis; conservation; *SP403*.

Cooling; electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse; community services; *16153*.

Cooling; heating; hot water; performance criteria; solar energy; standards; buildings; *NBSIR 76-1187*.

Cooperative programs; information exchange; international building research; international organization memberships; special foreign currency programs; building research; *NBSIR 76-1162*.

Copper-base alloy properties; electrical resistivity; Smith-Palmer equation; thermal conductivity; *NBSIR 76-1003*.

Corps of Engineers; cost sharing; efficiency; hurricane protection; shoreline management; shoreline protection; beach erosion control; *16059*.

Correlation; economic; energy; imports; international; petroleum; *SP403*, pp. 21-41 (June 1976).

Corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars; bridge decks; chloride ions; *16189*.

Cost; energy; heating; conservation; cooling; *SP403*, pp. 163-191 (June 1976).

Cost sharing; economic efficiency; environment; equity; financing; grants; pollution abatement; user fees; wastewater; water pollution; water resources; *16564*.

Cost sharing; efficiency; environment; financing; grants; pollution abatement; wastewater; water pollution; water resources; *15810*.

Cost sharing; efficiency; hurricane protection; shoreline management; shoreline protection; beach erosion control; Corps of Engineers; *16059*.

Costs; economics; energy; environment; *SP403*, pp. 215-223 (June 1976).

Costs; economics; energy; fuel; imports; *SP403*, pp. 3-12 (June 1976).

Costs; economics; energy; thermal; conservation; *SP403*, pp. 95-101 (June 1976).

Costs; energy; financial; resources; risk; *SP403*, pp. 237-241 (June 1976).

Costs; energy; heating; manufacturing; marketing; *SP403*, pp. 199-213 (June 1976).

Creep; fire endurance; fire tests; reinforced concrete; sensitivity analysis; steel; structural mechanics; uncertainty; *BSS76*.

Criteria; decision making; human systems; measuring instruments; research assistants; test device evaluation; *16091*.

Criteria; energy; engineering; industry construction; measurement techniques; standards; building research; *SP439*.

Criteria; project summaries; standards; technical bases; building research; building technology; codes; *SP446*.

Cross connections; health hazard; potable water; vacuum breaker; water supply; backflow; backflow preventers; back pressure; back-siphonage; *NBSIR 76-1070*.

Cyclones; disasters; structural engineering; tides; wind; buildings; *BSS86*.

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Damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind; buildings; *SP444*, pp. V-35 – V-49 (Apr. 1976).

Damage; earthquake; houses; residential dwelling; building codes; construction practices; *SP444*, pp. V-63 – V-65 (Apr. 1976).

Damage classification; extreme wind; tornado; wind loads; building code; *SP444*, pp. I-34 – I-39 (Apr. 1976).

Damping; damping coefficients; shear modulus; soil; tests; torsional excitation; *SP444*, pp. III-72 – III-83 (Apr. 1976).

Damping coefficients; shear modulus; soil; tests; torsional excitation; damping; *SP444*, pp. III-72 – III-83 (Apr. 1976).

Data processing; fire loads; load surveys; buildings; computers; *NBSIR 76-982*.

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lateral loads; pile head; piles; *SP444*, pp. IV-90 – IV-112 (Apr. 1976).

Structural engineering; design; earthquakes; highway bridges; retrofitting; soil-structure interaction; *SP444*, pp. V-1 – V-24 (Apr. 1976).

Structural engineering; earthquake engineering; grant; RANN; sponsorship; *SP444*, pp. V-66 – V-79 (Apr. 1976).

Structural engineering; failure; probability theory; random process; safety; statistical analysis; *SP444*, pp. IV-1 – IV-15 (Apr. 1976).

Structural engineering; technological aid; earthquake; Japan; natural disaster; storm; *SP444*, pp. VI-25 – VI-31 (Apr. 1976).

design; dynamic analysis; earthquake; *SP444*, pp. V-50 – V-62 (Apr. 1976).

Seismic response; spherical tanks; structural design; dynamic analysis; earthquake; seismic design; *SP444*, pp. V-50 – V-62 (Apr. 1976).

Seismic response; structural engineering; analytical model; dynamic analysis; dynamic laoding; earthquake; energy dissipation; finite element; *SP444*, pp. IV-70 – IV-89 (Apr. 1976).

Seismic waves; seismometer; soil-structure interaction; earthquake; field data; ground response; *SP444*, pp. III-13 – III-23 (Apr. 1976).

Seismometer; soil-structure interaction; earthquake; field data; ground response; seismic waves; *SP444*, pp. III-13 – III-23 (Apr. 1976).

Sensitivity analysis; steel; structural mechanics; uncertainty; creep; fire endurance; fire tests; reinforced concrete; *BSS76*.

Serviceability; static; vibration; deflection; dynamic; floor systems; human responses; performance criteria; *TN900*.

Shake table; structural engineering; tests; dynamic tests; earthquake simulator; *SP444*, pp. V-25 – V-34 (Apr. 1976).

Shear modulus; soil; tests; torsional excitation; damping; damping coefficients; *SP444*, pp. III-72 – III-83 (Apr. 1976).

Shear tests; structural engineering; web reinforcement; column; ductility; earthquake; reinforced concrete; *SP444*, pp. IV-16 – IV-36 (Apr. 1976).

Shear wave; elastic medium; engineering seismology; ground layer; numerical solution; *SP444*, pp. III-1 – III-12 (Apr. 1976).

Shelter; durability; field inspection; foam and beam; honeycomb; impact; lightweight structures; military; reliability; sandwich panel; *NBSIR 76-1025*.

Shoreline management; shoreline protection; beach erosion control; Corps of Engineers; cost sharing; efficiency; hurricane protection; *16059*.

Shoreline protection; beach erosion control; Corps of Engineers; cost sharing; efficiency; hurricane protection; shoreline management; *16059*.

Shoring; standards; building; codes; concrete; construction; falsework; formwork; loads; reshoring; safety; *BSS80*.

Siding; structural engineering; wind; wind damage; wind engineering; building codes; design standards; masonry construction; roofs; *TN909*.

Skylights; windows; daylight gathering; daylighting of buildings; energy conservation; lenses; light conduits; light control; reflectors; *NBSIR 76-1098*.

Slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; *BSS73*.

Slenderness ratio; strength; structural analysis; structural design; ultimate strength; bending moments; building codes; column (supports); frames; long columns; reinforced concrete; *16412*.

Slides; avalanches; earthquakes; falls; flows; landslides; mechanisms; *SP444*, pp. III-52 – III-71 (Apr. 1976).

Slipperiness tester; static coefficient of friction measurement; floor slipperiness; *U.S. Patent 3,975,940*.

Slip-resistance; slip-resistance testers; walking friction; building safety; floor surface friction; occupancy safety; *TN895*.

Slip-resistance testers; walking friction; building safety; floor surface friction; occupancy safety; slip-resistance; *TN895*.

Slow crack growth; acoustical emission; fracture mechanics; mortars; polymer impregnated mortars; *16360*.

Smith-Palmer equation; thermal conductivity; copper-base alloy properties; electrical resistivity; *NBSIR 76-1003*.

Soil; tests; torsional excitation; damping; damping coefficients; shear modulus; *SP444*, pp. III-72 – III-83 (Apr. 1976).

Soil density; stability; earthfill dams; earthquakes; ground shaking; liquefaction; *SP444*, pp. III-24 – III-37 (Apr. 1976).

Soils; structural response; volcanoes; wind; bridges; buildings; codes; disaster; dynamic analysis; earthquakes; modeling; *SP444*.

Soil-structure interaction; earthquake; field data; ground response; seismic waves; seismometer; *SP444*, pp. III-13 – III-23 (Apr. 1976).

Soil-structure interaction; structural engineering; design; earthquakes; highway bridges; retrofitting; *SP444*, pp. V-1 – V-24 (Apr. 1976).

Solar; State; architecture; buildings; design; energy; legislation; *NBSIR 76-1082*.

Solar buildings; solar collectors; solar domestic hot water systems; solar heating; standards; thermal storage; *NBSIR 76-1059*.

Solar collector; solar energy; solar radiation; standard; standard test; thermal performance; thermal storage; *TN899*.

Solar collector; solar heating and cooling; thermal storage; energy conservation; GSA/Manchester building; *NBSIR 76-1056*.

Solar collectors; solar domestic hot water systems; solar heating; standards; thermal storage; solar buildings; *NBSIR 76-1059*.

Solar domestic hot water systems; solar heating; standards; thermal storage; solar buildings; solar collectors; *NBSIR 76-1059*.

Solar energy; solar radiation; standard; standard test; thermal performance; thermal storage; solar collector; *TN899*.

Solar energy; standards; buildings; *NBSIR 76-1143*.

Solar energy; standards; buildings; cooling; heating; hot water; performance criteria; *NBSIR 76-1187*.

Solar energy systems evaluation; thermal performance; data requirements; measurement uncertainty; *NBSIR 76-1137*.

Solar heating; standards; thermal storage; solar buildings; solar collectors; solar domestic hot water systems; *NBSIR 76-1059*.

Solar heating; surface temperature; built-up roofing; insulation; performance; radiative cooling; roofing; *NBSIR 76-987*.

Solar heating and cooling; thermal storage; energy conservation; GSA/Manchester building; solar collector; *NBSIR 76-1056*.

Solar radiation; standard; standard test; thermal performance; thermal storage; solar collector; solar energy; *TN899*.

Sonic boom; vehicular collision; bombs; building codes; design criteria; explosions; gas; hazardous materials; loads; progressive collapse; *BSS89*.

Special foreign currency programs; building research; cooperative programs; information exchange; international building research; international organization memberships; *NBSIR 76-1162*.

Specification; unitary heat pump; heating and cooling; military family housing; *NBSIR 76-1029*.

Specifications; structure; theory; wind; bridge; design; field data; gust response; model; *SP444*, pp. I-1 – I-20 (Apr. 1976).

Spectral analysis; vibration; analysis; experimental; floor systems; human response; random process; *TN904*.

Spherical tanks; structural design; dynamic analysis; earthquake; seismic design; seismic response; *SP444*, pp. V-50 – V-62 (Apr. 1976).

Splitting tensile strength; compressive strength; concrete; maturity; mechanical properties; nondestructive evaluation; pullout strength; *TN932*.

Sponsorship; structural engineering; earthquake engineering; grant; RANN; *SP444*, pp. V-66 – V-79 (Apr. 1976).

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APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).
Auburn: Auburn University, Ralph Brown Draughon Library (1907).
Birmingham:
- Birmingham Public Library (1895).
- Birmingham-Southern College Library (1932).
- Jefferson State Junior College, James B. Allen Library (1970).
- Samford University, Harwell G. Davis Library (1884).

Enterprise: Enterprise State Junior College Library (1967).
Florence: University of North Alabama, Collier Library (1932).
Gadsden: Gadsden Public Library (1963).
Huntsville: University of Alabama, Huntsville Campus Library (1964).
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
Maxwell A.F. Base: Air University Library (1963).
Mobile:
- Mobile Public Library (1963).
- Spring Hill College, Thomas Byrne Memorial Library (1937).
- University of South Alabama Library (1968).

Montgomery:
- Alabama State Department of Archives and History Library (1884).
- Alabama Supreme Court Library (1884).
- Auburn University at Montgomery Library (1971)—REGIONAL.

Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
St. Bernard: St. Bernard College Library (1962).
Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
University:
- University of Alabama, School of Law Library (1967).
- University of Alabama Library (1860)—REGIONAL

ALASKA

Anchorage:
- Anchorage Higher Education Consortium Library (1961).
- Supreme Court of Alaska Library (1973).

College: University of Alaska, Elmer E. Rasmuson Library (1922).
Juneau: Alaska State Library (1964).
Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).
Flagstaff: Northern Arizona University Library (1937).
Phoenix:
- Department of Library and Archives (unknown)—REGIONAL.
- Phoenix Public Library (1917).

Prescott: Yavapai College Library (1976).
Tempe: Arizona State University, Matthews Library (1944).
Thatcher: Eastern Arizona Junior College Library (1963).
Tucson:
- Tucson Public Library (1970).
- University of Arizona Library (1907)—REGIONAL.

Yuma: Yuma City-County Library (1963).

ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).
Batesville: Arkansas College Library (1963).
Clarksville: College of the Ozarks Library (1925).
Conway: Hendrix College, O. C. Bailey Library (1903).
Fayetteville: University of Arkansas Library (1907).
Little Rock:
- Arkansas Supreme Court Library (1962).
- Little Rock Public Library (1953).
- University of Arkansas at Little Rock Library (1973).

Magnolia: Southern Arkansas University, Mogale Library (1956).
Monticello: University of Arkansas at Monticello Library (1956).
Pine Bluff: University of Arkansas, Watson Memorial Library (1976).
Russellville: Arkansas Tech University, Tomlinson Library (1925).
Searcy: Harding College, Beaumont Memorial Library (1963).
State College: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcadia: Arcadia Public Library (1975).
Arcata: Humboldt State College Library (1963).
Bakersfield:
- California State College, Bakersfield Library (1974).
- Kern County Library System (1943).

Berkeley:
- University of California, General Library (1907).
- University of California, Law Library, Earl Warren Legal Center (1963).

Carson: Carson Regional Library (1973).
Chico: Chico State University Library (1962).
Claremont: Pomona College Documents Collection, Honnold Library (1913).
Compton: Compton Library (1972).
Culver City: Culver City Library (1966).
Davis:
- University of California at Davis Library (1953).
- University of California at Davis, School of Law Library (1972).

Dominguez Hills: California State College, Dominguez Hills, Educational Resources Center (1973).
Downey: Downey City Library (1963).
Fresno:
- Fresno County Free Library (1920).
- California State University Library (1962).

Fullerton: California State University at Fullerton Library (1963).
Garden Grove: Garden Grove Regional Library (1963).
Gardena: Gardena Public Library (1966).
Hayward: California State College at Hayward Library (1963).
Huntington Park: Huntington Park Library, San Antonio Region (1970).

Inglewood: Inglewood Public Library (1963).
Irvine: University of California at Irvine Library (1963).
La Jolla: University of California, San Diego, University Library (1963).
Lakewood: Angelo Iacoboni Public Library (1970).
Lancaster: Lancaster Regional Library (1967).
Long Beach:
- California State College at Long Beach Library (1962).
- Long Beach Public Library (1933).

Los Angeles:
- California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
- Los Angeles County Law Library (1963).
- Los Angeles Public Library (1891).
- Loyola University of Los Angeles Library (1933).
- Occidental College, Mary Norton Clapp Library (1941).
- Pepperdine University Library (1963).
- Southwestern University, School of Law Library (1975).
- University of California at Los Angeles Library (1932).
- University of California at Los Angeles, Law Library (1958).
- University of Southern California Library (1933).

Menlo Park: Department of the Interior, Geological Survey Library (1962).
Montebello: Montebello Library (1966).
Monterey: Naval Postgraduate School Library (1963).
Monterey Park: Bruggemeyer Memorial Library (1964).
Northridge: California State University at Northridge Library (1958).
Norwalk: Los Cerritos Regional Library (1973).
Oakland:
- Mills College Library (1966).
- Oakland Public Library (1923).

Ontario: Ontario City Library (1974).
Pasadena:
- California Institute of Technology, Millikan Memorial Library (1933).
- Pasadena Public Library (1963).

Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands, Armacost Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
- Riverside Public Library (1947).
- University of California at Riverside Library (1963).

Sacramento:
- California State Library (1895) – REGIONAL.
- Sacramento City-County Library (1880).
- Sacramento County Law Library (1963).
- Sacramento State College Library (1963).

San Bernardino: San Bernardino County Free Library (1964).
San Diego:
- San Diego State University, Love Library (1962).
- San Diego County Law Library (1973).
- San Diego County Library (1966).
- San Diego Public Library (1895).
- University of San Diego Law Library (1967).

San Francisco:
- Mechanics' Institute Library (1889).
- San Francisco Public Library (1889).
- San Francisco State College, Social Science and Business Library (1955).
- Supreme Court of California Library (1972).
- U.S. Court of Appeals for Ninth Circuit Library (1971).
- University of San Francisco, Richard A. Gleeson Library (1963).

San Jose: San Jose State College Library (1962).
San Leandro: San Leandro Community Library Center (1961).
San Luis Obispo: California Polytechnic State University Library (1969).
San Rafael: Marin County Free Library (1975).
Santa Ana:
- Orange County Law Library (1975).
- Santa Ana Public Library (1959).

Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz Library (1963).
Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
Stanford: Stanford University Libraries (1895).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Civic Center Library (1969).
Turlock: Stanislaus State College Library (1964).
Valencia: Valencia Regional Library (1972).
Van Nuys: Los Angeles Valley College Library (1970).
Ventura: Ventura County Library Services Agency (1975).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

COLORADO

Alamosa: Adams State College Learning Resources Center (1963).
Boulder: University of Colorado Libraries (1879) – REGIONAL.
Colorado Springs:
- Colorado College, Charles Leaming Tutt Library (1880).
- University of Colorado, Colorado Springs Library (1974).

Denver:
- Colorado State Library (unknown).
- Denver Public Library (1884) – REGIONAL.
- Department of Interior, Bureau of Reclamation Library (1962).
- Regis College, Dayton Memorial Library (1915).
- University of Denver, Penrose Library (1909).
- U.S. Court of Appeals for Tenth Circuit Library (1973).

Fort Collins: Colorado State University Library (1907).
Golden: Colorado School of Mines, Arthur Lakes Library (1939).
Greeley: University of Northern Colorado Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Lakewood: Jefferson County Public Library, Lakewood Regional Library (1968).
Pueblo:
- Pueblo Regional Library (1893).
- University Southern Colorado Library (1965).

U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).
Danbury: Western Connecticut State College, Ruth A. Haas Library (1967).
Danielson: Quinebaug Valley Community College (1975).
Enfield: Enfield Public Library (1967).

Hartford:
Connecticut State Library (unknown) – REGIONAL.
Hartford Public Library (1945).
Trinity College Library (1895).
Middletown: Wesleyan University Library (1906).
Mystic: Marine Historical Association, Inc., G. W. Blunt White Library (1964).
New Britain: Central Connecticut State College, Elihu Burritt Library (1973).
New Haven:
Southern Connecticut State College Library (1968).
Yale University Library (1859).
New London:
Connecticut College Library (1926).
U.S. Coast Guard Academy Library (1939).
Stamford: Stamford Public Library (1973).
Storrs: University of Connecticut, Wilbur Cross Library (1907).
Waterbury: Silas Bronson Library (1869).
West Haven: University of New Haven Library (1971).

DELAWARE

Dover:
Delaware State College, William C. Jason Library (1962).
State Department of Community Affairs and Economic Development, Division of Libraries (1972).
State Law Library in Kent County (unknown).
Georgetown:
Delaware Technical and Community College, Southern Branch Library (1968).
Sussex County Law Library (1976).
Newark:
University of Delaware, Morris Library (1907).
Delaware Law School Library (1976).
Wilmington:
New Castle County Law Library (1974).
Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

Washington:
Advisory Commission on Intergovernmental Relations Library.
Civil Aeronautics Board Library (1975).
Civil Service Commission Library (1963).
Department of Commerce Library (1955).
Department of Health, Education, and Welfare Library (1954).
Department of Housing and Urban Development Library (1969).
Department of the Interior Central Library (1895).
Department of Justice Main Library (1895).
Department of Labor Library (1976).
Department of State Library (1895).
Department of State, Office of Legal Advisor, Law Library (1966).
Department of Transportation, National Highway Traffic Safety Administration Library (1968).
District of Columbia Public Library (1943).
Federal City College Library (1970).
Federal Deposit Insurance Corporation Library (1972).
Federal Election Commission Library (1975).
Federal Reserve System Law Library (1976).
General Accounting Office Library (1975).
General Services Administration Library (1975).
Georgetown University Library (1969).
Indian Claims Commission Library (1968).
National War College Library (1895).
Navy Department Library (1895).
Navy Department, Office of Judge Advocate General Library (1963).
Office of Management and Budget Library (1965).
Office of The Adjutant General, Department of Army Library (1969).
Postal Service Library (1895).
Treasury Department Library (1895).
U.S. Court of Appeals, Judge's Library (1975).
Veterans' Administration, Central Office Library (1967).

FLORIDA

Boca Raton: Florida Atlantic University Library (1963).
Clearwater: Clearwater Public Library (1972).
Coral Gables: University of Miami Library (1939).
Daytona Beach: Volusia County Public Libraries (1963).
DeLand: Stetson University, duPont-Ball Library (1887).
Fort Lauderdale:
Broward County Library (1967).
Nova University Library (1967).
Gainesville: University of Florida Libraries (1907) – REGIONAL.
Jacksonville:
Haydon Burns Library (1914).
Jacksonville University, Swisher Library (1962).
University of North Florida Library (1972).
Lakeland: Lakeland Public Library (1928).
Leesburg: Lake-Sumter Community College Library (1963).
Melbourne: Florida Institute of Technology Library (1963).
Miami:
Florida International University Library (1970).
Miami Public Library (1952).
Opa Locka: Biscayne College Library (1966).
Orlando: Florida Technological University Library (1966).
Palatka: St. Johns River Junior College Library (1963).
Pensacola: University of West Florida, John C. Pace Library (1966).
Port Charlotte: Charlotte County Library System (1973).
St. Petersburg:
St. Petersburg Public Library (1965).
Stetson University College Law Library (1975).
Sarasota: Sarasota Public Library (1970).
Tallahassee:
Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
State Library of Florida (1929).
Florida State University, R. M. Stozier Library (1941).
Florida Supreme Court Library (1974).
Tampa:
Tampa Public Library (1965).
University of South Florida Library (1962).
University of Tampa, Merle Kelce Library (1953).
Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

Albany: Albany Public Library (1964).
Americus: Georgia Southwestern College, James Earl Carter Library (1966).
Athens: University of Georgia Libraries (1907).
Atlanta:
Atlanta Public Library (1880).
Atlanta University, Trevor Arnett Library (1962).
Emory University, Robert W. Woodruff Library (1928).
Emory University, School of Law Library (1968).
Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
Georgia State Library (unknown).
Georgia State University Library (1970).

Augusta: Augusta College Library (1962).
Brunswick: Brunswick Public Library (1965).
Carrollton: West Georgia College, Sanford Library (1962).
Columbus: Columbus College, Simon Schwob Memorial Library (1975).
Dahlonega: North Georgia College Library (1939).
Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).
Gainesville: Chestatee Regional Library (1968).
Macon: Mercer University Library (1964).
Marietta: Kennesaw Junior College Library (1968).
Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
Mount Berry: Berry College, Memorial Library (1970).
Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).
Statesboro: Georgia Southern College, Rosenwald Library (1939).
Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

Agana: Nieves M. Flores Memorial Library (1962).

HAWAII

Hilo: University of Hawaii, Hilo Campus Library (1962).
Honolulu:
- Chaminade College of Honolulu Library (1965).
- Hawaii Medical Library, Inc. (1968).
- Hawaii State Library (1929).
- Municipal Reference Library of the City and County of Honolulu (1965).
- Supreme Court Law Library (1973).
- University of Hawaii Library (1907).

Laie: Church College of Hawaii, Woolley Library (1964).
Lihue: Kauai Public Library (1967).
Pearl City: Leeward Community College Library (1967).
Wailuku: Maui Public Library (1962).

IDAHO

Boise:
- Boise State College Library (1966).
- Boise Public Library and Information Center (1929).
- Idaho State Law Library (unknown).
- Idaho State Library (1971).

Caldwell: College of Idaho, Terteling Library (1930).
Moscow: University of Idaho Library (1907) – REGIONAL.
Pocatello: Idaho State University Library (1908).
Rexburg: Ricks College, David O. McKay Library (1946).
Twin Falls: College of Southern Idaho Library (1970).

ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).
Carbondale: Southern Illinois University Library (1932).
Carlinville: Blackburn College Library (1954).
Carterville: Shawnee Library System (1971).
Champaign: University of Illinois Law Library, College of Law (1965).
Charleston: Eastern Illinois University, Booth Library (1962).
Chicago:
- Chicago Public Library (1876).
- Chicago State University Library (1954).
- DePaul University, Lincoln Park Campus Library (1975).
- Field Museum of Natural History Library (1963).
- John Crerar Library (1909).
- Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).
- Northeastern Illinois University Library (1961).
- University of Chicago Law Library (1964).
- University of Chicago Library (1897).
- University of Illinois, Chicago Circle Campus Library (1957).

Decatur: Decatur Public Library (1954).
De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).
Edwardsville: Southern Illinois University, Lovejoy Library (1959).
Elsah: Principia College, Marshall Brooks Library (1957).
Evanston: Northwestern University Library (1876).
Freeport: Freeport Public Library (1905).
Galesburg: Galesburg Public Library (1896).
Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).
Kankakee: Olivet Nazarene College, Benner Library and Resource Center (1946).
Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).
Lockport: Lewis University Library (1952).
Macomb: Western Illinois University Memorial Library (1962).
Moline: Black Hawk College, Learning Resources Center (1970).
Monmouth: Monmouth College Library (1860).
Morton Grove: Oakton Community College Library (1976).
Mt. Carmel: Wabash Valley College Library (1975).
Normal: Illinois State University, Milner Library (1877).
Oak Park: Oak Park Public Library (1963).
Oglesby: Illinois Valley Community College Library (1976).
Palos Hills: Moraine Valley Community College Library (1972).
Park Forest South: Governors State University Library (1974).
Peoria:
- Bradley University, Cullom Davis Library (1963).
- Peoria Public Library (1883).

River Forest: Rosary College Library (1966).
Rockford: Rockford Public Library (unknown).
Springfield: Illinois State Library (unknown) – REGIONAL.
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington: Indiana University Library (1881).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
- Evansville and Vanderburgh County Public Library (1928).
- Indiana State University, Evansville Campus Library (1969).

Fort Wayne:
- Indiana-Purdue Universities, Regional Campus Library (1965).
- Public Library of Fort Wayne and Allen County (1896).

Franklin: Franklin College Library (1976).
Gary:
- Gary Public Library (1943).
- Indiana University, Northwest Campus Library (1966).

Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
- Butler University, Irwin Library (1965).
- Indiana State Library (unknown) – REGIONAL.
- Indiana Supreme Court Law Library (1975).

Indiana University, Law Library (1967).
Indianapolis-Marion County Public Library (1906).
Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
Ball State University Library (1959).
Muncie Public Library (1906).
New Albany: Indiana University, Southeastern Campus Library (1965).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
Earlham College, Lilly Library (1964).
Morrison-Reeves Library (1906).
South Bend: Indiana University at South Bend Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

Ames: Iowa State University of Science and Technology Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs:
Free Public Library (1885).
Iowa Western Community College, Hoover Media Library (1972).
Davenport: Davenport Public Library (1973).
Des Moines:
Drake University, Cowles Library (1966).
Drake University Law Library (1972).
Iowa State Traveling Library (unknown).
Public Library of Des Moines (1888).
Dubuque:
Carnegie-Stout Public Library (unknown).
Loras College, Wahlert Memorial Library (1967).
Fayette: Upper Iowa College, Henderson-Wilder Library (1974).
Grinnell: Grinnell College, Burling Library (1874).
Iowa City:
University of Iowa, Law Library (1968).
University of Iowa Library (1884) – REGIONAL.
Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mason City: North Iowa Area Community College Library (1976).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Orange City: Northwestern College, Ramaker Library (1970).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: Benedictine College Library (1965).
Baldwin City: Baker University Library (1908).
Colby: Colby Community Junior College Library (1968).
Emporia: Kansas State College, William Allen White Library (1909).
Hays: Fort Hays Kansas State College, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence:
University of Kansas, Watson Library (1869) – REGIONAL.
University of Kansas Law Library (1971).
Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Kansas State College of Pittsburg, Porter Library (1952).
Salina: Kansas Wesleyan University, Memorial Library (1930).
Topeka:
Kansas State Historical Society Library (1877).
Kansas State Library (unknown).
Kansas Supreme Court Law Library (1975).
Washburn University of Topeka, Law Library (1971).
Wichita: Wichita State University Library (1901).

KENTUCKY

Ashland: Ashland Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Cravens Graduate Center and Library (1934).
Covington: Thomas More College Library (1970).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
Kentucky Department of Libraries (1967).
Kentucky State University, Blazer Library (1972).
State Law Library (unknown).
Highland Heights: Northern Kentucky State College Library (1973).
Hopkinsville: Hopkinsville Community College Library (1976).
Lexington:
University of Kentucky, Law Library (1968).
University of Kentucky, Margaret I. King Library (1907) – REGIONAL.
Louisville:
Louisville Free Public Library (1904).
University of Louisville, Belknap Campus Library (1925).
University of Louisville Law Library (1975).
Morehead: Morehead State University, Johnson Camden Library (1955).
Murray: Murray State University Library (1924).
Owensboro: Kentucky Wesleyan College Library (1966).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:
Louisiana State Library (1976).
Louisiana State University Law Library (1929).
Louisiana State University Library (1907) – REGIONAL.
Southern University Library (1952).
Eunice: Louisiana State University at Eunice, Le Doux Library (1969).
Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).
Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State University, Frazar Memorial Library (1941).
Monroe: Northeast Louisiana University, Sandel Library (1963).
Natchitoches: Northwestern State University, Watson Memorial Library (1887).
New Orleans:
Isaac Delgado College, Moss Technical Library (1968).
Law Library of Louisiana (unknown).
University of New Orleans Library (1963).
Loyola University Library (1942).
New Orleans Public Library (1883).
Southern University in New Orleans Library (1962).
Tulane University, Howard-Tilton Memorial Library (1942).

Tulane University Law Library (1976).
U.S. Court of Appeals, Fifth Circuit Library (1973).
Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).
Ruston: Louisiana Technical University Library (1896)–REGIONAL.
Shreveport:
Louisiana State University at Shreveport Library (1967).
Shreve Memorial Library (1923).
Thibodaux: Francis T. Nicholls State University, Leonidas Polk Library (1962).

MAINE

Augusta:
Maine Law and Legislative Reference Library (1973).
Maine State Library (unknown).
Bangor: Bangor Public Library (1884).
Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).
Castine: Maine Maritime Academy, Nutting Memorial Library (1969).
Lewiston: Bates College Library (1883).
Orono: University of Maine, Raymond H. Fogler Library (1907)–REGIONAL.
Portland:
Portland Public Library (1884).
University of Maine Law Library (1964).
Springvale: Nasson College Library (1961).
Waterville: Colby College Library (1884).

MARYLAND

Annapolis:
Maryland State Library (unknown).
U.S. Naval Academy, Nimitz Library (1895).
Baltimore:
Enoch Pratt Free Library (1887).
Johns Hopkins University, Milton S. Eisenhower Library (1882).
Morgan State College, Soper Library (1940).
University of Baltimore, Langsdale Library (1973).
University of Maryland, Baltimore County Library (1971).
University of Maryland, School of Law Library (1969).
Bel Air: Harford Community College Library (1967).
Beltsville: Department of Agriculture, National Agricultural Library (1895).
Chestertown: Washington College, Chester M. Miller Library (1891).
College Park: University of Maryland, McKeldin Library (1925)–REGIONAL
Cumberland: Allegany Community College Library (1974).
Frostburg: Frostburg State College Library (1967).
Germantown: Energy Research & Development Adm. Library (1963).
Patuxent River: Naval Air Station Library (1968).
Rockville: Montgomery County Department of Public Libraries (1951).
Salisbury: Salisbury State College, Blackwell Library (1965).
Towson: Goucher College, Julia Rogers Library (1966).
Westminster: Western Maryland College Library (1896).

MASSACHUSETTS

Amherst:
Amherst College Library (1884).
University of Massachusetts, Goodell Library (1907).
Belmont: Belmont Memorial Library (1968).
Boston:
Boston Athenaeum Library (unknown).
Boston College, Bapst Library (1963).
Boston Public Library (1859)–REGIONAL.
Northeastern University, Dodge Library (1962).
State Library of Massachusetts (unknown).
Brookline: Public Library of Brookline (1925).
Cambridge:
Harvard College Library (1860).
Massachusetts Institute of Technology Libraries (1946).
Chicopee: Our Lady of the Elms College Library (1969).
Lowell: Lowell Technological Institute, Alumni Memorial Library (1952).
Lynn: Lynn Public Library (1953).
Marlborough: Marlborough Public Library (1971).
Medford: Tufts University Library (1899).
Milton: Curry College Library (1972).
New Bedford: New Bedford Free Public Library (1858).
North Dartmouth: Southeastern Massachusetts University Library (1965).
North Easton: Stonehill College, Cushing-Martin Library (1962).
Springfield: Springfield City Library (1966).
Waltham: Brandeis University, Goldfarb Library (1965).
Wellesley: Wellesley College Library (1943).
Wenham: Gordon College, Winn Library (1963).
Williamstown: Williams College Library (unknown).
Worcester:
American Antiquarian Society Library (1814).
University of Massachusetts, Medical Center Library (1972).
Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).
Allendale: Grand Valley State College Library (1963).
Alma: Alma College, Monteith Library (1963).
Ann Arbor:
Great Lakes Basin Commission Library (1971).
University of Michigan, Harlan Hatcher Library (1884).
Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Cranbrook Institute of Science Library (1940).
Dearborn:
Henry Ford Centennial Library (1969).
Henry Ford Community College Library (1957).
Detroit:
Detroit Public Library (1868)–REGIONAL.
Marygrove College Library (1965).
Mercy College of Detroit Library (1965).
University of Detroit Library (1884).
Wayne State University Law Library (1971).
Wayne State University, G. Flint Purdy Library (1937).
Dowagiac: Southwestern Michigan College Library (1971).
East Lansing:
Michigan State University, Law Library (1971).
Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).
Flint:
Charles Stewart Mott Library (1959).
Flint Public Library (1967).
Grand Rapids:
Grand Rapids Public Library (1876).
Calvin College Library (1967).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson Public Library (1965).
Kalamazoo:

Kalamazoo Library System (1907).
Western Michigan University, Dwight B. Waldo Library (1963).
Lansing: Michigan State Library (unknown) – REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Monroe: Monroe County Library System (1974).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Olivet: Olivet College Library (1974).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Warren: Warren Public Library, Arthur J. Miller Branch (1973).
Wayne: Wayne Oakland Federated Library System (1957).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

Bemidji: Bemidji State College, A. C. Clark Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State College Memorial Library (1962).
Minneapolis:
Anoka County Library (1971).
Hennepin County Libraries (1971).
Minneapolis Public Library (1893).
University of Minnesota, Wilson Library (1907) – REGIONAL.
Moorhead: Moorhead State College Library (1956).
Morris: University of Minnesota at Morris Library (1963).
Northfield:
Carleton College Library (1930).
St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State College Library (1962).
St. Paul:
Minnesota Historical Society Library (1867).
Minnesota State Law Library (unknown).
St. Paul Public Library (1914).
University of Minnesota, St. Paul Campus Library (1974).
Saint Peter: Gustavus Adolphus College Library (1941).
Stillwater: Stillwater Public Library (1893).
Willmar: Crow River Regional Library (1958).
Winona: Winona State University, Maxwell Library (1969).

MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).
Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1920).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
Jackson State College Library (1968).
Millsaps College, Millsaps-Wilson Library (1963).
Mississippi Library Commission (1947).
Mississippi State Law Library (unknown).
Lorman: Alcorn Agricultural and Mechanical College Library (1970).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
University of Mississippi Library (1833) – REGIONAL.
University of Mississippi, School of Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State College, Kent Library (1916).
Columbia: University of Missouri Library (1862).
Fayette: Central Methodist College Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Jefferson City:
Lincoln University, Inman E. Page Library (1944).
Missouri State Library (1963).
Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
Kansas City Public Library (1881).
Rockhurst College Library (1917).
University of Missouri at Kansas City, General Library (1938).
Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).
Liberty: William Jewell College Library (1900).
Rolla: University of Missouri at Rolla Library (1907).
St. Charles: Lindenwood College, Margaret Leggat Butler Library (1973).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
St. Louis County Library (1970).
St. Louis Public Library (1866).
St. Louis University, Law Library (1967).
St. Louis University, Pius XII Memorial Library (1866).
University of Missouri at St. Louis, Thomas Jefferson Library (1966).
U.S. Court of Appeals, Eighth Circuit Library (1972).
Washington University, John M. Olin Library (1906).
Springfield:
Drury College, Walker Library (1874).
Southwest Missouri State College Library (1963).
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
Carroll College Library (1974).
Montana Historical Society Library (unknown).
Montana State Library (1966).
Missoula: University of Montana Library (1909) – REGIONAL.

NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
Nebraska Publications Clearinghouse, Nebraska Library Commission (1972) – REGIONAL.
Nebraska State Library (unknown).
University of Nebraska, Don L. Love Memorial Library (1907).
Omaha:

Creighton University, Alumni Library (1964).
Omaha Public Library (1880).
University of Nebraska at Omaha, University Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).
Wayne: Wayne State College, U.S. Conn Library (1970).

NEVADA

Carson City:
Nevada State Library (unknown).
Nevada Supreme Court Library (1973).
Las Vegas:
Clark County Library District Library (1974).
University of Nevada at Las Vegas, James R. Dickinson Library (1959).
Reno:
Nevada State Historical Society Library (1974).
University of Nevada Library (1907) – REGIONAL

NEW HAMPSHIRE

Concord:
Franklin Pierce Law Center Library (1973).
New Hampshire State Library (unknown).
Durham: University of New Hampshire Library (1907).
Franconia: Franconia College Library (1972).
Hanover: Dartmouth College, Baker Library (1884).
Henniker: New England College Library (1966).
Manchester:
Manchester City Library (1884).
New Hampshire College, H.A.B. Shapiro Memorial Library (1976).
St. Anselm's College, Geise Library (1963).
Nashua: Nashua Public Library (1971).

NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Free Public Library of Bloomfield (1965).
Bridgeton: Cumberland County Library (1966).
Camden: Rutgers University-Camden Library (1966).
Convent Station: College of St. Elizabeth, Mahoney Library (1938).
Dover: County College of Morris Library, Learning Resources Center (1975).
East Orange: East Orange Public Library (1966).
Elizabeth: Free Public Library of Elizabeth (1895).
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).
Hackensack: Johnson Free Public Library (1966).
Irvington: Free Public Library of Irvington (1966).
Jersey City:
Free Public Library of Jersey City (1879).
Jersey City State College, Forrest A. Irwin Library (1963).
Lawrenceville: Rider College Library (1975).
Madison: Drew University, Rose Memorial Library (1939).
Mahwah: Ramapo College Library (1971).
Mount Holly: Burlington County Library (1966).
New Brunswick:
Free Public Library (1908).
Rutgers University Library (1907).
Newark:
Newark Public Library (1906) – REGIONAL.
Rutgers---The State University, John Cotton Dana Library (1966).
Passaic: Passaic Public Library (1964).
Phillipsburg: Phillipsburg Free Public Library (1976).
Plainfield: Plainfield Public Library (1971).
Pomona: Stockton State College Library (1972).
Princeton: Princeton University Library (1884).
Rutherford: Fairleigh Dickinson University, Messler Library (1953).
Shrewsbury: Monmouth County Library (1968).
South Orange: Seton Hall University, McLaughlin Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
Toms River: Ocean County College Learning Resources Center (1966).
Trenton:
New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
Trenton Free Public Library (1902).
Union: Kean College of New Jersey, Nancy Thompson Library (1973).
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
Wayne: Wayne Public Library (1972).
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

Albuquerque:
University of New Mexico, Medical Sciences Library (1973).
University of New Mexico, School of Law Library (1973).
University of New Mexico, Zimmerman Library (1896) – REGIONAL.
Hobbs: New Mexico Junior College, Pannell Library (1969).
Las Cruces: New Mexico State University Library (1907).
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
Portales: Eastern New Mexico University Library (1962).
Santa Fe:
New Mexico State Library (1960) – REGIONAL.
Supreme Court Law Library (unknown).
Silver City: Western New Mexico University, Miller Library (1972).

NEW YORK

Albany:
New York State Library (unknown) – REGIONAL.
State University of New York at Albany Library (1964).
Auburn: Seymour Library (1972).
Bayside: Queensborough Community College Library (1972).
Binghamton: State University of New York at Binghamton Library (1962).
Brockport: State University of New York, Drake Memorial Library (1967).
Bronx:
Herbert H. Lehman College Library (1967).
New York Public Library, Mott Haven Branch (1973).
Bronxville: Sarah Lawrence College Library (1969).
Brooklyn:
Brooklyn College Library (1936).
Brooklyn Law School, Law Library (1974).
Brooklyn Public Library (1908).
Polytechnic Institute of Brooklyn, Spicer Library (1963).
Pratt Institute Library (1891).
State University of New York, Downstate Medical Center Library (1958).
Buffalo:
Buffalo and Erie County Public Library (1895).
State University of New York at Buffalo, Lockwood Memorial Library (1963).

Canton: St. Lawrence University, Owen D. Young Library (1920).
Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).
Cortland: State University of New York, College at Cortland, Memorial Library (1964).
Delhi: State University Agricultural and Technical College Library (1970).
Douglaston: Cathedral College Library (1971).
East Islip: East Islip Public Library (1974).
Elmira: Elmira College, Gannett-Tripp Learning Center (1956).
Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).
Flushing: Queens College, Paul Klapper Library (1939).
Garden City:
Adelphi University, Swirbul Library (1966).
Nassau Library System (1965).
Geneseo: State University College, Milne Library (1967).
Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1965).
Hamilton: Colgate University Library (1902).
Hempstead: Hofstra University Library (1964).
Ithaca:
Cornell University Library (1907).
New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).
Jamaica:
Queens Borough Public Library (1926).
St. John's University Library (1956).
Kings Point: U.S. Merchant Marine Academy Library (1962).
Mount Vernon: Mount Vernon Public Library (1962).
New Paltz: State University College Library (1965).
New York City:
City University of New York, City College Library (1884).
College of Insurance, Ecker Library (1965).
Columbia University Libraries (1882).
Cooper Union Library (1930).
Fordham University Library (1937).
Medical Library Center of New York (1976).
New York Law Institute Library (1909).
New York Public Library (Astor Branch) (1907).
New York Public Library (Lenox Branch) (1884).
New York University Libraries (1967).
New York University, Law Library (1973).
State University of New York, Maritime College Library (1947).
Newburgh: Newburgh Free Library (1909).
Niagara Falls: Niagara Falls Public Library (1976).
Oakdale: Dowling College Library (1965).
Oneonta: State University College, James M. Milne Library (1966).
Oswego: State University College, Penfield Library (1966).
Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).
Potsdam:
Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
State University College, Frederick W. Crumb Memorial Library (1964).
Poughkeepsie: Vassar College Library (1943).
Purchase: State University of New York, College at Purchase Library (1969).
Rochester:
Rochester Public Library (1963).
University of Rochester Library (1880).
St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).
Saratoga Springs: Skidmore College Library (1964).
Schenectady: Union College, Schaffer Lirary (901).
Southampton: Southampton College Library (1973).
Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).
Stony Brook: State University of New York at Stony Brook Library (1963).
Syracuse: Syracuse University Library (1878).
Troy: Troy Public Library (1869).
Utica: Utica Public Library (1885).
West Point: U.S. Military Academy Library (unknown).
Yonkers:
Yonkers Public Library (1910).
Yorktown Heights: Mercy College at Fox Meadow Library.

NORTH CAROLINA

Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).
Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).
Boone: Appalachian State University Library (1963).
Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
Chapel Hill: University of North Carolina Library (1884) – REGIONAL.
Charlotte:
Public Library of Charlotte and Mecklenburg County (1964).
Queens College, Everette Library (1927).
University of North Carolina at Charlotte, Atkins Library (1964).
Cullowhee: Western Carolina University, Hunter Library (1953).
Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).
Durham:
Duke University, William R. Perkins Library (1890).
North Carolina Central University, James E. Shepard Memorial Library (1973).
Elon College: Elon College Library (1971).
Fayetteville: Fayetteville State University, Chesnutt Library (1971).
Greensboro:
North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).
Greenville: East Carolina University, J. Y. Joyner Library (1951).
Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).
Lexington: Davidson County Public Library System (1971).
Mount Olive: Mount Olive College, Moye Library (1971).
Murfreesboro: Chowan College, Whitaker Library (1963).
Pembroke: Pembroke State University Library (1965).
Raleigh:
North Carolina State Library (unknown).
North Carolina State University, D. H. Hill Library (1923).
North Carolina Supreme Court Library (1972).
Wake County Public Libraries (1969).
Rocky Mount: North Carolina Wesleyan College Library (1969).
Salisbury: Catawba College Library (1925).
Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).
Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).
Winston-Salem:
Forsyth County Public Library System (1954).
Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:
- State Historical Society of North Dakota (1907).
- North Dakota State Law Library (unknown).
- State Library Commission Library (1971).
- Veterans Memorial Public Library (1967).

Dickinson: Dickinson State College Library (1968).

Fargo:
- Fargo Public Library (1964).
- North Dakota State University Library (1907)—REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.

Grand Forks: University of North Dakota, Chester Fritz Library (1890).

Minot: Minot State College, Memorial Library (1925).

Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).

Akron:
- Akron Public Library (1952).
- University of Akron Library (1963).

Alliance: Mount Union College Library (1888).

Ashland: Ashland College Library (1938).

Athens: Ohio University Library (1886).

Batavia: Clermont General and Technical College Library (1973).

Bluffton: Bluffton College, Musselman Library (1951).

Bowling Green: Bowling Green State University Library (1933).

Canton: Malone College, Everett L. Cattell Library (1970).

Chardon: Geauga County Public Library (1971).

Cincinnati:
- Public Library of Cincinnati and Hamilton County (1884).
- University of Cincinnati Library (1929).

Cleveland:
- Case Western Reserve University, Freiberger Library (1913).
- Cleveland Heights-University Heights Public Library (1970).
- Cleveland Public Library (1886).
- Cleveland State University Library (1966).
- John Carroll University, Grasselli Library (1963).
- Municipal Reference Library (1970).

Columbus:
- Capital University Library (1968).
- Columbus Public Library (1885).
- Ohio State Library (unknown)—REGIONAL.
- Ohio State University Library (1907).
- Ohio Supreme Court Law Library (1973).

Dayton:
- Dayton and Montgomery County Public Library (1909).
- University of Dayton, Albert Emanuel Library (1969).
- Wright State University Library (1965).

Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).

Elyria: Elyria Public Library (1966).

Findlay: Findlay College, Shafer Library (1969).

Gambier: Kenyon College Library (1873).

Granville: Denison University Library (1884).

Hiram: Hiram College, Teachout-Price Memorial Library (1874).

Kent: Kent State University Library (1962).

Marietta: Marietta College, Dawes Memorial Library (1884).

Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).

New Concord: Muskingum College Library (1966).

Oberlin: Oberlin College Library (1858).

Oxford: Miami University, Alumni Library (1909).

Portsmouth: Portsmouth Public Library (unknown).

Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).

Springfield: Warder Public Library (1884).

Steubenville:
- College of Steubenville, Starvaggi Memorial Library (1971).
- Public Library of Steubenville and Jefferson County (1950).

Tiffin: Heidelberg College, Beeghly Library (1964).

Toledo:
- Toledo-Lucas County Public Library (1884).
- University of Toledo Library (1963).

Westerville: Otterbein College, Centennial Library (1967).

Wooster: College of Wooster, the Andrews Library (1966).

Youngstown:
- Public Library of Youngstown and Mahoning County (1923).
- Youngstown State University Library (1971).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).

Alva: Northwestern State College Library (1907).

Bartlesville: United States ERDA-BERC Library (1962).

Bethany: Bethany Nazarene College, R. T. Williams Library (1971).

Durant: Southeastern State College Library (1929).

Edmond: Central State University Library (1934).

Enid: Public Library of Enid and Garfield County (1908).

Langston: Langston University, G. Lamar Harrison Library (1941).

Muskogee: Muskogee Public Library (1971).

Norman: University of Oklahoma Libraries (1893).

Oklahoma City:
- Oklahoma County Libraries (1974).
- Oklahoma City University Library (1963).
- Oklahoma Department of Libraries (1893)—REGIONAL.

Shawnee: Oklahoma Baptist University Library (1933).

Stillwater: Oklahoma State University Library (1907).

Tahlequah: Northeastern State College, John Vaughan Library (1923).

Tulsa:
- Tulsa City-County Library (1963).
- University of Tulsa, McFarlin Library (1929).

Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).

Corvallis: Oregon State University Library (1907).

Eugene: University of Oregon Library (1883).

Forest Grove: Pacific University Library (1897).

La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).

McMinnville: Linfield College, Northup Library (1965).

Monmouth: Oregon College of Education Library (1967).

Portland:
- Department of the Interior, Bonneville Power Administration Library (1962).
- Lewis and Clark College, Aubrey R. Watzek Library (1967).
- Library Association of Portland (1884).
- Portland State University Library (1963)—REGIONAL.
- Reed College Library (1912).

Salem:
- Oregon State Library (unknown).
- Oregon Supreme Court Library (1974).

Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
Altoona: Altoona Public Library (1969).
Bethlehem: Lehigh University, Linderman Library (1876).
Blue Bell: Montgomery County Community College, Learning Resources Center Library (1975).
Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College, Myrin Library (1963).
Doylestown: Bucks County Free Library, Center County Library (1970).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: State Library of Pennsylvania (unknown)—REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
- Drexel University Library (1963).
- Free Library of Philadelphia (1897).
- St. Joseph's College Library (1974).
- Temple University, Samuel Paley Library (1947).
- U.S. Court of Appeals, Third Circuit (1973).
- University of Pennsylvania, Biddle Law Library (1974).
- University of Pennsylvania Library (1886).

Pittsburgh:
- Bureau of Mines, Pittsburgh Research Center Library (1962).
- Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
- Carnegie Library of Pittsburgh (1895).
- La Roche College, John J. Wright Library (1974).
- University of Pittsburgh, Hillman Library (1910).

Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College, Corgan Library (1949).
Williamsport: Lycoming College Library (1970).
York: York Junior College Library (1963).
Youngwood: Westmoreland County Community College, Learning Resource Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
- Brown University, John D. Rockefeller, Jr. Library (unknown).
- Providence College, Phillips Memorial Library (1969).
- Providence Public Library (1884).
- Rhode Island College Library (1965).
- Rhode Island State Library (before 1895).

Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).

SOUTH CAROLINA

Charleston:
- Baptist College at Charleston Library (1967).
- College of Charleston Library (1869).
- The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).
Columbia:
- Benedict College, Learning Resources Center (1969).
- South Carolina State Library (before 1895).
- University of South Carolina Undergraduate Library (1884).

Conway: University of South Carolina, Coastal Carolina Regional Campus Library (1974).
Due West: Erskine College, McCain Library (1968).
Florence:
- Florence County Library (1967).
- Francis Marion College, James A. Rogers Library (1970).

Greenville:
- Furman University Library (1962).
- Greenville County Library (1966).

Greenwood: Lander College Library (1967).
Orangeburg: South Carolina State College, Whittaker Library (1953).
Rock Hill: Winthrop College Library (1896).
Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).
Brookings: South Dakota State University, Lincoln Memorial Library (1889).
Pierre: South Dakota State Library (1973).
Rapid City:
- Rapid City Public Library (1963).
- South Dakota School of Mines and Technology Library (1963).

Sioux Falls:

Augustana College, Mikkelsen Library and Learning Resources Center (1969).
Sioux Falls Public Library (1903).
Spearfish: Black Hills State College Library (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

Bristol: King College Library (1970).
Chattanooga:
Chattanooga-Hamilton County Bicentennial Library (1907).
TVA Technical Library (1976).
Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
Cleveland: Cleveland State Community College Library (1973).
Columbia: Columbia State Community College Library (1973).
Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville:
Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).
University of Tennessee Law Library (1971).
University of Tennessee Library (1907).
Martin: University of Tennessee at Martin Library (1957).
Memphis:
Memphis and Shelby County Public Library and Information Center (1896).
Memphis State University, John W. Brister Library (1966).
Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
Nashville:
Fisk University Library (1965).
Joint University Libraries (1884).
Public Library of Nashville and Davidson County (1884).
Tennessee State Law Library (1976).
Tennessee State Library and Archives, State Library Division (unknown).
Tennessee State University, Martha M. Brown Memorial Library (1972).
Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene: Hardin-Simmons University Library (1940).
Arlington:
Arlington Public Library (1970).
University of Texas at Arlington Library (1963).
Austin:
Texas State Law Library (1972).
Texas State Library (unknown)—REGIONAL.
University of Texas at Austin Library (1884).
University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
University of Texas, School of Law Library (1965).
Baytown: Lee College Library (1970).
Beaumont: Lamar University Library (1957).
Brownwood: Howard Payne College, Walker Memorial Library (1964).
Canyon: West Texas State University Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
Corsicana: Navarro Junior College Library (1965).
Dallas:
Bishop College, Zale Library (1966).
Dallas Baptist College Library (1967).
Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center Library at Dallas (1975).
Denton: North Texas State University Library (1948).
Edinburg: Pan American University Library (1959).
El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary Couts Burnett Library (1916).
Galveston: Rosenberg Library (1909).
Houston:
Houston Public Library (1884).
North Harris County College, Learning Resource Center (1974).
Rice University, Fondren Library (1967).
University of Houston Library (1957).
Huntsville: Sam Houston State University, Estill Library (1949).
Irving: Irving Municipal Library (1974).
Kingsville: Texas Arts and Industries University Library (1944).
Lake Jackson: Brazosport College Library (1969).
Laredo: Laredo Junior College Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Tech University Library (1935)—REGIONAL.
Marshall: Wiley College, Cole Library (1962).
Mesquite: Mesquite Public Library (1975).
Nacogdoches: Stephen F. Austin State University Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
San Antonio College Library (1972).
San Antonio Public Library, Business and Science Department (1899).
St. Mary's University Library (1964).
Trinity University Library (1964).
University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: University of Houston, Victoria Center Library (1973).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)—REGIONAL.
Ogden: Weber State College Library (1962).
Provo:
Brigham Young University, Lee Library (1908).

Brigham Young University Law Library (1972).
Salt Lake City:
Utah State Supreme Court Law Library (1975).
University of Utah, Eccles Medical Sciences Library (1970).
University of Utah, Law Library (1966).
University of Utah, Marriott Library (1893).
Utah State Library Commission, Documents Library (unknown).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
St. Thomas Public Library (1968).
Christiansted (St. Croix): Christiansted Public Library (1974).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
University of Virginia, Alderman Library (1910)—REGIONAL.
University of Virginia Law Library (1964).
Chesapeake: Chesapeake Public Library System (1970).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College Library (1884).
Fairfax: George Mason College of the University of Virginia, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Harrisonburg: Madison College, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
Virginia Military Institute, Preston Library (1874).
Washington and Lee University, Cyrus Hall McCormick Library (1910).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
Armed Forces Staff College Library (1963).
Norfolk Public Library (1895).
Old Dominion University Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico:
Federal Bureau of Investigation Academy Library (1970).
Marine Corps Schools, James Carson Breckinridge Library (1967).
Reston: Department of the Interior, Geological Survey Library (1962).
Richmond:
State Law Library (1973).
University of Richmond, Boatwright Memorial Library (1900).
U.S. Court of Appeals, Fourth Circuit Library (1973).
Virginia Commonwealth University, James Branch Cabell Library (1971).
Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia:
Evergreen State College Library (1972).
Washington State Library (unknown)—REGIONAL.
Port Angeles: North Olympic Library System (1965).
Pullman: Washington State University Library (1907).
Seattle:
Seattle Public Library (1908).
University of Washington Library (1890).
University of Washington, School of Law Library (1969).
Spokane: Spokane Public Library (1910).
Tacoma:
Tacoma Public Library (1894).
University of Puget Sound, Collins Memorial Library (1938).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Bluefield: Bluefield State College Library (1972).
Charleeton:
Kanawha County Public Library (1952).
West Virginia Library Commission (unknown).
Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University Library (1925).
Institute: West Virginia State College Library (1907).
Morgantown: West Virginia University Library (1907)—REGIONAL.
Salem: Salem College Library (1921).
Shepherdstown: Shepherd College Library (1971).
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).
Beloit: Beloit College Libraries (1888).
Eau Claire: University of Wisconsin, Eau Claire, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).

Green Bay: University of Wisconsin at Green Bay Library (1968).

La Crosse:

La Crosse Public Library (1883).

University of Wisconsin-La Crosse, Murphy Library (1965).

Madison:

Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).

Madison Public Library (1965).

State Historical Society Library (1870) — REGIONAL, in cooperation with University of Wisconsin, Memorial Library.

University of Wisconsin, Memorial Library (1939).

Wisconsin State Library (unknown).

Milwaukee:

Alverno College Library (1971).

Milwaukee County Law Library (1934).

Milwaukee Public Library (1861) — REGIONAL.

Mount Mary College Library (1964).

University of Wisconsin-Milwaukee Library (1960).

Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).

latteville: University of Wisconsin-Platteville, Elton S. Karrmann Library (1964).

Racine: Racine Public Library (1898).

River Falls: University of Wisconsin-River Falls, Chalmer Davee Library (1962).

Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).

Superior:

Superior Public Library (1908).

University of Wisconsin-Superior, Jim Dan Hill Library (1935).

Waukesha: Waukesha Public Library (1966).

Wausau: Marathon County Public Library (1971).

Whitewater: University of Wisconsin-Whitewater, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).

Cheyenne: Wyoming State Library (unknown) — REGIONAL.

Laramie: University of Wyoming, Coe Library (1907).

Powell::Northwest Community College Library (1967).

Riverton: Central Wyoming College Library (1969).

Rock Springs: Western Wyoming College Library (1969).

Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

APPENDIX B. LIST OF FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

ALABAMA

Birmingham—Gayle C. Shelton, Jr., Director, Suite 200-201, 908 South 20th Street 35205, Area Code 205 Tel 254-1331, FTS 229-1331

ALASKA

****Anchorage**—Sara L. Haslett, Director, 412 Hill Building, 632 Sixth Avenue 99501, Area Code 907 Tel 265-5307

ARIZONA

Phoenix—Donald W. Fry, Director, 508 Greater Arizona Savings Building, 112 North Central Avenue 85004, Area Code 602 Tel 261-3285, FTS 261-3285

ARKANSAS

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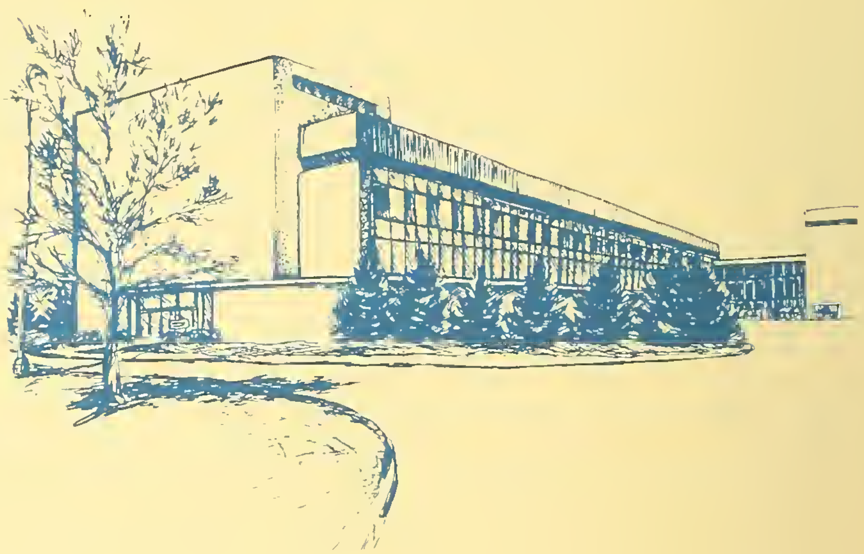

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