Building Technology Publications supplement 5: 1980

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Supplement 5: 1980

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Introduction

This report presents the National Bureau of Standards' Center for Building Technology (CBT) publications for 1980. It is the fifth supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975,* and lists CBT documents issued or recorded during the period January 1 to December 31, 1980. It includes titles and abstracts of each NBS publication and each paper published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This report communicates the results of CBT research to various technical audiences, as well as to the general public. Publications constitute a major end product to CBT's efforts and, in 1980, appeared in several NBS publication series (Building Science Series, Technical Notes, Special Publications, NBS Interagency Reports, and Grant/Contract Reports) as well in non-NBS media such as technical and trade publications. Publications appearing in non-NBS media have each been assigned a five-digit number. NBS publication series abbreviations are:

BSS - Building Science Series

TN - Technical Note

SP - Special Publication

NBSIR - National Bureau of Standards Interagency Report

GCR - Grant/Contract Report

This document is divided into three main sections. The first, *Titles and Abstracts,* provides the report title, author(s), date of publication, selected key words, and an abstract of each NBS publication and each paper published in an outside source. The *Author Index* cites each CBT author and gives the publication title and/or number referencing documents listed in this supplement. The *Key Word Index* is a subject index, listing word summaries of the building research topics for each publication and paper. By selecting a main word or subject, which are 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 National Engineering Laboratory, National Bureau of Standards. NBS undertakes basic and applied research in various areas. Interested readers will find other NBS publications listed in NBS Special Publication 305-12, *Publications of the National Bureau of Standards 1980,* from which parts of this report have been taken.

Obtaining Publications

Most current CBT publications (excluding *NBS Interagency Reports and Grant/Contract Reports)* are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 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 depository libraries (libraries designated to receive government publications) and Department of Commerce District Offices. The current price list and availability of publications listed in this report are given in Appendix C.

The depository libraries listed in Appendix A receive 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.

Department of Commerce District 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 District 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 District Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

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Building Science Series

Building Science Series reports disseminate technical information developed at the Bureau 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.

BSS121. **Soil classification for construction practice in shallow trenching,** F. Y. Yokel, R. L. Tucker, and L. C. Reese, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 121,* 89 pages (Mar. 1980) SN003-003-02162-8.

Key words: braced excavations; construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability; soil classification; soil pressure; soil testing; trenching.

Construction practices in trenching and data on potential causes of trenching accidents are reviewed. A study is made of the soil properties and site conditions that must be identified in order to determine the stability of shored and sloped excavations against cave-ins. Two possible alternate soil classification methods are recommended. The methods are simple enough to be used by construction foremen and at the same time use parameters which can be measured or identified without ambiguity. The classification methods are supplemented by appropriate field tests and correlated with allowable side slopes and lateral soil pressures on shoring.

BSS122. **A study of lumber used for bracing trenches in the United States,** L. I. Knab, F. Y. Yokel, W. L. Galligan, B. A. Bendtsen, and J. F. Senft, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 122,* 221 pages (Mar. 1980) SN003-003-02164-4.

Key words: construction lumber; construction safety; excavation; hardwood; lumber grading; shoring; softwood; timber engineering; trench bracing; trenching.

In certain areas of the United States, lumber is used extensively to brace trenches against collapse. The life and safety of the workers in these trenches therefore depends on the structural adequacy of the lumber bracing used. This report presents a study of the properties and characteristics of trenching lumber which are critical to its structural performance. Using these properties and characteristics, allowable stresses and use recommendations are proposed.

The National Bureau of Standards (NBS) conducted a field study of trenching lumber and found that either ungraded eastern species, primarily hardwood, or graded Douglas-fir is used. For graded Douglas-fir, allowable design stresses and other properties are established by existing standards. The eastern species, however, are ungraded and no accepted guidelines are used to assign allowable design stresses and other properties. The results of the field study indicate that 80 percent of the eastern species trenching lumber, when graded by existing softwood grading rules (Southern Pine Inspection Bureau Grading Rules, 1977 edition) is No. 2 grade or higher; 60 percent is No. 1 grade or higher. These percentages do not reflect the effects of wane (deficiency in cross-sectional area) and decay, which are additional problems. NBS therefore recommends that, for hardwood wales and struts, allowable stresses and other properties be based on a No. 2 minimum grade with appropriate provisions to control wane and decay.

Use recommendations were developed, which consider duration of load, mechanical damage to lumber, presence of bark, decay, insect attack, inspectability, exposure, and storage for various aspects of trenching lumber applications. These recommendations reflect a severe trenching environment, possible reuse of structural members, and the need for structural integrity to protect life and property.

BSS123. **The effect of moisture on the thermal conductance of roofing systems,** L. I. Knab, D. R. Jenkins, and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 123,* 46 pages (Apr. 1980) SN003-003-02168-7.

Key words: built-up roofing; insulation; moisture; roofing; thermal conductance; thermal conductivity; thermal resistance.

The results of laboratory tests are presented describing the effect of the moisture content on the thermal conductance of roofing systems containing insulation. Roofing systems, consisting of five types of rigid-board roof insulations with attached four-ply bituminous built-up membrane, were tested. Moisture was induced into the roofing system specimens by maintaining a constant water vapor pressure difference across them. Moisture gain in the insulation varied depending on the type and thickness of the insulation.

A procedure was developed, using a heat-flow meter apparatus (ASTM C 518 type), to carry out thermal conductance tests on roofing specimens containing moisture. More than 200 tests were performed over a wide range of moisture contents. The approximate moisture distribution in the insulation was determined from core samples.

Relationships between the thermal conductance and moisture content are presented. The relationships show that the presence of moisture in roofing systems can cause significant increases in the thermal conductance, depending on the type and thickness of the insulation.

BSS124. **Hurricane wind speeds in the United States,** M. E. Batts, M. R. Cordes, L. R. Russell, J. R. Shaver, and E. Simiu, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser.* **124,** 50 pages (May 1980) SN003-003-02177-6.

Key words: building (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology).

A Monte Carlo simulation technique is used to obtain estimates of hurricane wind speeds in the Gulf and East Coasts of the United States. The paper describes the sources of data, the probabilistic models for the climatological characteristics of hurricanes, and the physical models for the hurricane wind speed field used in the estimations. Estimated values of fastest-mile hurricane wind speeds at 10 m above ground in open terrain at the coastline and at 200 km inland are given for various mean

recurrence intervals. The estimated hurricane wind speeds were found to be best fitted by Weibull distributions with tail length parameters $\gamma > 4$. Estimates are given of various errors inherent in the estimated values of the hurricane wind speeds. Owing to uncertainties with respect to the applicability of the physical models used in this work to locations north of Cape Hatteras, estimated hurricane wind speeds given for these locations should be viewed with caution.

BSS125. **An economic model for passive solar designs in commercial environments,** J. W. Powell, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 125,* 146 pages (June 1980) SN003-003-02203-9.

Key words: benefit-cost analysis; building economics; commercial buildings; investment analysis; life-cycle cost analysis; passive solar energy; retrofit; revitalization; solar energy systems.

This report presents an economic model for evaluating passive solar designs in commercial environments. It discusses the literature on this topic and draws upon this literature to develop a general methodological framework. The model incorporates a life-cycle costing approach that focuses on the costs of purchase, installation, maintenance, repairs, replacement, and energy. It includes a detailed analysis of tax laws affecting the use of solar energy in commercial buildings. Possible methods of treating difficult-to-measure benefits and costs, such as effects of the passive solar design on resale value of the building and on lighting costs, rental income from the building, and on the use of commercial space are presented. The model is illustrated in two case examples of prototypical solar designs for low-rise commercial buildings in an urban setting. These designs were developed at NBS under the Solar Cities project. The two designs, a wall collector system and a street canopy, are evaluated for a neighborhood in Baltimore undergoing urban renewal. Results of the analyses indicate these designs may be economically feasible under a realistic range of economic conditions. Topics requiring further research are identified.

BSS126. **Geographical extrapolation of typical hourly weather data for energy calculation in buildings,** E. A. Arens, L. E. Flynn, D. N. Nall, and K. Ruberg, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 126,* 121 pages (Aug. 1980) SN003-003-02228-4.

Key words: building energy; computerized climate data.

Two techniques are developed and tested for creating composite and synthetic hourly weather data for a wide range of sites. The first technique selects real weather data segments from a source multiyear weather record, and links them into a composite synthetic year, in which the hourly values are unchanged from the source. The second technique adjusts the real hourly data values of the source to create a more completely synthetic year. The techniques may be applied individually or in combination. The resulting synthetic year or years can be used to provide data that is representative of long-term climate for building energy prediction either at the first-order station where the source hourly weather data were recorded, or at a nearby second-order station for which only summarized climate averages are available. Additionally, the adjustment technique can generate synthetic data to represent specific time periods at second-order stations for use in energy audits and experiments. The effectiveness of extrapolating weather data from one location to another is assessed, and the uses of the two techniques are described. The user-interactive Fortran programs, SELECT and ADJUST are appended.

BSS127. **Recommended technical provisions for construction practice in shoring and sloping of trenches and excavations,** F. Y. Yokel, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 127,* 84 pages (June 1980) SN003-003-02195-4.

Key words: braced excavation; construction; retaining structures; shoring; slope stability; soil classification; soil pressure; standards; trenching.

On the basis of studies conducted by the National Bureau of Standards technical provisions for the sloping and shoring of the banks of trenches and excavations are recommended. Included are a recommended standard practice for trenching which can be used by construction supervisors and compliance officers of the Occupational Safety and Health Administration, and proposed engineering guidelines for the design of shoring systems and other means to prevent mass movement of soil or rock in excavations.

BSS128. **Evaluation of electrical connections for branch circuit wiring,** W. J. Meese and R. W. Beausoliel, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 128,* 71 pages (Nov. 1980) SN003-003-02269-1.

Key words: contact resistance; electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; performance testing.

Performance criteria and test procedures are presented for the evaluation of electrical connections in branch circuit wiring. Investigations and research undertaken to determine needed characteristics of innovative electrical connections are summarized. Design and installation strategies to lessen the chances of electrical connection failures are discussed. Inherent weaknesses are described for design and installation methods of common types of branch circuit wiring connections or terminations, which appear to make them vulnerable to loosening and overheating. There are technology improvements which demonstrate that innovative electrical connections can be developed which may be less costly when installed, and have less chance of becoming hazardous, than common conventional connections.

BSS129. **Cost estimation and cost variability in residential rehabilitation,** R. E. Chapman, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 129,* 120 pages (Nov. 1980) SN003-003-02270-5.

Key words: applied economics; building codes; building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation.

This study analyzes four methods of estimating the costs of residential rehabilitation. Each method is critiqued with regard to its treatment of changes in the size of the renovation project, the productivity of labor, and the contractor's markup for overhead and profit. Cost comparisons and a discussion of the way in which the inherent riskiness of renovation activities may be assessed are also presented. A theoretical approach for dealing with cost variability which integrates the performance concept with established engineering economics techniques is also developed.

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.

TN1113-1. **Highway noise criteria study: Traffic noise data base,** D. R. Flynn, C. R. Voorhees, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.), Tech. Note 1113-1,* 381 pages (Apr. 1980) SN003-003-02169-5.

Key words: acoustics; environmental pollution; highway noise; motor vehicle noise; noise; noise control; sound; traffic noise; transportation noise.

This report documents a traffic noise data base that was obtained as part of a large research program developed to identify and quantify the important physical parameters which affect human response to time-varying traffic noise and to investigate various procedures for rating such noise so as to enable reliable predictions of subjective response to the noise. Fifteen-minute recordings of actual traffic noise were made at four microphone positions (7.5, 15, 30, and 60 m from the centerline of the near lane) at several times of the day at each of seven sites, five representing nominally constant-speed traffic and two representing stop-and-go intersection traffic. The 107 recordings that resulted were subjected to extensive analysis. The analysis procedures are described and tables and graphs are included which document, for each recording, the 1/3-octave band spectra and numerous noise descriptors computed from the time-histories of the A-weighted sound level. As a separate part of this study, recordings also were made of the noise from single-vehicle passbys and from simulated traffic consisting of controlled drive-bys of up to ten vehicles. These recordings also were extensively analyzed and the results of these analyses are given.

TN1113-2. **Highway noise criteria study: Outdoor/indoor noise isolation,** P. R. Donavan, D. R. Flynn, and S. L. Yaniv, *Nat. Bur. Stand. (U.S.), Tech. Note 1113-2,* 180 pages (Aug. 1980) SN003-003-02235-7.

Key words: acoustics; building acoustics; environmental pollution; noise control; noise isolation; sound.

This report documents a series of measurements of the outdoor-to-indoor noise isolation provided by nine houses in the Washington, DC, area. These measurements were carried out as part of a large research program developed to identify and quantify the important physical parameters which affect human response to time-varying traffic noise and to investigate various procedures for rating such noise so as to enable reliable predictions of subjective response to the noise. While a small truck was driven past each test house, simultaneous recordings were made of the sound level at three outdoor microphones and at four indoor microphones (three of which were positioned at representative listener positions). These recordings were analyzed to yield one-third octave band sound levels as functions of time and from these levels outdoor-to-indoor level differences were computed. Analyses are given of the influence of different experimental variables. It is found that microphone placement, both indoors and outdoors, is the major source of measurement uncertainty. The data from this study are in good agreement with sound isolation data reported in the literature for houses in colder climates.

TN1115. **A report on the relevance of the Second Law of Thermodynamics to energy conservation,** D. Didion, D. Garvin, and J. Snell, *Nat. Bur. Stand. (U.S.), Tech. Note 1115,* 51 pages (Aug. 1980) SN003-003-02231-4.

Key words: availability analysis; energy; energy conservation; process efficiency; Second Law of Thermodynamics; system efficiency.

This is a study of the relevance to Federal energy conservation programs of the use of the concept of energy efficiency as being the ratio of the minimum available work necessary for accomplishing a given task to the available work in the actual fuel used to accomplish this task. Included within the study is a review of selected elements of thermodynamics and efficiency concepts, and identification of the technology pertinent to energy conservation programs. The study examines the potential benefits, if any, that would accrue from the application of Second Law of Thermodynamics principles to these technologies. Results indicate the positive value of the Second Law analytical techniques in the planning and design stages of system development, and the rather limited value of its use during the performance monitoring stage. Needs for advancing the acceptance and use of the Second Law analytical techniques are identified.

TN1118. **Stone consolidating materials—A status report,** J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 1118,* 52 pages (May 1980) SN003-003-02191-1.

Key words: conservation; consolidating materials; deterioration of stone; preservation; stone; stone consolidation.

Information on types of stone consolidating materials, their performances, and uses are critically reviewed. Processes responsible for the deterioration of stone and criteria for selecting stone consolidants are also reviewed. The main function of stone consolidants is to reestablish the cohesion between particles of deteriorated stone. In addition, a good consolidant should meet performance requirements concerning durability, depth of penetration, effect on stone porosity, effect on moisture transfer, compatibility with stone, and effect on appearance.

Stone consolidants can be divided into four main groups, according to their chemistry. These groups are inorganic materials, alkoxysilanes, synthetic organic polymers, and waxes. Epoxies, acrylics, and alkoxysilanes are currently the most commonly used consolidating materials. Certain waxes have been found to have excellent consolidating abilities. Waxes, however, tend to soften and to accumulate grime and dust. Inorganic materials and some organic polymers have a tendency to form shallow, brittle layers near the surface of stone. These treated layers often separate from the untreated stone. Alkoxysilanes have excellent penetrabilities and are considered by some stone conservators as the most promising consolidating materials.

However, a universal consolidant does not exist and many factors must be considered in selecting a consolidant for a specific stone structure.

TN1120. **An approach to improved durability tests for building materials and components,** G. Frohnsdorff, L. W. Masters, and J. W. Martin, *Nat. Bur. Stand. (U.S.), Tech. Note 1120,* 35 pages (July 1980) SN003-003-02213-6.

Key words: accelerated aging tests; building components; building materials; durability; life testing; prediction; recommended practice; reliability service life.

Durability tests usually provide relative measures of the time building materials and components will perform their intended functions under the expected service conditions. This is not adequate to ensure the proper selection of new building materials and components because quantitative measures of long-term performance are needed. Although many tests have been developed to accelerate degradation processes of building materials, they are seldom fully adequate for reliably predicting long-term performance. In this paper, a recommended practice, ASTM E 632-78, which provides a framework for the development of improved durability tests, is outlined. The application of the recommended practice, which does not specify an analysis procedure, is illustrated by examples from the literature using both deterministic and probabilistic approaches.

While probabilistic concepts have not been applied extensively to materials durability problems in the construction industry, these concepts offer new opportunities for obtaining improved quantitative predictions of the service life of building materials.

TN1123. **A computer data base system for indexing research papers,** L. J. Kaetzel, R. A. Glass, and G. R. Smith, *Nat. Bur. Stand. (U.S.), Tech. Note 1123,* 90 pages (Oct. 1980) SN003-003-02245-4.

Key words: data base; information retrieval; interactive processing.

The KGS data base system allows the indexing and retrieval of scientific research papers through the use of a minicomputer system in an interactive mode. Criteria are entered through the user's computer terminal which produces subsets of the data base in a report format as well as statistical summaries of data base elements.

TN1131. **Field investigation of the performance of residential retrofit insulation,** J. L. Weidt, R. J. Saxler, and W. J. Rossiter, Jr., *Nat. Bur. Stand. (U.S.), Tech. Note 1131,* 67 pages (Sept. 1980) SN003-003-02243-8.

Key words: conservation; energy; field survey; insulation; moisture content; residences; retrofit; thermal resistivity.

A study was conducted to obtain information on the performance of in-service insulations of the type commonly used in the United States to retrofit sidewalls of housing: urea-formaldehyde based foam, loose-fill cellulose, and loose-fill mineral fiber.

In the field phase of the study, observations were made on performance-related factors such as: the completeness of filling the cavity, the condition of the insulation and wall components, and evidence of moisture accumulation such as water stains on sheathing, studs and other wall components. Shrinkage was observed to have occurred for all urea-formaldehyde based foam specimens. Where measurable, it was found to be within a range of 4 to 9 percent. For the six test houses containing loose-fill insulation which were opened at the top of the wall cavity, only one with cellulose contained a void of undetermined origin at the location.

Insulation specimens removed from the walls were tested to determine their density, thermal resistivity and moisture content. The pH and moisture absorption of the urea-formaldehyde based foam specimens were also determined. Results of the laboratory measurements are discussed and compared with data from other studies. Relationships between the moisture contents of the samples and their thermal resistivities were not found. Results indicated that the retrofitting of the inspected sidewalls was for the most part accomplished without adverse effect upon them.

TN1132. **Solar energy systems—Standards for cover plates for plate solar collectors,** E. J. Clark, W. E. Roberts, J. W. Grimes, and E. J. Embree, *Nat. Bur. Stand. (U.S.), Tech. Note 1132,* 162 pages (Dec. 1980) SN003-003-02277-2.

Key words: cover plate durability; cover plate materials; cover plate standards; standards; weathering of cover plates.

Laboratory studies were performed to obtain data needed for the development of standards to evaluate the performance and durability of cover plates for flat plate solar collectors used in solar heating and cooling systems. Ten cover plate materials were evaluated to assess their durability after exposure to heat aging, natural weathering and accelerated weathering. Laboratory tests included measurement of solar energy transmittance, linear dimensional stability, warpage and the effect of the dirt retention. The temperatures cover plate materials attain on solar collectors were determined by measurement and by computer simulations. A procedure was developed for the natural weathering exposure of cover plate materials at elevated temperatures which approximate stagnation conditions of solar collectors.

The results of the laboratory tests are presented and draft standards for evaluating cover plate materials for flat plate solar collectors are proposed.

TN1134. **Guidelines for the installation of solar components on low-sloped roofs,** R. G. Mathey and W. J. Rossiter, Jr., *Nat. Bur. Stand. (U.S.), Tech. Note 1134,* 81 pages (Nov. 1980) SN003-003-02261-6.

Key words: collector installation; field survey; guidelines; low-sloped roofs; roofing performance; solar collectors.

Guidelines were prepared for the installation of solar collectors and related equipment on low-sloped roofs of commercial and industrial type buildings. The guidelines are concerned primarily with the waterproofing integrity of the roofing system, access to the collectors and roofing, attachment of different types of collector support frames and safety. Technical information from the literature, building codes, roofing field surveys and acceptable roofing practice provided the basis for the guidelines. The guidelines include recommendations for the design of the solar installation with regard to roofing performance, workmanship during collector installation and maintenance of roofs with solar components.

A field survey was conducted to inspect the condition of low-sloped built-up roofing systems which were retrofitted with solar collector systems. Literature and field surveys were conducted to identify roofing problems attributed to solar equipment installation on roofs and the effect of the installation on roofing performance. The results of the literature and field surveys are presented. Applicable building codes and related documents were examined to obtain information concerning the effect of the installation of solar components on rooftop safety.

Handbooks

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

H132. **Energy conservation in buildings: An economics guidebook for investment decisions,** H. E. Marshall and R. T. Ruegg, *Nat. Bur. Stand. (U.S.), Handb. 132,* 149 pages (May 1980) SN003-003-02192-0.

Key words: benefit cost; building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows.

Energy conservation in buildings has become critical in the planning and design of buildings due to increasing energy prices and the threat of fuel shortages. Architects, engineers, builders, and others concerned with the design and operation of buildings need principles and guidelines for making economically efficient investment decisions in energy conservation. This guidebook provides principles, techniques, step-by-step illustrations, and sample problems on how to evaluate the economics of energy conservation and solar energy investments. Techniques of economic evaluation including life-cycle costing, net benefits, savings-to-investment ratio, internal rate-of-return, and discounted payback analyses are described and compared in terms of their advantages and disadvantages. Discounting, a procedure for taking into account the time value of money, is illustrated in the analysis of an investment in heat pumps. Practice problems for discounting and for applying each of the five techniques are presented. Factors that affect benefits and costs, including time horizons, discount rates, inflation, incentives, taxes, salvage values, and measures of uncertainty, are discussed, and guidance is provided for selecting appropriate values for these factors when making economic evaluations. Comprehensive case illustrations for solar heating and for window design management are described. Appendices provide tables and formulae for evaluating the economics of alternative conservation investments.

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.

SP446-3. **Building technology project summaries 1979,** M. Olmert and N. Raufaste, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 446-3,* 82 pages (Feb. 1980) SN003-003-02150-4.

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 building technology programs of the Federal, State and local governments; 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 years 1978-79. It enables individuals to get a clear impression of CBT research activities.

SP446-4. **Building technology project summaries 1979-1980,** N. Raufaste and M. Olmert, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 446-4,* 79 pages (July 1980) SN003-003-02236-5.

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

The Center for Building Technology's (CBT) mission is to increase the usefulness, safety, and economy of buildings through the advancement of building technology and its application to the improvement of building practice. CBT's research activities support the building technology programs of Federal, state, and local governments; assist design professions, building officials, and the research community by developing improved design criteria; and assist manufacturers of building products by developing methods for evaluating innovative materials, components, and systems.

This report summarizes CBT's research for 1979-1980. Each summary lists the project title, its progress, point of contact within CBT, and sponsor.

The summaries presented in this report are arranged according to the 11 prime research areas that comprise the scope of work at CBT. This year the report also features a Building Community Index, which keys CBT research to individual segments of the industry.

SP457-4. **Building technology publications—Supplement 4: 1979,** K. Porterfield, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457-4,* 74 pages (June 1980) SN003-003-02205-5.

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

This report presents NBS' Center for Building Technology (CBT) publications for 1979. It is the fourth supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975,* and lists CBT documents issued or recorded during January 1-December 31, 1979. It includes titles and abstracts of each NBS publication and each paper published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

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SP474. **Building for people—Behavioral research approaches and directions,** A. I. Rubin and J. Elder, *Nat. Bur. Stand. (U.S.), Spec. Publ. 474,* 315 pages (June 1980) SN003-003-01803-1.

Key words: architecture; audition; built environment; color; environmental psychology; illumination; perception; questionnaires; research methodology; sensory environment; social sciences; thermal environment.

The primary goal of this report is to acquaint the practicing architect and the architectural student with the potential contributions of the social sciences to the solution of building design problems. The report is divided into seven major parts, each part containing several chapters.

Part I explores problems connected with today's buildings and advocates a design approach based on a team concept including architects, behavioral researchers, and engineers.

Part II takes up the scientific approach to research, stressing the need for employing experimental controls and systematic procedures to collect objective data.

Parts III, IV, and V describe methods employed by researchers to collect Man/Environment (M/E) data. The emphasis is on the need to develop systematic procedures to collect information, because only in this way can significant progress be made in developing a discipline of M/E studies.

Part VI summarizes the major points and indicates approaches and directions for developing such a discipline.

Part VII contains reference information to broaden the perspective of the reader with respect to M/E issues. The final part of the work contains a glossary, bibliographic information, and an index.

SP544. **Simplified energy design economics: Principles of economics applied to energy conservation and solar energy investments in buildings,** H. E. Marshall, R. T. Ruegg, F. Wilson, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 544,* 54 pages (Jan. 1980) SN003-003-02156-3.

Key words: benefit-cost; building design; construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio.

This publication introduces the architect and engineer to economic analysis techniques for evaluating alternative energy conservation investments in buildings. Life-cycle cost, benefit-cost, savings-to-investment, payback, and rate-of-return analyses are explained and illustrated. The procedure for discounting is described for a heat pump investment. Formulas, tables of discount factors, and detailed instructions are provided to give the reader all information required to make economic evaluations of energy conserving building designs.

SP560. **Wind and seismic effects.** Proceedings of the Tenth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources held at the National Bureau of Standards, Gaithersburg, MD, May 23-26, 1978, H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 560,* 644 pages (Oct. 1980) SN003-003-02252-7.

Key words: accelerograph; codes; design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunami; wind loads; winds.

This volume includes thirty-eight technical papers presented at the Tenth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects. It also includes the formal resolutions and the reports of the Panel's eight task committees. The subjects covered in the Joint Meeting include: (1) natural wind characterization and extreme wind records, (2) characterization of earthquake ground motions and strong-motion earthquake data, (3) engineering seismology, (4) response of hydraulic and earth structures to seismic forces, (5) structural responses to wind loading, (6) recent developments in seismic design criteria, (7) design and analysis of special structures, (8) damage evaluation, repair and retrofit, (9) earthquake hazard mitigation, and (10) storm surge and tsunami. *These proceedings include the following papers (indented):*

On the distribution of extreme winds expected in Japan, T. Okubo and N. Narita, *SP560,* pp. 1-1—1-12 (Oct. 1980).

Boundary layer winds, D. A. Haugen, *SP560,* pp. 2-1—2-4 (Oct. 1980).

On the damage to buildings in Oki-erabu from the September 1977 typhoon, T. Murota and Y. Ishiyama, *SP560,* pp. 3-1—3-27 (Oct. 1980).

Recent developments in atmospheric remote sensing and their implication for wind engineering, W. H. Hooke, *SP560,* pp. 4-1—4-16 (Oct. 1980).

Extreme wind data base development at the National Climatic Center, M. Changery, *SP560,* pp. 5-1—5-7 (Oct. 1980).

A strong-motion record information retrieval system, A. M. Converse and R. B. Matthiesen, *SP560,* pp. 6-1—6-2 (Oct. 1980).

Integration of strong-motion accelerograms, S. Iai, E. Kurata, H. Tsuchida, and S. Hayashi, *SP560,* pp. 7-1—7-16 (Oct. 1980).

Some recent developments in national and international seismic data exchanges, J. F. Lander, *SP560,* pp. 8-1—8-6 (Oct. 1980).

Report on the International Workshop on Strong-Motion Earthquake Instrument Arrays, May 2-5, 1978, at Hawaii, T. Okubo and H. Tsuchida, *SP560,* pp. 9-1—9-3 (Oct. 1980).

Expectancy of maximum earthquake motions in Japan, M. Watabe and Y. Kitagawa, *SP560,* pp. 10-1—10-8 (Oct. 1980).

Determination of design earthquake for the dynamic analysis of the Fort Peck Dam, W. F. Marcuson III, and E. L. Krinitzsky, *SP560,* pp. 11-1—11-12 (Oct. 1980).

The Izu-Ohshima Kinkai earthquake of January 1978, M. Tajima, H. Sato, M. Otsuka, K. Sudo, and K. Ishibashi, *SP560,* pp. 12-1—12-13 (Oct. 1980).

Empirical and analytical methods of estimating soil liquefaction risk, R. K. McGuire, F. Tatsuoka, T. Iwasaki, and K. Tokida, *SP560,* pp. 13-1—13-8 (Oct. 1980).

A practical procedure for assessing earthquake-induced liquefaction of sandy deposits, M. Ohashi, T. Iwasaki, F. Tatsuoka, and K. I. Tokida, *SP560,* pp. 14-1—14-22 (Oct. 1980).

Wind—resistant design of cable-stayed bridges in Japan, T. Okubo, N. N. Narita, and M. M. Katsuragi, *SP560,* pp. 15-1—15-14 (Oct. 1980).

Aerodynamic stability of proposed Ohio River cable-stayed bridge, L. R. Cayes, *SP560,* pp. 16-1—16-16 (Oct. 1980).

Some aerodynamic considerations in the design of the Ruck-a-Chucky Bridge, R. H. Scanlan, *SP560,* pp. 17-1—17-5 (Oct. 1980).

A summary of wind-tunnel test results for the Luling, Louisiana, cable-stayed bridge, H. R. Bosch, *SP560,* pp. 18-1—18-15 (Oct. 1980).

A technique for measuring fluctuating wind loads on a tall-building model irrespective of model motion, T. A. Reinhold, *SP560,* pp. 19-1—19-15 (Oct. 1980).

A study of building damage caused by wind, J. R. McDonald and P. A. Lea, *SP560,* pp. 20-1—20-9 (Oct. 1980).

Recent earthquake-resistant design methods for different types of bridge foundations in Japan, Y. Shioi, T. Furuya, M. Okahara, and Y. Mitsuie, *SP560,* pp. 21-1—21-10 (Oct. 1980).

Recent developments in seismic design codes, R. L. Sharpe, *SP560,* pp. 22-1—22-17 (Oct. 1980).

Logical analysis of seismic design provisions, J. Harris, *SP560,* pp. 23-1—23-7 (Oct. 1980).

Highlights of California school and hospital building regulations, J. F. Meehan, *SP560,* pp. 24-1—24-12 (Oct. 1980).

Summary of research projects in the Large-Structures Testing Laboratory from 1967-1977, M. Hirosawa, Y. Ishiyama, and T. Goto, *SP560,* pp. 25-1—25-25 (Oct. 1980).

Dynamic behavior of rectangular water tanks assembled with panels, K. Ohtani and C. Minowa, *SP560,* pp. 26-1—26-12 (Oct. 1980).

Part 1—Inelastic behavior of non-bearing walls in an 11-story steel-reinforced concrete frame, and Part 2—Aseismatic safety of external surface finishes and coatings, M. Watabe, T. Kutoba, A. Baba, T. Fukuta, and H. Ito, *SP560,* pp. 27-1—27-16 (Oct. 1980).

Seismic evaluation of existing multistory residential buildings, G. R. Fuller, *SP560,* pp. 28-1—28-7 (Oct. 1980).

Damage to engineering structures during the near Izu-Ohshima earthquake of January 1978, K. Nakazawa, T. Iwasaki, K. Kawashima, M. Watabe, H. Yamanouchi, and Y. Yamazaki, *SP560,* pp. 29-1—29-27 (Oct. 1980).

Repair and retrofit of buildings, J. K. Wight and R. D. Hanson, *SP560,* pp. 30-1 30-6 (Oct. 1980).

The distribution of property losses caused by historical earthquakes, E. Kuribayashi and T. Tazaki, *SP560,* pp. 31-1—31-36 (Oct. 1980).

The disaster-resistance of cities and their lifelines, K. Nakazawa and E. Kuribayashi, *SP560,* pp. 32-1—32-17 (Oct. 1980).

Rescue and rehabilitation after the Izu-Ohshima Kinkai earthquake of 1978, E. Kuribayashi, T. Tazaki, and T. Hadate, *SP560,* pp. 33-1—33-54 (Oct. 1980).

National Science Foundation activity in earthquake hazard mitigation, C. C. Thiel and J. Scalzi, *SP560,* pp. 34-1—34-21 (Oct. 1980).

Rapid seismic analysis procedures for buildings, T. K. Lew, S. K. Takahashi, and C. V. Chelapati, *SP560,* pp. 35-1—35-32 (Oct. 1980).

US-Southeast Asia Symposium on Engineering for Natural Hazards Protection, A. H. S. Ang, *SP560,* pp. 36-1—36-20 (Oct. 1980).

Storm surge, C. S. Barrientos, *SP560,* pp. 37-1—37-16 (Oct. 1980).

Operation of tsunami warning system in the Pacific, M. G. Spaeth, *SP560,* pp. 38-1—38-6 (Oct. 1980).

SP575. **Design for better window performance (wall chart),** S. R. Hastings and P. Driscoll, *Nat. Bur. Stand. (U.S.), Spec. Publ. 575,* wall chart (May 1980) SN003-003-02238-1.

Key words: design elements; energy performance of windows; window attributes; window design; window design elements; window performance.

The wall chart "Design for Better Window Performance" describes window and other design elements and the impact of these design elements singly and in combination on window performance and building attributes. The design elements are grouped into four categories: Exterior—windbreaks, shades, coverings and sun orientation; Frame—insulating frame, opening type, weather strip and hardware; Glazing—multi-glazing, reflective glazing, plastic glazing and glass block; Interior—interior shading, interior coverings, integral lighting and interior mass.

The impacts of these design elements are described in a matrix form and address the following window and building attributes: Airtightness, Water tightness, Natural ventilation, Insulation, Solar admittance, Daylighting, Visual separation, Acoustical isolation, Safety, Access/Egress, Ease of operation, Forced entry resistance, and Durability/Maintenance. The chart is designed for ready reference during the design process.

SP577. **Development of a probability based load criterion for American National Standard A58—Building code requirements for minimum design loads in buildings and other structures,** B. Ellingwood, T. V. Galambos, J. G. MacGregor, and C. A. Cornell, *Nat. Bur. Stand. (U.S.), Spec. Publ. 577,* 228 pages (June 1980) SN003-003-02200-4.

Key words: aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber.

Recommended load factors and load combinations are presented which are compatible with the loads recommended in the proposed 1980 version of American National Standard A58, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures (ANSI A58.1-1980 D). The load effects considered are due to dead, occupancy live, snow, wind and earthquake loads. The load factors were developed using concepts of probabilistic limit states design which incorporate state-of-the-art load and resistance models and available statistical information. Reliabilities associated with representative structural members and elements designed according to current (1979) structural specifications were calculated for reinforced and prestressed concrete, structural steel, cold-formed steel, aluminum, masonry and glued-laminated timber construction. The report presents the rationale for selecting the criterion format and load factors and describes the methodology to be followed by material specification groups for determining resistance factors consistent with the implied level of reliability and the statistical data. The load factors are intended to apply to all types of structural materials used in building construction.

SP581. **Radon in buildings.** Proceedings of a Roundtable Discussion of Radon in Buildings held at the National Bureau of Standards, Gaithersburg, MD, June 15, 1979, R. Collé and P. E. McNall, Jr., Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 581,* 84 pages (June 1980) SN003-003-02196-2.

Key words: buildings; environment; health; measurements; radiation; radon; radon daughters; ventilation.

This is the proceedings of a Roundtable Discussion of Radon in Buildings held June 15, 1979 at the National Bureau of Standards in Gaithersburg, Maryland. The meeting brought together a number of participants with diverse interdisciplinary interest in radiation protection, radiation measurement and building technology, provided a forum to exchange information, and drew attention to some of the problems and research needs associated with radiation exposure due to radon in buildings. Emphasis was placed on (1) the characterization of the sources and pathways of radon in buildings; (2) the biological and health effects; (3) measurement considerations; and (4) strategies and control technologies to minimize indoor radiation exposure. *These proceedings include the following papers (indented):*

The physics and interaction properties of radon and its progeny, R. Collé, *SP581,* pp. 1-21 (June 1980).

The biological and health effects of radon: A review, D. A. Morken, *SP581,* pp. 21-26 (June 1980).

Techniques for measuring radon in buildings, A. J. Breslin, *SP581,* pp. 27-35 (June 1980).

Radon and radon daughters in buildings: A survey of past experience, C. R. Phillips, S. T. Windham, and J. A. Broadway, *SP581,* pp. 37-44 (June 1980).

Residential building technology trends and indoor radon and radon daughter concentrations, P. E. McNall, Jr., and S. Silberstein, *SP581,* pp. 45-51 (June 1980).

SP586. **Research and innovation in the building regulatory process.** Proceedings of the Fourth NBS/NCSBCS Joint Conference held in St. Louis, MO, on Sept. 11, 1979, in conjunction with the Twelfth Annual Meeting of the National Conference of States on Building Codes and Standards (NCSBCS), Inc., S. A. Berry, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 586,* 261 pages (June 1980) SN003-003-02212-8.

Key words: building code enforcement; buildings; design; energy conservation; housing codes; regulatory approaches.

The Proceedings of the 4th Annual NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process contain nineteen technical papers, the opening re-

marks and Keynote Address. The subject matter covered in these Proceedings includes: Issues in Building Code Enforcement; Legal, Political and Educational Aspects of Code Enforcement; Studies Dealing with Housing Codes; Energy Conservation and the Built Environment; Design Considerations and Their Impact on Code Enforcement; and, Innovative Regulatory Approaches for Metrication, Insulation Standards, and Climatic Conditions. *These proceedings include the following papers (indented):*

Development fee schedule survey, D. D. Fontaine and D. M. Coffey, *SP586,* pp. 13-16 (June 1980).

Key words: affordable housing; development fee; planning cost; Proposition 13.

Criterion for the thermal insulation quality of a building, J. Uyttenbroeck, *SP586,* pp. 19-31 (June 1980).

Key words: heat loss; standard; thermal insulation; U-value.

In an effort to conserve energy in Belgium, the Belgian Standardization Institute has published a draft of a proposed standard for thermal insulation of a building. The concept and methodology is described in this paper.

The global thermal insulation value, U_m, varies as a function of the ratio of volume of the building to the exposed area of the building (V/A). The relationships are simple and the implementation, through legislation and enforcement, is relatively straight-forward.

A report—Indiana building code enforcement survey 1979, D. L. Bills, *SP586,* pp. 33-42 (June 1980).

Key words: building departments; building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments.

This survey of Indiana cities, towns, and counties was undertaken by the Division of Code Enforcement of the Indiana Administrative Building Council. Its purpose was to determine the status and effectiveness of local building code administration and enforcement agencies. Its findings will be used to provide guidance and priority to state level programs to encourage the development and advancement of local building regulatory agencies, which is a statutory mission of the Division.

The survey measured manpower resources and productivity; inspection frequency; building permit fees; inspector training, and the status of local ordinances pertaining to adoption of the statewide building code, establishment of building departments, and regulation of unsafe buildings.

The survey results depict the condition of statewide building regulation in a rural, small community environment with traditional political influence on local governmental operations and services.

Legal relations and considerations for code officials and design professionals, J. R. Groves, Jr., *SP586,* pp. 45-57 (June 1980).

Key words: appeals process; architect; certification; checklists; code official; consultant; engineer; equivalent life safety; municipal attorney; product endorsement; professional liability; variances.

In the last several years, the number of statutes, ordinances, and the volume of case law affecting architects and engineers has increased dramatically. The changing legal responsibilities of architects and engineers has been a matter of great concern to individuals in those professions. Professional liability insurance, negligence, statutes of limitation, reasonable care, duty, contract relationships, and numerous other subjects have moved to the forefront of continuing education efforts for registered design professionals. During this process, code officials as well have found themselves increasingly involved with sometimes complex legal considerations. Code officials, in particular, have moved out of the shelter of freedom from liability based on government immunity into a legal posture in some ways similar to that of design professionals. This has been intensified by the often overlapping relationship between registered design professionals and code officials in the administration of a variety of codes.

In the past, programs and articles on this subject have often taken an approach of admonishment rather than education. Code officials and design professionals have been told that caution and self-protection are emerging as the basis for the conduct of day-to-day affairs. This concept has been further supported with numerous cases and incidents involving property damage, personal injury or death and resulting in the legal determination of extremely large monetary judgments. While this process may have a dramatic impact, it often ignores the need to continue a normal professional relationship placing basic competency as the fundamental principle directing those concerned. Certainly lawsuits illustrating a variety of problems confronting both design professionals and building officials will continue. The notion, however, the judgment, common sense and risk can or should be eliminated from the construction and code administration process is in practice unrealistic. The legal education of parties to the process cannot seek to eliminate every possible misfortune which could befall those involved. To attempt to do so would cause the entire process to grind to a halt.

Based on the premise that scare tactics are not the appropriate vehicle for the legal education of code officials and design professionals, this paper will proceed to discuss a number of current legal developments of interest to both. The goal will be to help in establishing prudent but sensible ways of discharging professional obligations and enforcing laws, codes and ordinances in a manageable and professional manner. Inherent in the process will be the translation of basic legal concepts into workable professional practice techniques and procedures.

The effects of civil service, unions, statutory law and economics on systems development in municipal regulatory agencies, N. S. Remmer, *SP586,* pp. 59-70 (June 1980).

Key words: civil service; code administration agencies; idealized system; reorganization.

In 1973, the City Council of Worcester, Massachusetts voted to create a new Department of Code Inspection which would incorporate all the responsibilities for administration and enforcement of code and regulatory activities in the City in one Department under one administrative head.

The initial concept was to include building and trade inspection, construction inspection, zoning, housing, fire prevention, weights and measures, environmental inspection, subdivision, license board and license commission inspections.

The plan was to proceed forward in three phases: 1. The immediate incorporation of building, zoning and housing responsibilities into the new department from the department of public works and department of public health, respectively. 2. The integration of administrative processes for the building, housing and zoning responsibilities and the development of necessary procedures for the incorporation of the additional functions and responsibilities. 3. The incorporation of the additional functions and responsibilities over a period of time and systematic development of the administrative programs for integrating the functions.

It became apparent early in the process that the ability to pass home rule ordinances had no relationship with the ability to implement the ordinance due to union considerations, civil service requirements and over-riding statutory

requirements. The attempted implementation of an idealized system of management and organization required many modifications and trade-offs to try to accommodate the constraints of law, budget and time which developed. Even the determination of the sequence of many of the steps became a crucial factor in trying to organize such an integrated regulatory system.

While the process is still continuing, the lessons already learned about the limitations imposed on the creation of an idealized system are important, and the questions for the future of such efforts, especially in Massachusetts and states with similar situations are important to consider.

Licensing of building code officials: The educational requirements, K. Albert, *SP586,* pp. 71-83 (June 1980).

Key words: building codes; building inspectors; code enforcement; course development; educational requirements; inspection; licensing; testing; training code officials.

The State of New Jersey has recently adopted a statewide body of regulations known as the "New Jersey Uniform Construction Code." The code is designed to achieve innovation and economy in building construction and uniformity of standards throughout the State.

A unique set of standards and procedures for licensing code enforcement officials has been established along with the adoption of existing recognized standards as subcodes. The first part of this paper focuses on the problems associated with the development and the regulation of the specialized courses for building inspectors and code administrators which have been developed and implemented to meet the educational standards established by the code. The broader issues of licensing code officials and the establishment of educational criteria are discussed.

The second part of the paper proposes a model program for the implementation of the education component of the certification process.

Housing standards: Objectives and agendas, D. L. Schodek, *SP586,* pp. 87-102 (June 1980).

Key words: building regulations; housing policies; housing standards; minimum property standards.

Housing standards imply a set of values and objectives that are rarely made explicit. In addition to stated goals of health and safety, standards also implement certain national policies and agendas relating to social planning. The nature of these objectives and their influence on the formulation of housing standards form the subject of this paper.

The paper traces the general development of national housing policies in the United States and briefly highlights those in other countries. It is argued that space and usability standards promote housing types responsive only to a limited set of biased objectives and mitigate against the development of housing responses to a broader range of lifestyles, cultural values and climatic conditions.

Housing standards: Their derivation and rationale, U. P. Gauchat, *SP586,* pp. 103-115 (June 1980).

Key words: equivalency; housing standards; minimum standards; space standards.

The quality of housing is mandated by minimum standards. The standards are based on egalitarian principles and on the assumption that housing anywhere in the United States would meet certain norms. Space standards, in particular, imply social planning objectives which apply throughout the country regardless of location, climate, or user group. These standards, perhaps unwittingly, promote the notion of an "American House."

Although fair in the sense of providing equality, the present system does not allow an adequate range of responses to different lifestyles and cultural backgrounds. It is the purpose of this paper to propose housing solutions that more adequately reflect regional characteristics and personal predilections. The proposals are based on the premise that housing standards should be based on the notion of equivalency rather than equality.

This paper first examines the key determinants of quality in housing; then analyzes the effects of current property standards; and finally, suggests modifications that would render housing standards more responsive and flexible.

Comparative analysis of provisions in housing codes and rehabilitation guides, P. W. Cooke, *SP586,* pp. 117-133 (June 1980).

Key words: code provisions; comparison; existing buildings; housing codes; model codes; performance levels; regulations; rehabilitation.

The performance levels of existing buildings generally do not comply with the standards for safety or function that are required of new buildings. To have a solid base for regulatory authorities and others to use in establishing minimum requirements pertaining to life safety and health issues pertinent to the reuse of existing buildings and to assure an adequate level of acceptance in terms of the traditional intent of codes, it is essential to have a good understanding of the regulatory provisions for codes currently in place that address occupancy, maintenance and rehabilitation.

This paper highlights some of the more explicit comparisons that were available from a comprehensive analysis of the content of seven code documents that relate exclusively to the occupancy, maintenance or rehabilitation of existing residential buildings. This sampling of detailed comparisons indicates some of the inconsistencies among code documents with respect to uniformity as well as non-scientific approaches taken in the development of code provisions.

Problems in housing code enforcement: A focus on the budget, C. B. Meeks, *SP586,* pp. 135-148 (June 1980).

Key words: budgets; economic analysis; enforcement; housing codes; personnel.

A housing code is one option available to communities concerned with maintenance of housing quality. Housing code administrators in New York State identified lack of financial and human resources as two key problems in code enforcement.

Primary attention in this paper is given to analysis of community housing code budgets which varied considerably among communities.

In a log-log regression equation, the size of per capita housing code budgets was significantly influenced by the number of housing code inspections conducted, the percent of revenues obtained from property taxes and the percent of owner occupied housing.

Practitioners can compare the results with their own situation.

Development and evaluation of solar standards and criteria, R. D. Dikkers, *SP586,* pp. 151-160 (June 1980).

Key words: buildings; cooling; durability/reliability; performance criteria; safety; solar collectors; solar energy; standards; thermal performance.

Many organizations, including the National Bureau of Standards (NBS), American Society of Heating, Refrigerating and Air-Conditioning Engineers and the American Society for Testing and Materials, have been very active during the past several years carrying out activities relating to the development of standards and performance criteria for solar heating and cooling applications. This paper, which describes various activities and accomplishments to date pertaining to the development and evaluation of solar heating and cooling standards and criteria, updates previous

information presented by the author at the First NBS/NCSBCS Joint Conference held in 1976.

Thermal mass effects in log homes, W. Magruder and S. Winter, *SP586,* pp. 161-179 (June 1980).

Key words: BLAST; effective U-value; heat capacity; log home; mass factor; thermal mass; ΔR effect.

To improve thermal standards for log homes, certain adjustment factors must be established to account for the effects of thermal mass. Alternative definitions for these factors are presented as the "mass factor" and the "ΔR effect." These factors will be a function of at least six parameters, which are discussed here in terms of their relevance to log homes. The six parameters of concern are wall mass, wall color, location of mass, air infiltration, HVAC set-point schedule, and climate. The paper concludes with a summary of the results of a BLAST computer analysis of a log home in Des Moines.

Analysis of code related responses from the solar demonstration program, J. Greenberg, *SP586,* pp. 181-185 (June 1980).

Key words: building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This paper is based on a report prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the Solar Heating and Cooling Demonstration Program. The report documents and analyzes building regulatory information gathered by HUD Contractor personnel during the course of the Solar Residential Demonstration Program—from inception of the program (late 1975) through September 30, 1978.

Although not all builders and local code officials participating in the demonstration program were interviewed for the study, the total number of participants interviewed was of sufficient size to postulate trends and draw reasonable conclusions regarding the building regulatory aspects of the program. The report concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training and better back-up material to properly evaluate solar systems.

This paper summarizes and presents the major findings included in the report.

Contracting for value management during design, D. E. Parker, *SP586,* pp. 189-196 (June 1980).

Key words: economic analysis; life cycle cost; value management; value study.

This paper describes the content and application of the General Services Administration (GSA) Value Management (VM) Program requirements incorporated by regulation in all architect-engineer (A-E) contracts.

The objective of this VM Program is to control the cost of construction by performing VM studies at various points in the design process with the objective of recommending changes to design work in progress.

The VM process requires the understanding and agreement of two parties—the client and the designer. VM study forces the enhancement of communication between these two parties. It provides the freedom to challenge codes, criteria, needs, desires, and specifications in a professional atmosphere.

Because the economic measure of value is life cycle cost, the program controls life cycle cost as well as initial cost. Thus, it has been effective in reducing maintenance and energy cost in addition to ensuring the project budget is met.

Required VM service design contracts can be expected to provide an average $10 return for every dollar invested in cost of the service.

Building recertification and Dade County, Florida, R. Warburton, *SP586,* pp. 197-203 (June 1980).

Key words: architects; codes; earthquake; engineers; Florida; inspection; legislation; recertification.

One of the major problems in maintaining environmental quality is the need for continual routine monitoring of existing private-sector construction to ensure structural integrity over time. Dade County, Florida has an operating ordinance which provides a model deserving significant consideration in this regard, so that extensive loss of life and property can be minimized.

On May 21, 1975, the Dade County, Florida Commission adopted Ordinance 75-34, providing for routine examination by private-sector architects and engineers of structures over 40 years old (and re-examination at 10 year intervals thereafter) to verify their continued eligibility for a Certificate of Occupancy. The ordinance covers all private-sector buildings providing facilities for over 10 persons and having over 2,000 sq. ft. of floor area, except for 1 and 2 family residential structures.

At present, about 6,000 buildings have felt the effects of this ordinance, with about 75% receiving immediate recertification and about 10% requiring enforcement measures. Buildings are currently coming under the ordinance provisions at the rate of about 700 per year.

Evaluation of potential generic issues, considering the program development to date, indicates no serious defects in the program and the immense benefits to the public from such an ordinance covering private-sector buildings.

In fact, the Dade County Ordinance presents a model worthy of national attention and adoption as appropriate as part of new state/local building code legislation as well as through revisions to professional established standards and policies.

Computer-aided design review: Predicting the emergency egress potential of proposed buildings, F. I. Stahl, *SP586,* pp. 205-224 (June 1980).

Key words: building codes; building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation.

This paper discusses the potential use of computer simulation techniques by building code officials, as tools which aid in the prediction of building performance. As a case in point, the BFIRES program for simulating emergency egress during building fires, developed at NBS, is presented. The program is described from the user's viewpoint, and a specific example of its application in assessing building design is treated.

Metrication—An opportunity for the harmonization of American building codes, H. J. Milton, *SP586,* pp. 227-251 (June 1980).

Key words: building codes; conversion strategies; harmonization; metrication; metric transition.

The merits of more harmonious building codes have been debated for many years, receiving support from professional groups, manufacturers, contractors, and other sectors of the construction community. But it has always been difficult to make drastic changes to the status quo, although the variety of building and associated codes has been narrowed gradually by the model codes movement and regulatory activities of the States.

The inevitable change to metric (SI) units of measurement in the U.S. construction community, proposed for the

1980's, will pose some problems as well as a unique opportunity for harmonization and rationalization. At one end of the spectrum, unilateral activity by the private model code groups and, subsequently, the state and local administering authorities, could lead to short-term confusion of sizeable magnitude, especially if further divergency in measurement references is introduced. Not only would code compliance be complicated for professionals, manufacturers and contractors, but diversity would make it difficult to familiarize building code officials and inspectors with metric usage and application in plan approval and site inspection. At the other extreme, metrication provides a once-only opportunity to resolve many of the differences in code formats, approaches, and required acceptance levels at the same time as new and rationalized metric values (hard conversions) are introduced. Such harmonization would make it possible to develop a national approach to metric familiarization and training for code officials by means of explanatory metric reference manuals, which could also be used by designers and other groups to ensure maximum compliance.

There are a number of possible approaches between these extremes, such as the partial harmonization of model and State building codes in all areas of national significance, technologically and economically; for example, in the provisions relating to energy conservation, fire safety, access and egress, structural factors, seismic considerations, etc.

This paper discusses the issue of metrication as an opportunity to take a positive approach to building code harmonization, and suggests some basic guidelines to minimize problems during the transitional period. It deals with soft conversion to equivalent values and hard conversion to metric alternatives which would no longer be interchangeable. Practical examples are used to illustrate possibilities of code harmonization.

Setting formaldehyde standards, R. L. Meyer, *SP586,* pp. 253-258 (June 1980).

Key words: committee; concentration; department; formaldehyde; formaldehyde-based chemicals; formaldehyde level; standards; urea-formaldehyde resins.

Formaldehyde is utilized in the manufacture of a variety of products. The most significant use is in the production of phenolic, melamine and urea formaldehyde resins. It is also used in agriculture, for chemical analysis, concrete and plaster, cosmetics and deodorants, disinfectants and fumigants, dyes, hydrocarbon products, for leather tanning, paper manufacture, photography, rubber production, solvents and plasticizers, starch, wood, textiles, and embalming fluid. It is also a byproduct of combustion found in automotive exhaust and cigarette smoke.

There are an increasing number of complaints received from persons residing in mobile homes caused from the emission of formaldehyde vapor.

The department is developing standards for formaldehyde vapor.

While formaldehyde standards have been established to protect the worker from formaldehyde vapor, no standards have been set for formaldehyde in non-working environments.

The paper will deal with Wisconsin's experience in developing standards for formaldehyde vapor.

Snow—Wind—Ice, its changing effect on building construction, C. V. Opdyke, *SP586,* pp. 259-270 (June 1980).

Key words: building collapse; ice; snow; wind.

The impacts of the effects of "Weather" is being experienced across the nation as it relates to the destructive forces of snow, wind and ice on building construction.

In an effort to deal with these problems individually or collectively, we must re-evaluate all of our engineering principles, practices and theories that have been used through the years and have been accepted as gospel.

This paper deals with new and innovative design principles and methods of construction to overcome, wind loads, snow loads, icing conditions, freeze-thaw cycles, ventilation problems, roof leaks and structural failure. It also covers new types of roof designs and how to deal with them.

The report speaks to the many types of freezes, the wind pattern effect, the snow effect and the general combined effects of all three.

Finally, the paper speaks to a general lack of accurate local climatology recording on a uniform basis.

SP587. **Lighting issues in the 1980's.** Summary and Proceedings of a Lighting Roundtable held at the Sheraton Center, New York, NY, June 14-15, 1979, A. I. Rubin, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 587,* 175 pages (July 1980) SN003-003-02218-7.

Key words: biological effects of lighting; energy conservation; illumination levels; lighting; lighting design; lighting education; lighting research; post-occupancy evaluation; power budget; task lighting; visual performance.

The Lighting Roundtable described in this report was conducted to foster an open discussion of the goals, issues, and responsibilities of the lighting community. It was not a problem-solving session, but rather a time to examine the long-term aspirations and objectives of lighting and barriers that may stand in the way of achieving them. Eight major issues were addressed by nine panelists and a number of invited auditors. The issues are as follows: 1. The Public Image of the Lighting Community; 2. U.S. Role in the Worldwide Lighting Community; 3. Factors Affecting Human Activities in the Built Environment; 4. Effect of Lighting on Environmental Quality; 5. Effects of Barriers; 6. Establishment of Illuminance Levels; 7. Integration of Subsystems; and 8. Professional Development and Lighting Education.

The present publication consists of two parts; (1) A summary of the proceedings and (2) a complete transcript.

SP592. **An investigation of the Miyagi-ken-oki, Japan, earthquake of June 12, 1978,** B. R. Ellingwood, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 592,* 232 pages (Oct. 1980) SN003-003-02257-8.

Key words: bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering.

On June 12, 1978, a destructive earthquake with Richter magnitude of 7.4 occurred off the east coast of Miyagi Prefecture, Japan. Preliminary estimates by the National Land Agency of Japan indicated that the earthquake caused an equivalent of $800 million in total damage. There is a cooperative agreement between the Governments of the United States and Japan termed the U.S.-Japan Program in Natural Resources (UJNR). Following the earthquake, it was arranged through UJNR that teams of U.S. structural engineers and geologists would visit Miyagi Prefecture and inspect the damage caused by the earthquake. This report assembles the information and collective experiences of the investigation team so as to describe the earthquake and document its effects. Field investigations conducted by geologists and structural engineers are described in detail and some of the implications for seismic resistant design and construction of structures in the United States are also discussed.

SP595. **International and national standards on dimensional coordination, modular coordination, tolerances and joints in building,** H. J. Milton, *Nat. Bur. Stand. (U.S.), Spec. Publ. 595,* 154 pages (Oct. 1980) SN003-003-02254-3.

Key words: building module; dimensional coordination; metric design and construction; modular coordination; standards.

This publication lists international, multi-national [regional], and national standards from over 50 countries dealing with the principles and application of dimensional or modular coordination in building, including joints and tolerances. It is based on NBSIR 79-1791, with the same title, which was sent to national and multi-national standards organizations for review and comment.

The document shows the widespread adoption of the international building module of 100 mm (also designated as M) as a basis for dimensional rationalization in building design, production and construction. The listing includes international (ISO) standards, multi-national (COPANT, ICAITI, and CMEA) standards, and national standards from all major countries. Brief summaries of contents have been included where available, and titles in English for documents printed in other languages. Appendixes illustrate international cooperation on the subject, a multi-lingual vocabulary of 20 key terms, and review comments received.

The main purpose of the document is to assist the U.S. construction community by providing information on international precedent to facilitate decisionmaking relative to new standards for dimensional [modular] coordination in building, especially those to be developed in metric (SI) units. Key findings have been summarized. The document may also assist exporters of building products and/or services.

SP598. **Metric conversion in the construction industries—Technical issues and status,** H. J. Milton and S. A. Berry, *Nat. Bur. Stand. (U.S.), Spec. Publ. 598,* 145 pages (Oct. 1980) SN003-003-02265-4.

Key words: construction industries; dimensional coordination; metric bibliography; metric conversion timetable; metric decision; metric product sizes; metric system (SI).

This Special Publication was prepared at the request of the Metric Symposium Planning Committee of the National Institute of Building Sciences (NIBS). It is intended to provide information on technical issues and status of metric conversion in the United States construction industries. It will be made available to attendees at the NIBS Symposium on "Metric Conversion in the Construction Community" to be held December 2-3, 1980, in Chicago, IL. In addition, it will be available to other affected parties in the construction community.

The report contains information on planning for the metric change, current metric activities of professional and industry groups, technical implications in the construction industries, dimensional coordination, metric building products and services, research issues, and timing. It is intended to provide assistance for informed decisionmaking relative to metric conversion for the U.S. construction industries. Also included in the report is a bibliography of relevant construction industries' metric technical information.

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 78-1578. **Investigation of construction failure of reinforced concrete cooling tower at Willow Island, West Virginia,** H. S. Lew, S. G. Fattal, J. R. Shaver, T. A. Reinhold, and B. J. Hunt, 195 pages (Nov. 1979). Order from NTIS as PB80-192883.

Key words: collapse; concrete; concrete strength; construction; cooling tower; failure; hyperbolic shell; shell.

The collapse of the natural-draft hyperbolic concrete cooling tower unit no. 2 at the Pleasants Power Station at Willow Island, West Virginia has been investigated. This investigation included onsite inspections, laboratory tests of construction assembly components and concrete specimens, and analytical studies.

Based on the results of these field, laboratory and analytical investigations, it was concluded that the most probable cause of the collapse was due to the imposition of construction loads on the shell before the concrete of lift 28 had gained adequate strength to support these loads. The analysis of the shell indicates that the collapse initiated at the part of the shell in lift 28 where cathead no. 4 was located. It further showed that calculated stress resultants at several points in that part equaled or exceeded the strength of the shell in compression, bending and shear. The failure of these points in that part of the shell would have propagated to cause the collapse of the entire lift 28.

NBSIR 79-1780. **Post-occupancy evaluation: A case study of the evaluation process,** J. Elder, G. E. Turner, and A. I. Rubin, 67 pages (Aug. 1979). Order from NTIS as PB80-119712.

Key words: building evaluation; design process; man/environment research; post-occupancy evaluation; questionnaire; user needs.

Within the past decade, growing numbers of architects, educators, building users and researchers have begun to question the state-of-the-art of building design. The most common complaint is that buildings do not adequately fulfill the needs of their users. This report addresses the problem by examining the need to identify, develop and apply user information as an integral part of the design process.

The study reported here was conducted for GSA at the Richard H. Poff Courthouse and Federal Building in Roanoke, Virginia. This was a limited study examining: (1) the design process, (2) the information available to those making design decisions, (3) how that information was used and (4) the effects of selective design decisions. In addition, design problems of particular interest to GSA were considered from the viewpoint of several groups involved with the design and use of the building—GSA, the architect, the building manager, the agencies and the employees.

NBSIR 79-1787. **MIUS feasibility—Five exploratory studies,** R. J. Mitchell, 158 pages (Jan. 1980). Order from NTIS as PB80-154719.

Key words: energy conservation; environmental impact; feasibility study; integrated utilities; MIUS; on-site utilities.

This report highlights the collaborative efforts of the National Bureau of Standards, the National Aeronautics and Space Administration and their contractors in the analysis of a Modular Integrated Utility System (MIUS) and conventional utilities for five separate housing projects. The collaborative efforts consist of three separate tasks: 1. Comparative Environmental Analysis; 2. Comparative Energy Analysis; 3. Utility System Design and Cost Analysis.

NBSIR 79-1793. **Privacy as information management: A social psychological and environmental framework,** S. T. Margulis, 28 pages (Sept. 1979). Order from NTIS as PB300986.

Key words: architectural psychology; bibliography; buildings; communication; cost; human characteristics; personal control; physical environment; privacy.

A social-psychological and environmental framework for a theory of privacy is summarized. The framework focuses on the management of information the loss of which would or could have costly consequences for the target of the information. Key concepts, such as information, communication, personal control, cost, and barrier, are defined and discussed. Particular emphasis is placed on influence of the objective physical environment on privacy.

NBSIR 79-1902. **Economic aspects of fire safety in health care facilities: Guidelines for cost-effective retrofits,** R. E. Chapman, P. T. Chen, and W. G. Hall, 118 pages (Nov. 1979). Order from NTIS as PB80-120165.

Key words: applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation.

This study focuses upon one aspect of the fire safety problem in health care facilities; the use of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards for determining equivalence to the Life Safety Code. The Life Safety Code, a voluntary code developed by the National Fire Protection Association, is currently the most widely used guide for identifying the minimum level of fire safety in buildings. Using the Fire Safety Evaluation System as a basis, this study develops a computerized procedure which permits the least-cost means of achieving compliance to the Life Safety Code in health care facilities to be identified. Since each of the parameters used in the Fire Safety Evaluation System has a unique value which corresponds to strict compliance, it is possible to quantify the cost savings attributable to the

use of the Fire Safety Evaluation System over strict compliance to the Life Safety Code. Preliminary studies conducted by the National Bureau of Standards of a prototypical hospital have concluded that the use of this computerized procedure can result in cost savings of 50 percent or more over those associated with strict compliance to the Life Safety Code.

NBSIR 79-1906. **The evacuation of non-ambulatory patients from hospital and nursing home fires: A framework for a model,** J. Archea and S. T. Margulis, Ed., 65 pages (Nov. 1979). Order from NTIS as PB80-119530.

Key words: building codes; building evaluation; elderly; fire safety; handicapped occupants; health care facilities; nursing homes; user needs.

This report is directed toward the problem of evacuating dependent, non-ambulatory persons from fires in nursing homes and other health care facilities. It deals only with those behavioral and building factors that bear on the activities that follow directly from a decision to evacuate patients from a fire zone in a nursing home or similar facility. The examination is based on the rejection of the model which is the basis for current life safety regulations because it assumes independent occupant mobility. This assumption does not apply to dependent, non-ambulatory persons. The major objective of the report is to identify those factors that must be considered in order to determine the ideal performance of a hospital or nursing home evacuation system for non-ambulatory patients when all components or persons in that system act as they are designed or trained to act. These factors are presented as part of an analysis of evacuation as a five phase process: manpower supply phase, patient preparation phase, patient removal phase, rest and recovery phase, and manpower resupply phase. Research findings are reviewed and a research agenda is proposed.

NBSIR 79-1908. **Solar energy systems: Test methods for collector insulations,** M. Godette, J. Lee, and J. Fearn, 39 pages (Oct. 1979). Order from NTIS as PB80-132038.

Key words: accelerated aging; collector insulation; insulation; solar collector; standard insulation test methods.

A preliminary study was performed to evaluate potential procedures for screening the insulation used in solar collectors. Both ASTM standard test methods and newly developed nonstandard procedures were used to evaluate twenty-one insulation materials. The insulation parameters measured in this study were selected on the basis of how and to what extent they were affected by the unique environmental conditions within solar collectors. Results of the laboratory tests are discussed and those procedures which offer a potential for screening insulations used in solar collectors are presented. It is intended that these procedures fulfill the first step in the development of a standard set of test methods for evaluating insulations for solar collectors.

NBSIR 79-1917. **Solar energy systems—Standards for rubber hose,** R. D. Stiehler and J. L. Michalak, 36 pages (Nov. 1979). Order from NTIS as PB80-129828.

Key words: hose; hose specifications; rubber hose; solar energy systems.

A study of commercial rubber hose was made to develop standards for hose used in solar energy systems. Twelve hoses were evaluated by cycling between temperatures of about 100 °C and temperatures as low as −40 °C during a period of about seven months. Laboratory tests for bursting strength, compatibility with metals, compression set, ozone resistance, and water vapor transmission were also made.

The results of this study and tests are presented. Based on these findings, a standard for rubber hose used in solar energy systems is proposed.

NBSIR 79-1919. **Evaluation of a proposed ASTM standard guide to assess the compatibility of metal-heat transfer liquid pairs in solar heating and cooling systems,** P. W. Brown and J. W. Grimes II, 45 pages (Nov. 1979). Order from NTIS as PB80-161748.

Key words: corrosion; elevated temperature; heat transfer; liquid flow rate; solar-heat transfer liquid containment; stagnation.

This study was undertaken as part of a round-robin evaluation of a proposed American Society for Testing and Materials (ASTM) testing methodology entitled, "Standard Guide for Laboratory Screening of Metallic Containment Materials for Use with Liquids in Solar Heating and Cooling Systems." This study was undertaken solely to evaluate the procedural aspects of each test method and the results of this study are not intended to provide an assessment of the suitability of any of the metals evaluated for use in solar heating and cooling systems. It was determined that the tests described in this Standard Practice can be carried out as a basis for evaluating metal-heat transfer liquid pair interactions under conditions simulative of various modes of solar containment system operation.

NBSIR 79-1923. **Residential solar data center grant reports,** P. M. Christopher and M. J. Aronoff, 74 pages (Oct. 1979). Order from NTIS as PB80-119928.

Key words: automatic data processing; computer reports; grant data; residential buildings; solar database; solar energy system; solar heating and cooling.

The Residential Solar Data Center project staff in the Center for Building Technology, National Bureau of Standards, is responsible for the establishment and operation of a computerized database containing non-instrumented residential data generated by the Solar Heating and Cooling Demonstration Program sponsored by the Department of Energy and the Department of Housing and Urban Development (HUD). This document includes computer reports of data contained in the Grant file, one of six computer files comprising the database. These reports contain data recorded on applications submitted to HUD by organizations or individual builders applying for grants to build solar energy systems in new and/or existing homes. To date, approximately 450 grants have been awarded in the first four award cycles.

NBSIR 79-1925. **Equal apparent conspicuity contours with five-bar grating stimuli,** G. T. Yonemura, E. J. Rinalducci, R. L. Tibbott, and L. A. Fogelgren, 38 pages (May 1980). Order from NTIS as PB80-199292.

Key words: conspicuity; contrast; energy conservation; illumination; illumination levels; lighting; suprathreshold seeing; visibility; vision.

The report discusses the results of laboratory studiès on equal conspicuity (contrast) contours using as the test stimuli five-bar grating patterns, with the results of other experiments in this series conducted by NBS. These results are in agreement with the earlier studies. Basic groundwork is provided for additional experiments and analysis which will form a practical basis for recommending energy-conserving design illumination levels that conform to real-world office activities.

NBSIR 79-1929. **A computerized approach for identifying cost-effective fire safety retrofits in health care facilities,** R. E. Chapman, W. G. Hall, and P. T. Chen, 125 pages (Jan. 1980). Order from NTIS as PB80-194798.

Key words: applied economics; building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation.

This study focuses on how a computerized version of the Fire Safety Evaluation System developed by the Center for Fire Research at the National Bureau of Standards can be used to determine equivalence to the Life Safety Code in the least costly manner. This study presents a programmer-oriented discussion of the mathematical, economic and engineering considerations that went into the development of the linear programming algorithm for identifying cost-effective retrofits. Programmer-oriented topics treated in this report include: a discussion of user options; program documentation; format statements; flow charts; sample computer runs; and a complete listing of the computer program.

NBSIR 79-1935. **Proceedings, Federal Workshop on Excavation Safety, September 19 and 20, 1978,** L. A. Salomone and F. Y. Yokel, 117 pages (Dec. 1979). Order from NTIS as PB80-130511.

Key words: acceptable work practices; excavation; geotechnical engineering; safety; shoring; soil classification; trench; workshop.

A two-day workshop was held at the Department of Labor in Washington, DC, on Sept. 19-20, 1978 to obtain opinions from knowledgeable people on tentative conclusions and recommendations of a NBS Study on excavation safety. The workshop agenda included a series of presentations on Tuesday, Sept. 19, 1978, and a series of group discussions on Wednesday, Sept. 20, 1978. The topic areas covered in the group discussions were: 1) Soil Classification; 2) Acceptable Measures to Protect Workers Against Death by Caving of Banks in Trenches and Excavations; and, 3) Role of the Professional Engineer and Engineering Guidelines.

This report summarizes and synthesizes opinions expressed in these group discussions and presents comments provided by correspondence after the two-day workshop.

NBSIR 79-1936. **An analysis of the responses from an Associated General Contractors of America (AGC) Survey of trenching and shoring practices,** L. A. Salomone and F. Y. Yokel, 61 pages (Jan. 1980). Order from NTIS as PB80-140817.

Key words: construction practices; construction safety; excavation; shoring; trenching.

Results of an Associated General Contractors of America (AGC) survey of present practice in excavation, trenching and shoring and of the impact of the OSHA Regulations for Excavation, Trenching and Shoring as perceived by a selected number of the membership are presented. The survey consisted of forty-seven (47) questions. A response of about fifty percent resulted in twenty-three (23) questionnaires being completed and returned to AGC. Although the twenty-three responses did not merit a rigorous statistical analysis, the data are useful in making some general statements about trenching and excavation operations.

NBSIR 79-1937. **Review of current codes and standards for scaffolds,** S. G. Fattal, C. L. Mullen, H. S. Lew, and B. J. Hunt, 70 pages (Apr. 1980). Order from NTIS as PB80-184369.

Key words: codes and standards; construction safety; design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces.

This report presents a critical review of the provisions in existing codes and standards for the design, erection, operation and maintenance of scaffolds used in construction work and other applications. The requirements in these documents were examined from the standpoint of clarity, consistency and completeness. Ambiguities arising from conflicting requirements or from provisions that led to more than one interpretation, and lack of consideration of major safety-related structural, environmental and human factors are highlighted. In addition, the adequacy of, and the rationale behind, the prescribed provisions are examined. These are supplemented by a specific application appearing in Appendix B. Appendix A illustrates common types of scaffolding systems that have been addressed by at least one of the codes or standards examined. The findings of this study serve to identify principal areas of needed research to improve present scaffolding practices.

NBSIR 79-1948. **Optimizing weatherization investments in low-income housing: Economic guidelines and forecasts,** R. E. Chapman, R. W. Crenshaw, K. A. Barnes, and P. T. Chen, 155 pages (Feb. 1980). Order from NTIS as PB80-162142.

Key words: benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization.

This study establishes a framework for systematically analyzing the economic viability of alternative methods of weatherizing low-income housing. These methods include but are not limited to insulation, weatherstripping and caulking, and installation of storm windows and doors. The economic framework is illustrated through the development of a series of forecasts (economic guidelines) which show the optimal level of weatherization for low-income residences in 15 cities across the nation. These economic guidelines are designed to assist the Community Services Administration in carrying out its Weatherization Demonstration Program. In particular, they are designed to achieve a more balanced level of weatherization per dollar spent. The optimal level of weatherization is balanced in the sense that for a given weatherization budget no increases in net savings (total savings minus total costs) can be achieved by trading one method for another.

NBSIR 79-1955. **Analysis of scaffolding accident records and related employee casualties,** S. G. Fattal, C. L. Mullen, B. J. Hunt, and H. S. Lew, 56 pages (Jan. 1980). Order from NTIS as PB80-161466.

Key words: accidents; accident statistics; construction regulations; construction safety; employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; scaffolds.

This report analyzes the causes of scaffold accidents involving employee casualties based on existing records of such incidents. Where possible, the causes are identified with system failures, environmental factors or human factors. System failures are further subdivided into categories to pinpoint the exact nature of the event that triggered the accident. The study provides an insight into the major safety-related aspects of scaffolding practices and points out the types of remedial measures that should be instituted to mitigate the frequency and consequences of scaffolding incidents. Simultaneously, it identifies critical research needs to develop the technical basis for the improvement of the safety aspects of scaffolding practices.

NBSIR 79-1957. **Analysis of code related responses from the solar demonstration program,** J. Greenberg, 153 pages (Jan. 1980). Order from NTIS as PB80-153968, $3.50; microfiche only.

Key words: building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This report was prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the National Solar Heating and Cooling Demonstration Programs. This report documents and analyzes the building regulatory information gathered during the course of the Residential Solar Demonstration Program from inception of the program through September 30, 1978. The report is based primarily on data collected by HUD

contractor personnel and are data which have been transmitted to NBS for inclusion in the NBS Solar Data Base. Although not all builders and local code officials participating in the demonstration program were interviewed for this study, the total number of participants interviewed was of sufficient size to postulate trends and draw reasonable conclusions regarding the building regulatory aspects of the program. The report concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training and better back-up material to properly evaluate solar systems.

NBSIR 80-1961. **Simplified heating and cooling energy analysis calculations for residential applications,** T. Kusuda and T. Saitoh, 137 pages (July 1980). Order from NTIS as PB80-213986.

Key words: energy analysis calculation; energy retrofit; home audit; thermal time constant.

In order to shorten the lengthy computational labor and cost common to most existing hourly simulation computer programs, a simplified energy calculation procedure was developed for the evaluation of energy conservation effectiveness of home retrofitting. The procedure utilizes monthly normal weather parameters such as temperature, humidity, wind data, and solar radiation, in lieu of the traditional degree-day procedure.

The thermal time constant was used to account for the effect of building thermal mass on seasonal heat transfer performance. In addition to standard retrofit procedures such as addition of thermal insulation, use of storm windows, and sealing of cracks, included in the procedure are the energy conservation effects due to the use of solar collectors, hot water tank insulation, and insulation around the heat distribution systems such as ducts and pipes.

NBSIR 80-1964. **Recommended guidelines for safety inspection of construction of concrete cooling towers,** H. S. Lew, S. G. Fattal, and B. J. Hunt, 36 pages (Feb. 1980). Order from NTIS as PB80-170525.

Key words: concrete; construction; cooling tower; formwork; hoisting system; regulations; safety; standards.

As a result of the natural draft cooling tower construction disaster at Willow Island, West Virginia, the National Bureau of Standards (NBS) reviewed existing Occupational Safety and Health Administration (OSHA) construction safety and health regulations and developed guidelines for use by the OSHA compliance officers for safety evaluation of reinforced concrete shell cooling tower construction.

The guidelines furnished are based on existing OSHA regulations, but highlight their application to this type of construction by pointing out critical construction operations, their safety aspects, and needed compliance inspection procedures. Major regulatory provisions affecting the basic construction plans, safety aspects of design criteria and responsibilities, record keeping, and inspections are summarized. Special attention is given to construction loadings, construction sequences, hoisting systems, and personnel safety training.

Detailed identification is made of items relating to concrete inspection, concrete control, formwork operations, construction loadings, hoisting systems, and construction safety planning.

NBSIR 80-1974. **Lead chromate pigments—A literature survey on environmental and toxic effects,** M. A. Post and P. G. Campbell, 43 pages (Feb. 1980). Order from NTIS as PB80-160666.

Key words: air pollution; chromate ore; environmental effects; lead chromate pigments; storm water runoff; toxicity; water pollution.

In connection with an evaluation of the performance of possible alternative yellow pigments, a literature search was made on the toxicity and environmental effects of lead chromate pigments. The literature reveals that workers in chromate plants in the U.S., Europe and Japan have had a high incidence of lung cancer as well as other respiratory ailments. Further, reports on the biologic interactions of chromium show that chromium in its hexavalent state (chromate, dichromate) penetrates body membranes such as skin and the walls of red blood cells and is subsequently reduced to the trivalent state and complexed with organic molecules. While the carcinogen in the chromate manufacturing process has not been identified, animal experiments have shown that calcium chromate can produce cancer in rats. Information is presented on sources of chromium in air and water pollution. Also, the pollution aspects of lead and chromium in storm water runoff and as street contaminants are reviewed.

NBSIR 80-1977. **Forecasting lead paint abatement costs: A computerized approach,** R. E. Chapman and K. A. Barnes, 88 pages (Mar. 1980). Order from NTIS as PB80-162886.

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

This report describes a computerized procedure for estimating the cost of eliminating the lead-based paint hazard from buildings. This procedure is based on the results of an extensive field test program in which lead-based paint hazard abatement activities were carried out in approximately 200 dwelling units. The computerized cost estimation procedure which emerged is particularly useful because it takes into consideration both variations in the conditions of the dwelling unit as well as in the prices for labor and materials. As a result, it permits the least costly abatement technique to be identified under a wide variety of circumstances. In addition, when contract cost estimates are desired, the computer program groups dwelling units together into contracts in such a way that the sum of the expected bid prices is minimized.

This report is intended to serve as a user's manual for staff members concerned with the problem of estimating lead-based paint abatement costs. Specific cases with respect to the preparation of cost estimates for individual dwelling units or of budget estimates for program managers, policy makers, or other decision makers, are treated.

NBSIR 80-1980. **Data requirements and thermal performance evaluation procedures for solar heating and cooling systems,** E. R. Streed, Ed., 85 pages (Aug. 1979). Order from NTIS as PB80-120173.

Key words: heating and cooling performance; solar energy system; thermal performance evaluation.

This document provides standardized nomenclature and procedures to serve as a guide to monitor and evaluate research or demonstration type solar hot water or heated and/or cooled systems, components and buildings. Performance factors, data requirements, measurement parameters and data analysis methods are described for typical solar energy systems. The document has resulted from the review and comments submitted by representatives of countries participating in Task 1. Material developed by the United States for use in the National Solar Heating and Cooling Demonstration Program and published as NBSIR 76-1137, was used as the primary reference. The contact persons for each country participating in Task 1 are listed in Appendix A.

NBSIR 80-1982. **BFIRES/Version 2: Documentation of program modifications,** F. I. Stahl, 113 pages (Mar. 1980). Order from NTIS as PB80-169949.

Key words: architectural research; building fires; computer-aided design; environmental psychology; fire research; fire

safety; human behavior in fires; modeling technique; programming; simulation of human behavior.

Several shortcomings of BFIRES/Version 1 are discussed. Chief among these are the program's inability to simulate rescue activities during fire events, and to simulate direct interactions between occupant behavior and toxic qualities of smoke filled environments. This report documents a revised program, BFIRES/Version 2, which contains new subroutines developed to mitigate these problems. These subroutines are grouped into two modules: (1) a "smoke" module designed to simulate the experience of inhabiting a smoke filled environment, and (2) a "rescue" module intended to permit the rescue of physically immobile occupants. Additional improvements incorporated into BFIRES/Version 2 include more efficient file management and data input facilities, and expanded output capabilities.

NBSIR 80-1988. **A study of work practices employed to protect workers in trenches,** J. Hinze and N. J. Carino, 124 pages (Mar. 1980). Order from NTIS as PB80-167497.

Key words: construction safety; construction standards; excavation; safety regulations; shoring; trenching.

Results of a field study of trenching practices, safety related problems in trenching, and the effect of the Occupational Health and Safety Administration (OSHA) regulations for excavation, trenching and shoring are presented. The data were gathered from over 100 interviews with contractors and formen in various regions of the country and from the answers to questionnaires sent by contractors' associations to their membership. The data indicate: 1) the technical aspects of trenching work, 2) the industry's opinion of the current OSHA regulations, and 3) factors affecting safety performance in trenching work.

NBSIR 80-1993. **Economic analysis of improved efficiency for central air conditioners,** S. R. Petersen, G. E. Kelly, and D. A. Didion, 55 pages (June 1980). Order from NTIS as PB80-209885.

Key words: central air conditioners; economic analysis; incremental savings; life-cycle costs; minimum efficiency standards; minimum energy-efficiency levels.

The development of minimum performance standards for central air is required by the National Energy Act of 1978 and is the responsibility of the Department of Energy (DOE). This report attempts to assist DOE in this endeavor by providing an analysis of the life-cycle savings and costs associated with improvements in the energy efficiency of central air conditioners. It develops a rational methodology that can be used in setting minimum standards which are economically and technically justified and makes recommendations which the authors feel meet these criteria for both split and package central air conditioners.

NBSIR 80-2001. **Economics of the product certification industry: Some research needs,** C. Chapman Rawie, 75 pages (Mar. 1980). Order from NTIS as PB80-160716.

Key words: accreditation of testing laboratories; certification; certification industry; economics; government policy; product certification; standardization research needs; standards.

A number of private organizations certify products for safety and other qualities. With the increase in safety regulation, product liability suits, and interest in encouraging the use of new technologies through certification, certification is likely to become more and more important as a way to show conformance with voluntary or regulatory standards. There have been a number of Federal and State government activities related to product certification. However, the potential impact of past and proposed government actions is not clear. One reason may be that there has been insufficient study of the economics of the product certification industry. This paper asserts that such study is needed as a basis for setting government policy and raises issues that should be addressed concerning structure and performance of the product certification industry.

NBSIR 80-2002. **Method of testing, rating and estimating the heating seasonal performance of heat pumps,** W. H. Parken, G. E. Kelly, and D. A. Didion, 65 pages (Apr. 1980). Order from NTIS as PB80-185622.

Key words: central air conditioners; central heating equipment; heating seasonal performance; heat pumps; rating procedure; residential heating; seasonal performance; test method.

Test and rating procedures are presented for electrically-driven residential air-to-air heat pumps operating in the heating mode. The procedures are designed to include the effects of part-load (cyclic) operation, variations in outdoor temperature, and frost formation on the heating performance. Using the test procedure results, a calculation procedure is presented for estimating the heating seasonal performance (HSPF) and cost of operation of residential heat pump units.

NBSIR 80-2015. **Economics applied to standards: A guide to the literature,** S. F. Weber and B. C. Cassard, 92 pages (Apr. 1980). Order from NTIS as PB80-186034.

Key words: benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; economics; evaluation; literature search; regulation; standardization; standards.

This report provides a guide to the available literature on the application of economics to the analysis of standards and standardization. One hundred eighty-nine relevant articles, reports, and books were found and organized into four major categories of interest: (1) General methods of economic evaluation; (2) Economics useful for standards analysis; (3) Evaluation of specific developed standards; and (4) Economics applied to the development of standards. The significant findings within each of these categories are briefly discussed in the text. The annotations which accompany the bibliographical entries provide more detailed information. The text includes a discussion of the approach followed in the literature search. An author index is also provided.

NBSIR 80-2040. **Recommended practice for measuring life-cycle costs of buildings and building systems.** R. T. Ruegg, S. R. Petersen, and H. E. Marshall, 76 pages (June 1980). Order from NTIS as PB80-203649.

Key words: benefit-cost analysis; building economics; buildings; building systems standard; cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice.

Rising prices of labor, material, and particularly energy have forced builders, architects, engineers, building owners and operators, and code writers to identify building designs and building systems that will be cost effective in the long run. This report describes how to measure the life-cycle costs of buildings and building systems. Life-cycle cost analysis, when applied to building decisions, provides an economic evaluation of the net dollar effect, over time, of purchasing, constructing/installing, maintaining, operating, repairing, and replacing buildings or building systems. This recommended practice for making life-cycle cost evaluations will assist the private and public building communities in making cost-effective decisions.

NBSIR 80-2052. **Energy budget procedures and performance criteria for energy conserving building illumination systems,** A. T. Hattenburg, J. L. Heldenbrand, D. K. Ross, R. G. Stein, and W. Tao, 121 pages (May 1980). Order from NTIS as PB80-184229.

Key words: building illumination systems; energy budget; energy conservation; energy performance criteria; illumination; lighting; power budget.

This report covers subsystem energy budget development procedures and performance criteria for building illumination which were developed by a consultant team of practitioners experienced in building illumination systems. A general procedure is described wherein the energy required for efficient illumination of a building is examined and corresponding power and annual energy budget guidelines are developed.

This methodology is applied to three classes of building—offices, schools, and residences—to illustrate the method. Representative power and energy budgets are developed.

The model performance criteria and illumination energy budget methodology are recommended as the basis for development of national consensus standards, covering the principal classes of new buildings designed primarily for human occupancy.

NBSIR 80-2065. **Microprocessor applications and building control systems to achieve energy conservation,** Y. M. L. Chang and J. Y. Shih, 47 pages (July 1980). Order from NTIS as PB80-207-848.

Key words: building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers.

A well insulated building may be considered a thermally efficient building. However, the systems and controls within the building must also be energy efficient in order to conserve energy. Thus, building controls is an important subject in energy conservation. In recent years, building control engineers have been developing energy conserving control methodologies. The availability of microprocessors and minicomputers has made it possible to apply many control strategies requiring extensive computations. Since a large segment of energy is consumed in buildings, the enhancement of control methodologies will help achieve national energy goals. This report is mainly to investigate the capabilities of microprocessors in building control applications so that requirements to expedite these applications may be developed. Microprocessor applications in both conventional control systems and in local-loop energy conservation devices are examined. In addition, special applications of microprocessors in buildings are explored. The development of microprocessor technology is also discussed.

NBSIR 80-2068. **Review of current calculation procedures for building energy analysis,** T. Kusuda, 61 pages (July 1980). Order from NTIS as PB80-219819.

Key words: calculation procedures; computer simulation; energy analysis; energy conservation.

Existing calculation procedures for building energy analysis, both computer-based and manual, were surveyed by questionnaires to determine the extent to which they were used and their technical content. It was found that most of the Nation's building energy consumption analyses are done by computerized simulation of HVAC system and equipment performance. This report provides brief descriptions of some energy analysis procedures which merit further study. It also identifies items not covered in the existing procedures which need to be developed for the improvement of energy calculation technology.

NBSIR 80-2076. **Expanded NBSLD output for analysis of thermal performance of building envelope components,** S. R. Petersen and J. P. Barnett, 103 pages (July 1980). Order from NTIS as PB80-224330.

Key words: building design; computer analysis; energy conservation; HVAC loads; thermal insulation; thermal performance.

The NBS Load Determination Program (NBSLD) for the calculation of space heating and cooling loads in buildings is a potentially useful tool for the improved thermal design of building envelopes. However, its usefulness is limited because only the net heating and cooling loads are determined. In order to design building envelopes which are to be, from inception, more energy efficient than existing buildings, the thermal performance of the individual envelope elements (e.g., walls, windows, ceilings and floors) must be known and the interrelationships among these components understood. NBSLD-XO is an expanded output version of NBSLD which provides this data on an hourly, daily, monthly and/or annual basis. This report outlines the NBSLD-XO program, format, and output and provides several examples of its use based on a prototypical single-family residential building. A considerable amount of information about the thermal performance of the various envelope elements and their interrelationships is provided as exemplary of the use of the NBSLD-XO computer program.

NBSIR 80-2079. **An economic analysis of efficiency improvements to residential gas- and oil-fired central heating equipment,** S. R. Petersen and G. E. Kelly, 55 pages (July 1980). Order from NTIS as PB80-212749.

Key words: boilers; central heating equipment; economic analysis; furnaces; incremental savings; life-cycle costs; minimum efficiency levels; minimum efficiency standards.

Minimum performance standards for new residential gas- and oil-fired furnaces and boilers will be promulgated by the Department of Energy in the early 1980's. These standards will implicitly require that a number of design modifications be made to improve the seasonal efficiency of many basic furnace/boiler configurations. This report examines the potential improvement in seasonal efficiency due to a number of such modifications, as well as their life-cycle cost effectiveness. Included in the analysis are intermittent ignition devices (for gas-fired equipment), improved heat exchangers, stack dampers, external venting (with preheated air), and improved blower motor efficiencies (for forced-air furnaces). NBS DEPAF simulation data, the DOE/NBS furnace and boiler test procedures, current estimates of modification costs, and a wide range of annual heating requirements and fuel costs are used in the analysis. Minimum efficiency criteria for new furnaces and boilers are developed, based on the estimated performance of current configurations representative of lower efficiency models, upgraded with those energy-saving modifications which are generally cost effective and can be implemented without serious disruption in the industry.

NBSIR 80-2087. **Testing flat-plate water-heating solar collectors in accordance with the BSE and ASHRAE procedures,** J. P. Jenkins and J. E. Hill, 82 pages (Aug. 1980). Order from NTIS as PB81-104770.

Key words: instantaneous efficiency; optical efficiency; solar collectors; thermal losses; thermal performance testing.

Five solar collectors were tested according to the BSE and ASHRAE test procedures and the results compared. All five collectors tested were modular, flat-plate, and water-heating, and included single- and double-glazed designs with and without selectively-coated absorbers. In both procedures, collector efficiency curves are determined. The ASHRAE procedure consists exclusively of outdoor testing, whereas the BSE procedure requires a combination of outdoor and indoor testing (no irradiation) to determine the collector's optical and thermal loss characteristics, respectively. During the indoor testing in this study, the environmental test conditions were controlled and regulated by use of specially-built environmental simulators to investigate the effect of wind and "sky" temperature on the thermal loss characteristics of the collectors. The simulators provided stable, uniform wind speeds in the range of 0 to 7.1 m/s across the collectors and "sky" temperatures above the collector ranging from t_a (ambient air temperature) to $t_a - 19$ °K.

NBSIR 80-2090. **Estimating the heating seasonal operating cost of residential hybrid heat pump systems, including units retrofitted to oil, gas and electric furnaces,** P. Domanski and G. E. Kelly, 43 pages (July 1980). Order from NTIS as PB80-223142.

Key words: add-on heat pumps; furnaces; heat pumps; hybrid heat pumps; hybrid systems; rating procedure; seasonal cost of operation.

A method is presented for estimating the heating seasonal operating cost of a residential, hybrid heating system consisting of an electric heat pump and a warm-air furnace. The approach described is applicable to a heat pump/control system/gas or oil-fired furnace which is sold as a package or to a heat pump/control system which is intended to be added to an existing gas, oil or electric furnace. Recommendations are made regarding how such systems can be rated and the type of information that would assist consumers in comparing the operating cost of a hybrid heat pump system with that of a conventional heat pump or furnace. Different control strategies are accounted for and examples are presented (in the appendix) for estimating the heating seasonal operating cost of hybrid systems employing both single and two-speed compressors.

NBSIR 80-2093. **Analysis of computer-simulated thermal performance of the Norris Cotton Federal Office Building,** W. B. May, Jr., and L. G. Spielvogel, 65 pages (Nov. 1980). Order from NTIS as PB81-131922.

Key words: building models; building performance data; computer simulations, building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings.

Five computer-based simulations of the Norris Cotton Federal Office Building (NCFOB) in Manchester, New Hampshire, were performed using the Ross Meriwether Energy Systems Analysis Program. The NCFOB is a medium-size office building, occupied in September 1976, designed to serve as a demonstration of and feasibility test for energy-conserving building features. The simulations included two simulations in accordance with the original design—with and without a solar system; a simulation of the building as actually operated; a simulation of the building with modifications to actual operation; and a simulation of an alternative building design. Results of the five simulations are compared with each other and with actual measured data at several levels of detail, including total energy consumption, consumption by fuel type, and heating and cooling requirements. Good agreement between the simulation and actual data is demonstrated, and consequences of design features are discussed.

NBSIR 80-2100. **Thermal resistance measurements of a built-up roof system,** S. J. Treado, 28 pages (Oct. 1980). Order from NTIS as PB81-140063.

Key words: built-up roofs; measurement technology; moisture accumulation; nondestructive tests; thermal resistance.

This report describes factors which affect the thermal performance of built-up roof systems, and a technique for making in-place measurements of thermal resistance. This measurement technique utilizes a combination of infrared thermographic imaging, surface heat-flow meters, and surface thermopiles. The thermal resistance of the roof system is computed based on temperature differences across the roof and the measured heat flow through the roof.

A field test of the measurement procedure is detailed, along with an examination of the time period required to perform a roof thermal resistance measurement, as related to the thermal time lag for heat flow through the roof due to the effect of the thermal mass of the roof.

Roof thermal resistance determinations performed according to this measurement procedure are found to be very accurate, if measurements are performed over a sufficient time interval, the minimum interval being dependent upon the thermal mass of the roof system.

NBSIR 80-2105. **Air leakage measurements of an unpartitioned mobile home,** S. Silberstein, 27 pages (Aug. 1980). Order from NTIS as PB80-226707.

Key words: air leakage measurements; environmental chamber; fan depressurization; mobile home; sulfur hexafluoride; tracer gas.

Air exchange rates, $I(h^{-1})$, of an unpartitioned mobile home were measured at various indoor-outdoor temperature differences, $\Delta T(K)$, using SF_6 tracer in an environmental chamber, and found to be lower than for conventional buildings but similar to other mobile homes. There was little scatter from the regression equation $I = 0.0182 + 0.0118\ |\Delta T|$, with relative standard errors of the first and second coefficients of 62 and 2.5%, respectively.

A fan depressurization experiment was also performed, and yielded a flow coefficient of $C = 1.64 \times 10^{-4}$ m/s·Pa$^{0.65}$, which is also comparable to that of a previously measured mobile home. It was further found that: (1) For $I = 0.24\ h^{-1}$, no SF_6 could be detected in the environmental chamber even after five hours, but when $I = 9\ h^{-1}$ for more than five minutes, the tracer gas method could not be used accurately in the environmental chamber even with exhaust fans operating; (2) The standard error is useful for monitoring whether sufficient concentration measurements were taken at each step; (3) An air bag sampling technique appeared as good as the conventional monitoring method for determining infiltration rate; (4) Reported intercepts of regression equations vary greatly from building to building, and it may be difficult to analyze the significance; (5) The possibility that $I = O\ h^{-1}$ at $\Delta T = O$ K cannot be excluded.

NBSIR 80-2111-2. **Review and refinement of ATC 3-06 tentative seismic provisions. Report of technical committee 2: Structural design,** J. R. Harris, 91 pages (Oct. 1980). Order from NTIS as PB81-111759.

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

The TENTATIVE PROVISIONS FOR THE DEVELOPMENT OF SEISMIC REGULATIONS FOR BUILDINGS were developed by the Applied Technology Council to present, in one comprehensive document, current state-of-knowledge pertaining to seismic engineering of buildings. The TENTATIVE PROVISIONS are in the process of being assessed by the building community. This report is one of a series of reports that documents the deliberations of a group of professionals jointly selected by the Building Seismic Safety Council and the National Bureau of Standards and charged with reviewing the TENTATIVE PROVISIONS prior to the conduct of trial designs. The report contains the recommendations and records of the committee charged with review of the general structural design and analysis provisions. The committee made 27 recommendations for revisions to the TENTATIVE PROVISIONS and five additional recommendations concerning subsequent activities, such as the conduct of trial designs. These recommendations were made to the parent group, the Joint Committee on Review and Refinement, and their action on these recommendations is documented in a companion report.

NBSIR 80-2111-9. **Review and refinement of ATC 3-06 tentative seismic provisions. Report of technical committee 9: Regulatory use,** J. H. Pielert and P. W. Cooke, 70 pages (Oct. 1980). Order from NTIS as PB81-111742.

Key words: building; building codes; building design; disaster mitigation; earthquakes; engineering; standards.

THE TENTATIVE PROVISIONS FOR THE DEVELOPMENT OF SEISMIC REGULATIONS FOR BUILDINGS were developed by the Applied Technology Council to present,

in one comprehensive document, current state-of-knowledge pertaining to seismic engineering of buildings. The TENTATIVE PROVISIONS are in the process of being assessed by the building community. This report is one of a series of reports that documents the deliberations of a group of professionals jointly selected by the Building Seismic Safety Council and the National Bureau of Standards and charged with reviewing the TENTATIVE PROVISIONS prior to the conduct of trial designs. The report contains the recommendations and records of the committee charged with review of the regulatory implementation and enforcement aspects of the provisions. The committee made two recommendations for revisions to the TENTATIVE PROVISIONS and five additional recommendations concerning subsequent activities, such as the conduct of trial designs. These recommendations were made to the parent group, the Joint Committee on Review and Refinement, and their action on these recommendations is documented in a companion report.

NBSIR 80-2116. **Dimensional considerations in solar installations,** H. J. Milton, 154 pages (Sept. 1980). Order from NTIS as PB81-106312.

Key words: dimensions; flat plate collectors; preferred sizes; solar installations; standardization.

The Interim Report contains a study of dimensional considerations in solar installations using non-integrated flat plate collectors. Special attention is given to sizes of collectors and their constituent materials, to dimensions that affect the collector array, and to sizes for thermal storage tanks.

One of the aims of the investigation was to assess the scope for future standardization of collector sizes and their configurations, with the object to facilitate the processes of collector design, production and distribution, system design, installation, operation, and maintenance. An additional aspect was to assess the potential impacts of a change to metric units and product sizes in U.S. industry.

The report deals principally with a listing and evaluation of dimensional data for 185 flat plate collectors in production and/or use in 1978, (141 liquid, 37 air, and 8 special types), produced by 152 manufacturers. Measured sizes cover a wide range of width/length combinations, but some preferred sizes can be observed. Solar water heaters have followed standardization patterns of hot water tank manufacturers. The report suggests that greater standardization of solar systems and components is feasible, and points to some benefits that would result. The report also contains recommendations for follow-up and future investigations.

The Interim Report is intended to provide an overview of trends in the industry in 1978/79, and not an evaluation of individual commercially available components.

NBSIR 80-2117. **Probabilistic assessment of tornado-borne missile speeds,** E. Simiu and M. R. Cordes, 86 pages (Sept. 1980). Order from NTIS as PB81-128431.

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

A procedure was developed for estimating speeds with which postulated missiles hit any given set of targets in a nuclear power plant or similar installation. Hit speeds corresponding to probabilities of occurrence of 10^{-7} were calculated for a given nuclear power plant under various assumptions concerning the magnitude of the force opposing missile take-off, direction of tornado axis of translation, number and location of missiles, and size of target area. The results of the calculations are shown to depend upon the parameters: $C_D A/m$, where C_D = drag coefficient, A = projected area, m = mass of missiles, and the ratio, k, between the minimum aerodynamic force required to cause missile take-off, and the weight of the missile.

NBSIR 80-2119. **State-of-the-art summary of incentives for residential water conservation,** J. Elder, 38 pages (Oct. 1980). Order from NTIS as PB81-115958.

Key words: consumer education; energy conservation; feedback; incentives; metering; rate structures; water conservation.

Water conservation programs are being discussed and implemented throughout the country. It appears, however, that unless there is a water crisis, these programs have little effect on domestic consumption. Why have water conservation programs been ineffective? What incentives exist for the individual homeowner to conserve water? This report addresses some programs and techniques that have been developed to encourage residential water conservation. Energy conservation techniques that appear to be directly relevant to water conservation have also been included. Specific areas covered are: consumer education and information programs, feedback techniques, possible incentives in mass-metered residences, and the impact of pricing on water consumption. An extensive bibliography is included.

NBSIR 80-2144. **Residential solar data center—MIRADS user's guide,** P. M. Christopher, M. Vogt, and D. Hall, 144 pages (Oct. 1980). Order from NTIS as PB81-132268.

Key words: automatic data processing; computer retrieval; data base retrieval; residential buildings; solar data base; solar energy system; solar heating and cooling.

The Residential Solar Data Center Project staff in the Center for Building Technology, National Bureau of Standards, maintains a computerized data base containing non-instrumented residential data from the DoE/HUD Solar Heating and Cooling Demonstration Program. Data contained in the solar data base are accessible online to users of the NBS Center Computer via remote terminals with a data base retrieval software package called MIRADS (Marshall Information Retrieval and Display System). This document is a self-teaching user's guide to the solar data base. It is complete with the basic MIRADS language rules, examples of use, and a step-by-step walk-through of a typical interactive session. Appendices contain all the data element names and coded values needed to use the solar data with MIRADS, as well as many examples of actual computer sessions.

NBSIR 80-2161. **A "reference building" approach to building energy performance standards for single-family residences,** S. R. Petersen and J. L. Heldenbrand, 39 pages (Oct. 1980). Order from NTIS as PB81-135642.

Key words: building design; building energy performance standards; building standards; component performance standards; energy conservation; housing.

The Department of Energy is currently developing building energy performance standards (BEPS) that are intended to significantly reduce the design energy requirements of new buildings. This report provides a modified approach to the DoE BEPS development program for residential buildings. The modified BEPS are not meant to replace component performance standards for new buildings but rather to augment them so that design tradeoffs can be made at the whole building level if they can be shown not to increase design energy requirements.

In the modified approach, equivalence must be demonstrated between the thermal performance of a proposed building design and a reference building design of the same type and size and in the same geographic location. A number of approved calculation methods could be used to demonstrate such equivalence. This modified approach to BEPS development is directly linked to reference component performance specifications for both shell and equipment through a reference building envelope configuration. This reference basis for the BEPS provides a great deal of information to the user about acceptable building designs, making the modified BEPS approach both more manageable and more flexible than the current DoE approach.

NBSIR 80-2167. **Weatherization investment costs for low-income housing,** S. F. Weber, M. J. Boehm, and B. C. Lippiatt, 84 pages (Nov. 1980). Order from NTIS as PB81-133829.

Key words: building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization.

This report presents the results of a project involving the collection and tabulation of field data on the costs of retrofitting low-income houses for energy conservation. This project is part of the Community Services Administration Weatherization Demonstration Program being carried out through the National Bureau of Standards. The program involves the installation and evaluation of a broad range of energy conservation techniques for over 200 single-family houses in 14 demonstration sites throughout the United States. The energy conservation techniques discussed in this report consist of a variety of architectural modifications to building envelopes for the purpose of reducing heat losses due either to air infiltration or conduction. The methods used to collect and synthesize the field data on the major cost components of installing these techniques are described. An analysis of these costs is presented in the form of summary statistics including the weighted mean and standard deviation of the unit cost of installing each architectural option in each demonstration site. The significant intercity variation found in the mean unit cost of most techniques suggests that unique cost estimating procedures may be needed for each city. Possible sources of variation in the mean unit costs are discussed. Recommendations for further research include investigating the effect on cost that can be attributed to selected sources of variation.

Grant/Contract Reports

Grant/contract reports are prepared by non-NBS persons or organizations working under a grant or contract from the National Bureau of Standards. The contract reports listed below may be ordered, using the indicated order number, directly from the National Technical Information Service (NTIS), Springfield, VA 22161, in paper or microfiche form.

NBS-GCR-79-180. **Snow and ice accumulation around solar collector installations,** M. J. O'Rourke, 72 pages (Aug. 1979). Order from NTIS as PB80-127053.

Key words: building; ice; load; roof; roof load; snow; solar collector; structural engineering.

This report presents observations on and measurements of snow and ice on eight structures with flat plate solar collectors mounted on the roof. The data was collected from January through March of 1979 in areas of New York, New Hampshire and Connecticut in the general vicinity of Albany, New York. Half the installations had the collectors mounted flush with the roof surface, while the remainder had collectors mounted on racks at an angle to the roof. Contours of snow depth on the roof, snow densities, measurements of snow on the ground adjacent to the buildings, sketches and photographs of the roofs, and comments of the owners of the installations are included in the report, in addition to a discussion of the state of the art of predicting snow accumulation on roofs of buildings. The effect of solar collectors on the design of roof structures for the support of snow loads is discussed and recommendations for future research are made.

NBS-GCR-79-184. **Solar collector fluid parameter study,** W. W. Youngblood, W. Schultz, and R. Barber, 130 pages (July 1979). Order from NTIS as PB80-125891.

Key words: efficiency; flow rate; heat transfer fluid; solar collector; thermal performance.

A series of instantaneous thermal performance tests were performed on four differently constructed, commercially available flat plate solar collectors with each of four commonly used heat transfer fluids. The tests were designed to illustrate the magnitude of fluid parameter effects on the thermal performance of flat plate solar collectors. The configurations were selected to provide a broad variety of flow condition. The heat transfer fluids used were as follows: (1) water; (2) an ethylene glycol (Prestone 11)— water solution (50 percent by weight); (3) a silicone based heat transfer fluid (SYLTHERM 444); and (4) a synthetic hydrocarbon (Therminol 44). Each collector was tested with flow rates in the range of approximately 0.010 to 0.047 kg/sec per square meter (7 to 35 lbm/hr.ft^2) of net aperture area. The efficiency of the heat collection process for each test was correlated with the heat transfer fluid flow rate. The ASHRAE 93-77 recommended flow rate of 0.02 kg/sec-m^2 (14.7 lbm/hr.ft^2) was used as a reference baseline. Results show a marked decrease in efficiency (5 to 8 percentage points) for all collectors tested when using the silicone oil and the synthetic hydrocarbon oil from the efficiency obtained when using water at the same flow rate. Decreases in efficiency of 2 to 4 percentage points were observed for all collectors tested when the Prestone-water solution was used compared to water at the same flow rate. The results indicate that a flat plate solar collector's thermal efficiency response to fluid parameter effects is a strong function of the absorber plate to fluid heat transfer path, and a weaker function of the collector's optical characteristics (i.e., $\tau\alpha$).

NBS-GCR-79-185. **Colorimetry of fluorescent specimens. A state-of-the-art report,** F. W. Billmeyer, Jr., (NBS contact: Pam Jackson), 47 pages (Oct. 1979). Order from NTIS as PB80-165590.

Key words: color; colorimetry; fluorescent; fluorescent specimens; measurement.

Accurate measurement of the color of fluorescent specimens, independent of instrument parameters, is very difficult because such materials absorb radiant power in one wavelength region (the excitation region) and emit power in a region of longer wavelengths (the emission region). There is a complicating overlapping wavelength region in which both excitation and emission take place. Measurement of the spectral radiance factors of fluorescent specimens, the quantity correlating with their visual appearance, requires the use of a spectrophotometer in which the specimen is irradiated by the exact source designed for the visual observations. Bidirectional illumination and viewing, normally 45°/0° must be used, since in the more common integrating-sphere arrangement the sample itself alters the irradiation away from that desired. Conformance to better color specifications requires irradiation by a source identical to CIE standard daylight illuminant D_{65}, but existing instrument daylight simulators provide a widely discrepant range of results. Calculation methods are described allowing these results to be converted to those for D_{65} by computation. Instrument modifications and accompanying material standards are proposed for direct measurements corresponding to D_{65} irradiation. A proposed field test method and instrument are described. Recommendations for implementing these techniques are made for both short-term and long-term time frames.

NBS-GCR-79-189. **Data requirements and thermal performance evaluation procedures for solar heating and cooling systems,** E. R. Streed, Ed., 87 pages (Aug. 1979). Order from NTIS as PB80-120173.

Key words: heating and cooling performance; solar energy system; thermal performance evaluation.

This document provides standardized nomenclature and procedures to serve as a guide to monitor and evaluate research or demonstration type solar hot water or heated and/or cooled systems, components and buildings. Performance factors, data requirements, measurement parameters and data analysis methods are described for typical solar energy systems. The document has resulted from the review and comments submitted by representatives of countries participating in Task 1. Material developed by the United States for use in the National Solar Heating and Cooling Demonstration Program and published as NBSIR 76-1137, was used as the primary reference. The contact

persons for each country participating in Task 1 are listed in Appendix A.

NBS-GCR-80-197. **An investigation of factors affecting geographic cost differentials on military construction projects,** J. M. Johannes, P. D. Koch, and R. H. Rasche (NBS contact: Pam Jackson), 100 pages (Mar. 1980). Order from NTIS as PB80-160427.

Key words: building economics; construction; cost estimation; econometric models; economic analysis; engineering economics; mathematical models; program planning.

The Center for Building Technology of the National Bureau of Standards is conducting a project to develop an economically sound method for estimating area cost factors for military construction projects. Accurate estimates of area cost factors are of crucial importance to the military since these factors are used as deflators to control for regional cost differentials among planned projects. The focus of this report is on the theoretical and empirical considerations associated with the estimation and use of cost functions to control for variations in construction cost due to changing location and structure type. Three classes of cost functions are estimated based on an assumed Cobb-Douglas production technology. A base city is then chosen for use as a deflator. This approach permits area cost factors for each major geographical region to be calculated. Included in the report are annual estimates of the area cost factors for military construction projects in each major geographical region between the years of 1975 and 1978.

NBS-GCR-80-202. **Trench pressure measurements with hydraulic shores,** R. L. Tucker, L. C. Reese, and M. H. Nicholas (NBS contact: Pam Benjamin), 86 pages (May 1980). Order from NTIS as PB80-192800.

Key words: construction; excavation; geotechnical engineering; retaining structures; shoring; slope stability.

A system was developed by which strut-loads in shallow trench bracing can be measured. The system makes use of commercially available hydraulic shores. The results of a pilot study in which the system was developed and used to measure strut loads are reported. Data on strut loads in a fissured clay, taken during and after the development of failure slip surfaces, are reported.

NBS-GCR-80-257. **Performance requirements for standards processing software,** S. J. Fenves (NBS contact: Pam Benjamin), 58 pages (Apr. 1979). Order from NTIS as PB80-221112.

Key words: codes; computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering.

A methodology for the analysis and synthesis of standards exists which can provide significant assistance to standard writers and developers. Several of the methods have been implemented as computer programs. With the experience gained in the use of the first generation of programs, this report presents a set of performance requirements for a new generation of standards processing software. It is intended that these requirements serve as a basis for defining functional specifications for the subsequent development of the new software. The performance requirements are organized into six categories (general, database, interaction, user interaction, analysis, and processing environment), and they provide an ability to work with all the major elements of the methodology: decision tables for the meaning of individual provisions, information networks for the precedence between provisions, and classification systems for the production of indexes and outlines. The report also presents a concise overview of the methodology for analysis and synthesis of standards with an annotated, chronological bibliography and brief descriptions of previously developed computer programs.

NBS-GCR-80-258. **Functional specifications for standards processing software,** S. J. Fenves (NBS contact: Pam Benjamin), 171 pages (June 1979). Order from NTIS as PB80-221120.

Key words: codes; computer program; decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering.

This is the second in a series of reports leading to the development of a standards processing software capability. The first report was *Performance Requirements for Standards Processing Software.* The reader of this report will need to have read and be familiar with the concepts and terms used in the first report. This report provides the complete functional specifications which establish the technical basis for the development of the software. The salient features are: 1) the integration of all user functions into a single system, 2) maintenance of all information in a data base, 3) facilities for convenient user interaction, 4) facilities for processing and combining large standards subdivided into several units, such as chapters, and 5) facilities for interfacing with additional capabilities to be developed in the future, both external and internal to the system.

NBS-GCR-80-259. **Use of technical analysis in editing,** L. Tavis and J. W. Melin (NBS contact: Pam Benjamin), 150 pages (Jan. 1980). Order from NTIS as PB80-149073.

Key words: codes; decision theory; editing; networks; specifications standards; systems analysis/engineering.

This manual puts forth a technology that enables analysts to assist authors of laws, regulations, codes, standards, and specifications in reducing the risk of imprecision. The techniques move from the basic premise that much imprecision in such documents occurs in the verbal expression of interconnection, and at significant levels of detail. The technology makes use of decision tables and trees to express interconnected logic, of an information network to express interconnected precedence, and of equivalency lists to express equivalence of terms used in the verbal expression. Three iterative cycles are used: the translation of the verbal expression of a text to a technical expression (i.e., the decision tables, information network, and equivalency lists); the preparation of an analytic commentary on the technical expression; and the editing of both the technical and the verbal expressions to reduce imprecision. Previously developed computer programs assist in the development and analysis of the technical expression.

NBS-GCR-80-286. **Literature Review: The building regulatory system in the United States,** E. S. Smyrl, Ed., (NBS contact: Steve Webber), 324 pages (Oct. 1980). Order from NTIS as PB81-128845.

Key words: building codes; building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology.

This review, annotated bibliography and index covers literature and legal citations on the U.S. building regulatory system. The scope of the review generally includes the period from 1950 through 1978.

The review is divided into two parts. The first part deals with court decisions and legal citations which serve to define code authority and establish the legal basis of building regulations in the United States. The second part deals with articles and other information on the development and philosophy of building codes, their economic impacts, regulatory obstacles, and the application of building codes to existing buildings and new technologies.

Papers Published in Non-NBS Media

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.

19067. Ruegg, R., **Calculating the solar dollar gains: Ins and outs of life cycle costing,** *Sol. Eng. Mag.,* pp. 11-14 (July 1979).

Key words: energy conservation; federal buildings; life-cycle costing; solar energy.

This article provides an overview of life-cycle costing and describes briefly how the federal government is applying the technique to different kinds of investment decisions in its programs to conserve non-renewable energy and to demonstrate the use of solar energy in federal buildings.

19073. Ruegg, R., **The grand scheme/An economist's view of energy conservation,** *Proc. Conf. Conservation: Energy Management by Design, El Paso, TX, Mar. 1979,* pp. 1-19 (Department of Energy, Washington, DC, 1979).

Key words: building economics; economic analysis; energy conservation; windows.

This paper gives an overview of the role of economics in planning and implementing energy conservation. It explains how the economist seeks to find the economically efficient balance among the alternatives to nonrenewable energy use. It discusses the use of economic analysis to solve problems of importance to designers, engineers, builders, manufacturers, public utilities, government policy makers, and consumers. A brief case study of the life-cycle cost performance of alternative window systems is presented to show how economic analysis can guide decisions of mutual concern to different members of the building community.

19077. Clifton, J. R., Mathey, R. G., Anderson, E. D., **Creep of coated reinforcing bars in concrete,** *ASCE J. Struct. Div.* **105,** No. ST10, 1935-1947 (Oct. 1979).

Key words: concrete (reinforced); creep tests; evaluation; organic coating; pullout tests; reinforcing steels; structural engineering.

The creep properties of organic coated and uncoated No. 6 deformed steel reinforcing bars, embedded in concrete prisms, were determined for corresponding tensile stresses in the bars at the loaded ends of 15,000 psi (103 MN/m^2) and 30,000 psi (206 MN/m^2). Slip of the bars in the concrete under static loading was measured at both the free and loaded ends of the specimens at periodic intervals for two years. Twenty-four reinforcing bars were included in the tests, they consisted of 18 bars coated (in duplicates) with 9 different epoxy materials; 2 bars coated with a poly(vinyl chloride) material; and 4 uncoated reinforcing bars.

Reinforcing bars coated with six of the epoxy materials developed slip-time relationships (creep) after two years of testing that were nearly the same as those for the uncoated bars. The remaining epoxy coated bars exhibited higher rates of slip in the concrete and were judged to have poor creep properties. The excessive rates of slip of the poly(vinyl chloride) coated bars in the concrete should preclude their substitution for uncoated reinforcing bars in concrete.

The relative performance of some coated reinforcing bars in the creep study were different than those obtained in earlier pullout tests. Therefore, from the data obtained in this study, it appears that the long-term structural performance of organic coated reinforcing bars in concrete cannot be estimated solely on the basis of their bond strength determined from pullout tests.

19079. Pommersheim, J. M., Clifton, J. R., **Mathematical modeling of tricalcium silicate hydration,** *Cem. Concr. Res.* **9,** 765-770 (1979).

Key words: cement; hydration; mathematical modeling; tricalcium silicate.

Based on conceptual models for the stages in the hydration of tricalcium silicate, a mathematical model was developed. The separate resistances in the mathematical model correspond to the phenomenological stages of the conceptual model. Comparison of model output with available hydration data gave a reasonable fit between the model and the data.

19091. Gross, J. G., Spence, J. C., Crist, R. A., **Solving problems in the structural design field,** *Consult. Eng.,* pp. 86-90 (Jan. 1980).

Key words: building regulations; building standards development; consensus standards; development of standards; structural design standards.

This paper provides background information on the development and use by the United States building community of structural design standards. The use of such standards for regulatory purposes is discussed. Standard generation methods, with particular emphasis on the "consensus process," are compared. Potential new structural design standards resulting from technical advancements and changing societal needs are identified. Federal Government, building community, legal and consumer interest concerns for changing developmental processes are reviewed. Five possible major changes in approach are foreseen.

19102. Ruegg, R. T., **Life-cycle costing translating cost-saving potential into real dollars in the area of building energy management,** *Build. Oper. Manage.* **26,** No. 3, 52-56 (Mar. 1979).

Key words: buildings; cost-effective; energy conservation; investment problems; life-cycle costing.

This article provides an overview of life-cycle costing as an aide to making energy conservation investment decisions in buildings. It reports briefly on the current status of the life-cycle costing approach in government and business as applied to energy conservation, reviews essential features of the method, and explains how it can be used to solve five common investment problems. It is aimed at operators, owners, and managers of commercial, industrial, institutional, and educational buildings.

19106. Arens, E. A., **Designing for an acceptable wind environment,** *Proc. ASCE Convention and Exposition, Atlanta, GA, Oct. 23-25, 1979, ASCE Preprint 3756,* pp. 1-19 (American Society of Civil Engineers, New York, NY, 1979).

Key words: cool environments; microclimatic prediction; pedestrian comfort; wind; wind environment.

The comfort of pedestrians has been neglected by designers because first, there are few suitable outdoor comfort criteria, and second, it is difficult to predict the climatic characteristics around proposed buildings.

This paper summarizes available information on comfort in cool and cold environments. The mechanical effects of wind on comfort are now better understood than the thermal effects of climate and provide a practical basis for assessing pedestrian comfort in outdoor spaces. The limits of acceptable windspeed become the criteria to determine whether a space is comfortable or uncomfortable at a given time.

The report concludes with microclimatic-prediction techniques and procedures for determining the probability of a proposed pedestrian area being uncomfortable over time. Such a probability figure may indicate project acceptability, and suggest the level of mitigation measures worth taking.

19121. Simiu, E., **Revised procedure for estimating along-wind response,** *J. Struct. Div. Am. Soc. Civ. Eng.* **106,** No. ST1, 1-10 (Jan. 1980).

Key words: acceleration; buffeting; buildings; buildings (codes); deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures.

A revised version is presented of a procedure for calculating along-wind response previously developed by the author. This version differs from the previous procedure in three respects. First, it incorporates recent improvements in the modeling of mean wind profiles and of the turbulence intensity. Second, it includes a correction in the Monte Carlo integration algorithm employed to obtain the rms values of the fluctuating response and thus results in more accurate values of the calculated along-wind response; and third, it is simpler to use. A numerical example is given illustrating the use of the procedure.

19140. Grot, R. A., **Field performance of gas and electric water heaters,** *Proc. Conf. on Major Home Appliance Technology for Energy Conservation, Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, West Lafayette, IN, Feb. 27-Mar. 1, 1978,* D. R. Tree, G. E. Courville, V. O. Haynes, and H. Phillips, Eds., pp. 110-120 (Available as CONF-780238 from the National Technical Information Service, Springfield, VA 22161, 1978).

Key words: energy; insulation; temperature reduction; usage patterns; water heaters.

The results of a field experiment for assessing the performance of gas and electric residential storage water heaters are presented. Energy requirements for hot water supply, hot water consumption and usage pattern data are presented and analyzed using statistical techniques in order to obtain average load curves and variations from the average. The effects of various retrofit measures such as wrapping the water heater with additional insulation and reducing the hot water temperature are assessed under actual usage conditions.

19143. Simiu, E., **Laboratory simulation of turbulent wind spectra,** *J. Eng. Mech. Div. Am. Soc. Civ. Eng.* **105,** No. EM6, 1050-1054 (Dec. 1979).

Key words: aerodynamics; buildings (codes); dynamics; structural engineering; towers; turbulence; wind (meteorology).

A discussion is presented of the implications of recent results of atmospheric boundary layer research for the wind tunnel simulation of the along-wind response of tall structures. It is shown, on the basis of similarity considerations and of recently developed models of the atmospheric flow structure, that the turbulent fluctuations which cause resonant amplification effects in tall buildings do not appear to be similar in long wind tunnels to the corresponding fluctuations in atmospheric flows. It is suggested that corrections to the laboratory along-wind measurements may be required in order to account for possible differences between turbulence spectra in the atmosphere and the measured turbulence spectra obtained in the wind tunnel.

19147. Burch, D. M., Contreras, A. G., Treado, S. J., **The use of low-moisture-permeability insulation as an exterior retrofit system—A condensation study,** (Proc. ASHRAE Annul. Symp. on Field Measurements on Effectiveness of Thermal Retrofitting of Structures. ASHRAE Annl. Mtg., Detroit, MI, June 25-27, 1979), *ASHRAE Trans.* **85,** Part 2, 547-562 (1979).

Key words: condensation in walls; effect of moisture on heat transmission; moisture within wood-frame cavity walls.

Laboratory and field studies were carried out to determine whether the use of low-moisture-permeability insulation as an exterior retrofit system increases winter moisture accumulation within the existing wood siding, sheathing, and cavity insulation. A full-scale insulated test wall was sandwiched between a hot and cold box apparatus in the laboratory. The exterior surface of one half of this test wall was fitted with a low-permeability insulation retrofit system. The exterior surface of the test wall was subsequently exposed to two consecutive steady-state winter conditions, while the interior surface was exposed to a typical indoor condition for a residence. The moisture accumulations within various components of the two halves of the test wall were compared. The moisture-transfer processes which occurred in the test wall were modeled with an ASHRAE diffusion model modified with a term to account for air leakage from the hot to the cold box. A limited field survey of several wall constructions was carried out to compare field observations of moisture conditions with laboratory results.

In addition, the effect of accumulated moisture of wall heat transmission was examined.

19156. Kusuda, T., **Engineering and the health sciences,** *ASHRAE J.* **21,** No. 11, 78 (Nov. 1979).

Key words: air quality; contaminants from building materials; engineering and health effects; environmental contaminants; health science.

Recently, Section 2 of the ASHRAE R&T Committee is concerned with such health problems as Legionnaires' disease (possibly carried by cooling tower effluents), effects of glass fiber from duct linings, indoor radioactivity due to radon emanation from building materials, and various other organic and inorganic contaminants coming from building materials and HVAC systems. Energy conservation measures have also created new environmental problems. For example, airtight buildings increase humidity which increases condensation and subsequent deterioration of building materials and growth of microorganisms; low ventilation rates lead to increased concentration of radon from building materials and of such termite treatments as chlordane; new thermostat settings can significantly affect thermal comfort and productivity.

Although the biomedical or epidemiological aspects of environmental parameters are outside of the traditional ASHRAE members technical expertise, it is becoming increasingly imperative that Section 2 must deal with health and safety-related subjects.

19160. Pielert, J. H., Gross, J. G., **Technical evaluation needs for building rehabilitation,** *Proc. 2d Canadian Building Congress—Rehabilitation of Buildings, Toronto, Canada, Oct. 15-17, 1979,* pp. 93-99 (National Research Council of Canada, Ottawa, Canada, 1979).

Key words: building codes; building regulations; building technology; economics; rehabilitation.

The paper will review an aspect of the Building Rehabilitation Technology Program in the Center for Building Technology (CBT) of the National Bureau of Standards related to the development of performance evaluation methods needed to make rehabilitation decisions.

Generally, building codes for new construction written in a prescriptive format are the existing bases for regulating building rehabilitation. This approach presents difficulties since retroactive application of codes for new construction to existing buildings increases costs and discourages rehabilitation. There are currently several activities both at the U.S. Federal and State levels where model code provisions for alterations and additions to existing buildings are under development and implementation. The Housing and Community Development Act of 1978 calls on the Department of Housing and Urban Development "to develop model rehabilitation guidelines for the voluntary adoption by States and communities." New provisions for building rehabilitation have been incorporated into the Massachusetts State building code. Since the development of these provisions is intended to be in performance terms, there is a need for technical evaluation methods and guidelines for application of performance-based provisions. CBT is developing manuals which will include state-of-the-art listings of technical data for building components and specific health safety and general welfare attributes; e.g., strength and stability, accident safety, health and sanitation, and energy conservation. These manuals will cover: (1) test methods for destructive and nondestructive evaluation of existing construction, (2) methods of analyses to predict the performance of existing construction, (3) field inspection and evaluation methodologies, (4) data on the performance of systems no longer used, and (5) data on rehabilitation experiences.

The status of these various technical evaluation activities will be discussed, and an overview will be given of the other aspects of the CBT Building Rehabilitation Technology Program.

19175. Jones, D. E., Hill, J. E., **An evaluation of ASHRAE standard 94-77 for testing pebble-bed and phase-change thermal energy storage devices,** (Proc. ASHRAE Annual Meeting, Detroit, MI, June 1979), *ASHRAE Trans.* **85,** Pt. 2, 607-629 (1979).

Key words: ASHRAE standard 94-77; Glauber's salt; latent heat storage; pebble-bed; phase-change unit; solar energy storage; thermal storage device.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has recently adopted ASHRAE Standard 94-77—Methods of Testing Thermal Storage Devices Based on Thermal Performance. Experiments have been completed at the National Bureau of Standards in which a 7 m^3 (250 ft^3) pebble bed and a similarly-sized 264 MJ (250,000 Btu) phase-change unit utilizing sodium sulfate decahydrate, both using air as the transfer fluid, were tested in accordance with this Standard. A description of the test procedure, test apparatus, and detailed test results are given. Some problems were encountered in using the Standard for these kinds of thermal storage devices, and modifications to the Standard are recommended based on these experiments.

19218. Hunt, C. M., **Ventilation measurements in the Norris Cotton Federal Office Building in Manchester, NH,** (Proc. ASHRAE Semi Annual Meeting Symposium on Air Leakage, Philadelphia, PA, Jan. 1979), *ASHRAE Trans.* **85,** Pt. 1, 828-839 (June 1979).

Key words: ASHRAE Standard 62-73; building ventilation; carbon dioxide and ventilation; energy-efficient building.

Winter ventilation measurements were made in the Norris Cotton Building in Manchester, NH. Air exchange rates, averaged for the entire building, were of the order of 0.7 to 0.8 air changes per hour by the SF_6 tracer technique. This was obtained with outside air dampers closed. From this estimate and from counts of the number of occupants, ventilation rates of the order of 41 to 58 cfm (0.95 to 1.34 m^3/min) per person were calculated.

The use of measured CO_2 concentration as an index of ventilation was reexamined. About 65 percent of the concentrations in selected rooms on each floor were between 700 to 1200 ppm. In one room where 11 people were taking an examination, 2440 ppm CO_2 was found. Ventilation rates per person, calculated from CO_2 concentrations, were less than those estimated from the overall building ventilation rate, but nevertheless met the requirements in the ASHRAE Ventilation Standard 62-73 when the building was operated with the outside air dampers closed.

19224. Arens, E. A., Nall, D. H., Carroll, W. L., **The representativeness of try data in predicting mean annual heating and cooling requirements,** (Proc. ASHRAE Semi Annual Meeting, Philadelphia, PA, Jan. 1979), *ASHRAE Trans.* **85,** Pt. 1, 707-721 (1979).

Key words: building energy calculations; hourly climate date; test reference (TRY).

The report assesses 'Test Reference Year' (TRY) hourly climate date tapes to determine how well they represent long term average climate when used for estimating average annual heating and cooling requirements. A method is presented to adjust the heating and cooling requirements of a typical building type that have been computed using TRY data, in order to make them represent long term average heating and cooling requirements.

19235. Weber, S. F., **Economic analysis of alternative envelope designs for new residences in the United States,** (Proc. Second Inst. Symp. on Energy Conservation in the Built Environment, Copenhagen, Denmark, May 1979), *Energy* **5,** No. 1, 63-68 (1980).

Key words: building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating.

An economic evaluation is conducted for selected energy-conservation investments in the envelope design of new single-family housing in the U.S. Alternative investment levels in the four major components of the building envelope are evaluated: (1) attic, (2) walls, (3) floor, and (4) windows. The analysis is conducted for five cities of widely diverse climate conditions and for the major forms of energy used for heating and cooling in the U.S. For each investment level, the internal rate of return (IRR) is calculated on an incremental basis, that is, in comparison with the next lowest level of investment for that component. This marginal IRR is used to rank alternative levels of investment for all four components so that economically optimal envelope designs can be selected for each city and energy type. Two points of view are considered in the selection of optimal designs: that of an individual homebuyer and that of a public policy planner.

19237. Holton, J. K., **Updating solar performance criteria and standards,** *Proc. 1978 Annual Meeting of the American Section of the Int. Solar Energy Soc., Inc., Denver, CO, Aug. 28-31, 1978,* pp. 514-521 (Office of American Section, International Solar Energy Society, Inc., McDowell Hall, University of Delaware, Newark, DE, 1978).

Key words: solar performance criteria; solar standards; updating criteria.

The two solar performance criteria, "HUD Intermediate Minimum Property Standards (S/MPS)" and the "Interim Performance Criteria (IPC)" both residential and commercial, were developed by the National Bureau of Standards (NBS) early in the federal solar demonstration program to be of assistance in

promoting the manufacture and widespread use of solar energy systems. Considerable experience has been gained from the demonstration program and other sources that has revealed the actual problems that can occur in the manufacture, installation and use of solar energy systems and components. In order to keep the S/MPS and IPC reasonable and useful standards, they are continually being updated based on current experience. Findings are presented from the residential and commercial demonstration program and from a public commentary process that have led to the updating of numerous sections of the criteria and standards. A comparison is presented of the original criteria, the practical problems and the revised criteria. Topics covered include: system performance covering thermal losses, operating energy, system back-up, thermosyphoning, flow balancing, controls, safety, maintenance and check-out procedures; and component performance covering freeze protection, stratification, stagnation, materials deterioration, and heat transfer fluid quality.

19239. Jenkins, J. P., Hill, J. E., **A comparison of test results for flat-plate water-heating solar collectors using the BSE and ASHRAE procedures,** *J. Sol. Energy Eng.* **102/1,** pp. 2-15 (Feb. 1980).

Key words: collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance.

Five solar collectors were tested according to the BSE and ASHRAE test procedures and the results compared. All five collectors tested were modular, flat-plate, water heating, and included single- and double-glazed designs with and without selectively coated absorbers. In both procedures, collector efficiency curves are determined. The ASHRAE procedure consists exclusively of outdoor testing whereas the BSE procedure requires a combination of outdoor and indoor testing (no irradiation) to determine the collector's optical and thermal loss characteristics, respectively. During the indoor testing in this study, the environmental test conditions were controlled and regulated by use of specially built environmental simulators to investigate the effect of wind speed and "sky" temperature on the thermal loss characteristics of the collectors.

19274. Pierman, B. C., Lerner, N. D., **Testing symbols for fire situations,** *Fire Command* **47,** No. 3, 12-13 (Mar. 1980).

Key words: fire fighting; fire safety; pictograms; safety; signs; standardization; symbols; visual alerting.

This article describes the testing and development of pictorial signs for fire situations. The use of symbols for visual communication and issues of standardization are discussed. The National Bureau of Standards has cooperated actively with the National Fire Protection Association in studying two sets of symbols, and the testing programs are described. One set of pictograms included *fire safety symbols,* for alerting building occupants to aspects of egress, fire alarm, fire fighting, and fire safety. The other set was *fire fighting symbols,* to aid fire fighters in locating and identifying equipment and utilities. Work on both symbol sets is directed toward eventual standardization by NFPA.

19320. Pierman, B. C., **The application of fault trees to the evaluation of risk,** *Proc. Fourth Int. System Safety Conf., San Francisco, CA, July 9-13, 1979,* pp. 167-170 (System Safety Society, P.O. Box A, Newport Beach, CA, 1979).

Key words: accidents; fault trees; loss prevention; risk; safety.

Advances in the state of technology result in benefits that are often accompanied by increased risks which require critical evaluation. Many parameters contribute to the general acceptability of societal risk. A preliminary framework is developed to classify and display parameters in a systematic manner. Called SART—Situational Analysis and Risk Tree, the framework utilized a fault tree approach and results in a density display of risk parameters that are overrepresented in a given situation. A Standard Test Question for each tree element reflects that an issue occurs "more than average" in a situation. Completed SART trees for different risk situations can result in comparisons of the number of parameters affecting risk acceptability for those situations. The version presented requires detailed development, but serves to illustrate the concept.

19325. Jenkins, J. P., **A comparison of test results for flat-plate water-heating solar collectors using the BSE and ASHRAE procedures,** (Proc. Int. Congress Int. Solar Energy Society, Atlanta, GA, May 28-June 1, 1979), Paper in *SUN II,* K. W. Boer and B. H. Glenn, Eds., **1,** 365-369 (Pergamon Press, New York, NY, 1979).

Key words: collector efficiency; comparison German BSE vs ASHRAE 93-77 test procedures; environmental simulation for solar collector testing; optical and thermal loss characteristics of solar collectors; solar collectors; wind speed and sky temperature effects on solar collector performance.

The German Bundesverband Solarenergie (BSE) Working Group recently adopted and published a procedure for testing solar collectors based on thermal performance. Research facilities for testing flat-plate water-heating collectors have been built at NBS in accordance with the BSE procedure and the existing ASHRAE Standard 93-77. The purpose of this paper is to describe the BSE test procedure and compare experimental test results with those obtained using the existing ASHRAE Standard 93-77. Included is a description of the collector test facilities at NBS and the results obtained from testing five commercially available flat-plate water-heating collectors using both procedures.

19348. Sleater, G. A., **Preliminary performance criteria for stone preservatives,** *Proc. RILEM/ASTM/CIB Symp. Evaluation Performance External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1978,* **11,** 309-321 (1977).

Key words: accelerated decay; performance criteria; preservative testing; stone decay; stone preservatives.

As part of a program to develop performance criteria for the selection of stone preservatives, laboratory methods of accelerated stone decay have been used to obtain data on stone preservatives and to suggest criteria for their selection. Causes of stone decay were simulated in two types of testing: (1) a number of causes were combined in one testing operation, using a special test chamber; (2) the effects of single causes of stone decay were studied individually. Methods for measuring the effects of the test exposures are given, as are the preliminary performance criteria for selecting stone preservatives. No one stone preservative studied in the program met all criteria.

19350. Ruegg, R. T., **Economic feasibility of solar applications to office buildings and retail stores,** *Proc. Solar Energy Market Analysis and Evaluation Contractor's Review meeting, Washington, DC, Apr. 8-10, 1980,* pp. 1-7 (U.S. Department of Energy, Washington, DC).

Key words: active solar energy; break-even analysis; building economics; commercial buildings; economic feasibility; economic optimization; solar energy systems.

Comprehensive economic optimization models and a computer program for evaluating the economic feasibility of active solar energy for commercial buildings are developed by this study. Data and assumptions for use in the models are compiled. The models are applied to assess the economic feasibility of active solar hot water and combined space heating and hot

water systems for a new and an existing office building and retail store in 13 U.S. cities.

Net savings (or losses) of the solar energy systems are estimated in present value dollars over a 20 year life cycle, based on a set of representative data and assumptions. Break-even values of system costs, energy prices, and future energy price escalation rates are also calculated to determine the minimum conditions under which the solar energy systems become cost effective for the selected office buildings and retail stores. Sensitivity analysis is conducted for other key variables. The relationship between net savings (losses) and the solar fraction is tested for selected cities.

The approach, models, computer program, and data bases are of interest to analysts; the results, to the policy, research, and building communities.

19360. Simiu, E., **Hazards: High winds,** *J. Architect. Educ.* **33,** No. 4, 23-27 (1980).

Key words: buildings; climatology; hurricanes; structural engineering; tornadoes; winds.

The paper provides information, believed to be useful to architectural students and faculty, on damage caused by windstorms, extreme wind climatology, wind effects on buildings, tornado effects on buildings, effects of winds on users of buildings and outdoor spaces, sources of data on wind effects, and possible research topics on architectural implications of windstorms.

19364. Waksman, D., Streed, E., Dawson, A., **The influence of environmental exposure on solar collectors and their materials,** *Proc. American Section/International Solar Energy Society 1980 Annual Meeting, Phoenix, AZ, June 2-6, 1980,* pp. 415-419 (AS/ISES, Inc., McDowell Hall, University of Delaware, Newark, DE, 1980).

Key words: absorber materials; absorptive coatings; accelerated aging; cover plates; durability; environmental exposure; materials; polymeric materials; solar collectors.

Efforts in the development of reliability/durability tests for solar collectors and their materials have been hampered by the lack of data on the real time and accelerated degradation of these materials. The focus of this paper is upon research related to the development of standards for evaluating the reliability and durability of cover plate and absorber materials used in flat plate solar collectors. In this research, several different types of collectors, cover plates and absorbers are being studied in laboratory and field tests. Optical property measurements are being performed in conjunction with aging tests intended to induce degradation in the materials. The aging tests include accelerated laboratory exposure of material specimens and outdoor exposure of these materials in simulated solar collectors. Full-size solar collectors in which several of these materials are used are being concurrently subjected to outdoor and solar simulator exposure. Changes in thermal performance at the collector level are being compared with changes in optical properties at the materials level. The results obtained in the first year of this study are presented.

19366. Streed, E., Waksman, D., Dawson, A., Lunde, A., **Comparison of solar simulator and outdoor ASHRAE Standard 93 thermal performance tests,** *Proc. American Section/International Solar Energy Society 1980 Annual Meeting, Phoenix, AZ, June 2-6, 1980,* pp. 405-409 (AS/ISES, Inc., McDowell Hall, University of Delaware, Newark, DE, 1980).

Key words: ASHRAE Standard 93; collector rating; environmental influence; outdoor testing; solar collectors; solar simulators; thermal testing.

Standard test methods for determination of solar collector thermal performance permit the use of solar simulators. A comparison of efficiency measurements for seven collectors of varying construction and materials is used to illustrate the high bias in results when using two types of solar simulators as compared to outdoor measurements. Spectral distribution, sky temperature and collector tilt angle are shown to be parameters that must be considered in addition to the normal environmental test conditions of wind, irradiance, diffuse fraction and ambient temperature when camparing indoor and outdoor tests results.

19375. Fanney, A. H., Liu, S. T., **Test results on hot water systems show effects of system design,** (Proc. Symp. on Solar Hot Water Systems, Los Angeles, CA, Feb. 3-7, 1980), *Solar Eng.*, pp. 25-29 (May 1980).

Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Currently three computer programs, TRNSYS, f-CHART, and SOLCOST, are being extensively used for the design and evaluation of solar space heating and domestic hot water systems. Although widely used, the accuracy of their predictions needs to be verified with experimental data. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the staff of the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, Maryland site. The systems have been operating since June, 1978. This paper describes the testing done, the experimental results, and compares the experimental results with the computer predictions for the first twelve months of operation.

19377. Waksman, D., Dikkers, R. D., **Solar heating standards activities in the Unites States,** *Proc. Technical Meeting on Solar Energy Codes of Practice and Test Procedures, London, England, Apr. 25, 1980,* pp. 89-98 (UK-ISES, 19 Albemarle St., London, England, 1980).

Key words: codes; performance criteria; solar heating system; standards.

With the impending widespread use of solar technology, standards are urgently needed to ensure acceptable levels of technical performance. Such standards need to address not only thermal performance but also health, safety and reliability/durability. These standards will also be used as the basis for model state and local building code provisions as well as for Federal specifications. In addition, they are needed for purposes of consumer acceptance, mortgage insurance, tax credit or incentive programs, and industry commercialization. Mechanisms for the implementation of these standards, e.g. laboratory accreditation and certification procedures, are also needed.

This paper provides an overview of efforts that are currently underway in the United States to develop and implement standards for solar heating applications. A summary of standards development and building regulatory systems used in the United States is also provided.

19445. Burch, D. M., Luna, D. E., **A mathematical model for predicting attic ventilation rates required for preventing condensation on roof sheathing,** (Proc. ASHRAE Semiannual Meeting, Los Angeles, CA, Feb. 1980), *ASHRAE Trans.* **86,** Pt. 1, 201-220 (1980).

Key words: attic condensation; attic ventilation; moisture control in attics.

A mathematical model for predicting the heat transfer and moisture-transfer processes in residential attic spaces is presented. This model is utilized to predict attic ventilation rates required for preventing condensation or frost accumulation on the underside of roof sheathing. Attic ventilation charts are developed converting a wide range of outdoor temperatures, ceiling thermal resistances, and ceiling air penetration rates. The effectiveness of a ceiling vapor barrier is investigated. The effect of indoor humidification on the required attic ventilation rate is examined. Using measured data of Hinrichs, attic ventilation

rates predicted by the mathematical model are converted into net free ventilation areas for soffit venting. These values are subsequently compared with the attic ventilation requirements of ASHRAE and the HUD Minimum Property Standards.

19451. Streed, E. R., Waksman, D., **NBS solar collector durability/reliability program,** (Proc. 1st Int. Conf. on Durability of Building Materials and Components, Ottawa, Canada, Aug. 21-23, 1978), Paper in *Durability of Building Materials and Components,* P. J. Sereda and G. G. Litvan, Eds., pp. 219-242 (American Society for Testing and Materials, Philadelphia, PA, 1978).

Key words: durability/reliability; environmental degradation; materials degradation; solar collector.

There is evidence that significant deterioration in solar collectors used for residential and commercial building applications can occur as a result of exposure to environmental conditions. This problem indicates the need for validated testing and evaluation procedures that can be used to assess the deterioration of solar collectors and their associated materials. A program is being undertaken at the National Bureau of Standards (funded by the Department of Energy) to develop meaningful collector durability/reliability tests. Both laboratory and outdoor field exposure tests will be performed on collectors and collector materials. These tests will take into account the deterioration that can occur at the collector level as a result of exposure to stagnation conditions, thermal shock, moisture, wind, and snow loads, etc. Materials tests in the laboratory or field include ultraviolet (UV) degradation, thermal degradation, and moisture resistance. Correlations will be made between actual and simulated degradation for both collectors and their materials.

19459. Fanney, A. H., Liu, S. T., **Comparison of experimental and computer-predicted performance for six solar domestic hot water systems,** (Proc. Symp. on Solar Hot Water Systems, Los Angeles, CA, Feb. 3-7, 1980), *ASHRAE Trans.* **86,** Pt. 1, 823-835 (1980).

Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Currently three computer programs, TRNSYS, f-CHART, and SOLCOST, are being extensively used for the design and evaluation of solar space heating and domestic hot water systems. Although widely used, the accuracy of their predictions needs to be verified with experimental data. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the staff of the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, Maryland site. The systems have been operating since June, 1978. This paper describes the testing done, the experimental results, and compares the experimental results with the computer predictions for the first twelve months of operation.

19498. Liu, S. T., Fanney, A. H., **Comparing experimental and computer-predicted performance of solar hot water systems,** *ASHRAE J.* **22,** No. 5, 34-38 (May 1980).

Key words: computer; energy; heat transfer; hot water; measurement; modeling; solar; testing.

Three computer programs are currently used for the design and evaluation of solar space heating and domestic hot water systems. In order to provide data required for the validation of these computer programs for solar domestic hot water systems, the National Bureau of Standards fabricated and instrumented six typical systems at its Gaithersburg, MD site. The systems have been operating since June, 1978. This paper describes the testing, and experimental results, and compares these results with the computer predictions for the first twelve months of operation. This paper was presented at a symposium on Solar Hot Water Systems during ASHRAES's 1980 Semiannual meeting in Los Angeles, and will appear in Transactions, Vol. 86, Part 1.

19516. Milton, H. J., **Dimensional coordination in building,** Chapter 6 in *AIA Metric Building and Construction Guide,* pp. 43-60 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; modular coordination.

The chapter provides a general outline of the concepts of metric dimensional coordination in building, based on the international building module of 100 mm, and selected multimodules. The development of the idea of dimensional coordination in the U.S. is traced and contrasted with international developments. Definitions are provided of dimensional coordination and modular coordination. Major elements of a systematic approach to dimensional coordination are listed and include: modules and preferred dimensions; space reference systems, or grids; functional activity spaces; controlling dimensions for building design; coordinating dimensions for building products and assemblies; production (work) sizes, rules of fit, and joints; construction layout; and, drawing conventions, symbols and definitions. These elements are illustrated as needed. Detailed discussion deals with: modules and modular dimensions, including a rationale for their selection; reference grids; horizontal, vertical and intermediate controlling dimensions in building; and, preferred component and assembly sizes, and a matrix for their systematic selection. Suggestions for preferred dimensions and sizes are made for a number of building products, such as panels, masonry units, boards, sheet materials, tiles, partitions, doorsets, windows, skylights, and spacing of concealed members. Advantages of dimensional coordination, and pros and cons, have been summarized.

19518. Mahaffey, C. T., **The effect of metrication on building codes and standards,** Chapter 9 in *AIA Metric Building and Construction Guide,* pp. 85-90 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: building codes; building standards; dimensional coordination; metrication; regulatory coordination; standardization and international harmonization.

The chapter contains an analysis of major metric conversion issues relating to U.S. building standards and codes, with special emphasis on the need for proper planning and coordination. Among technical issues in the change, both the selection of correct SI units, and the consideration of dimensional coordination in the selection of new and preferred metric dimensions are stressed. International progress in standardization and in the harmonization of building regulations is addressed.

19519. Milton, H. J., Packard, R. T., **SI units in architecture,** Chapter 3 in *AIA Metric Building and Construction Guide,* pp. 13-20 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: convenient values; metric conversion; preferred dimensions; preferred values; SI units for building.

The chapter provides advice on conversion approaches, preferred dimensions and values, and SI units for use in architecture and building. Specific discussions relate to SI units for length, area, volume and section modulus, mass, time, and temperature.

19520. Milton, H. J., **Guidelines for metric training and the transitional period,** Chapter 10 in *AIA Metric Building and Construction Guide,* pp. 91-100 (John Wiley and Sons, Inc., New York, NY, May 1980).

Key words: adaptation of building materials; metric familiarization; metric products and non-metric buildings; repair and maintenance.

The chapter deals with two aspects of metrication: the training of people in the construction community, and technical adaptation during the transition period.

Formal metric training programs are contrasted with informal familiarization outside and within the work environment. Training needs of various groups and the scope for construction industry metric training programs are discussed. The value of metric recognition points and mental images as part of the familiarization program is stressed and some typical examples are given.

Strategies are offered for the technical adaptation of materials and components during the transitional phase, both for design and construction. A matrix shows various degrees of complexity of adaptation, ranging from negligible [no or minimal change] to costly and practically impossible, and recommends courses of adaptive action for designers and contractors. The impact of metrication in relation to existing buildings and their maintenance, repair, rehabilitation, extensions and additions is examined and various strategies for the minimization of costs and problems are recommended. Legal and contractual implications of the change are addressed.

19527. Warnick, W. L., Hill, J. E., **The solar collector industry and solar energy,** *Mon. Energy Rev. DOE-EIA Report 0035-02 (80),* pp. 1-6 (Department of Energy, Energy Information Administration, Washington, DC, Feb. 1978).

Key words: energy estimates; geographical distribution; low temperature collectors; manufacturing activity; medium temperature collector; solar energy; special collectors.

From a 1974 level of 1.3 million square feet, the production of solar collectors increased over ten-fold to 13.9 million square feet in 1979 (based upon the first 6-months' data). However, shipments of the various types of collectors, while increasing over-all, show sporadic growth patterns over the 5 1/2-year period. Furthermore, a 4-year period of exponential growth appears to have ended.

Solar energy incident on the Nation's inventory of solar collectors during 1979 was less than 0.03 quadrillion British thermal units (Btu). It is estimated that during 1979 the usable energy-output from solar collectors in the United States was about 0.008 quadrillion Btu, between 0.01 and 0.02 percent of domestic energy consumption.

19549. Batts, M. E., Cordes, M. R., Simiu, E., **Sampling errors in estimation of extreme hurricane winds,** (Proc. ASCE Engineering Mechanics Division Specialty Conf., Austin, TX, Sept. 17-19, 1979), *J. Struct. Div.* **106,** No. ST10, 2109-2115 (Oct. 1980).

Key words: climatological sampling errors; hurricanes; simulation sampling errors; wind loads.

An investigation is presented into the magnitude of sampling errors in the estimation of extreme hurricane winds by Monte Carlo methods. It is shown that the coefficient of variation of the sampling errors is of the order of 10% for wind speeds with mean recurrence intervals of the order of 50 years.

Results of calculations are presented showing the influence upon the estimates of the number of climatological data and the number of simulated hurricanes.

19615. Shingleton, J. G., Cassel, D. E., McCabe, M. E., **The use of operational results to identify potential improvements in the thermal performance of air solar heating systems and to establish performance criteria,** *Proc. Conf. Solar Heating and Cooling Systems—Operational Results Colorado Springs, CO, Nov. 27-30, 1979, SERI/TP-245-430,* pp. 203-209 (U.S. Department of Energy/Solar Energy Research Institute (SERI), Golden, CO, 1980).

Key words: air corrections; air leakage; computer simulation; damper leakage; performance criteria; solar heating systems.

The National Bureau of Standards is developing definitive performance criteria for solar heating, cooling, and hot water systems. This study was performed to quantify the effect of air leakage on the thermal performance of air type solar heating systems.

Field air flow measurements taken at seven instrumented residential air type solar heating systems show substantial air leakage. A TRNSYS computer model was developed based on the system at one instrumented site where air flow measurements were taken. Air leakage from this system had been reduced as much as possible. The effect of air leakage on system performance was examined analytically by including the measured air leakage in the system model.

The results of the computer simulations show that by eliminating all of the measured air leaks that remained after the modeled system was repaired, a reduction of as much as 19 percent in seasonal auxiliary energy can be realized. The relationship between air leakage and auxiliary energy use in this system is described.

19619. Shingleton, J. G., Cassel, D. E., McCabe, M. E., **Computer modeling of air leakage in a solar air heating system,** *Proc. 2d Annual Systems Simulation and Economic Analysis Conf., San Diego, CA, Jan. 23-25, 1980, SERI/TP-351-131,* pp. 265-271 (U.S. Department of Energy/Solar Energy Research Institute (SERI), Golden, CO, 1980).

Key words: air leakage; computer simulation; performance criteria; solar air heating systems; solar collector.

A detailed TRNSYS computer model developed to permit evaluation of the effects of air leaks on the performance of a solar air heating system is described. The model was developed to define reasonable limits of air leakage for specification in performance criteria for solar heating and cooling systems in commercial and residential buildings.

The computer model, based on a physical system in the HUD demonstration program, was designed to utilize air flow rates as measured in the physical system after extensive repairs had been made to reduce air leaks. The model accounts for the existence of air leaks in the collector array, the storage container, and the control dampers for both an actually measured and various hypothetical conditions. The subroutine developed to account for collector air leakage incorporates the equations of Close and Yusoff to model collector leakage with either infiltration or exfiltration. The subroutine developed to control system model operation varies the air flow rates and leak rates for each mode of operation according to preset parameters based on the field measurements.

Hour-by-hour simulations were performed for an entire heating season for various air leakage rates. Hourly simulation results are presented to demonstrate the immediate system effects (reduced collector outlet and house supply temperatures) that are the cause of long-term system performance degradation.

Seasonal simulations performed with the model indicate that the elimination of all the measured air leakage results in a 19 percent reduction in auxiliary energy use. Short-term simulations show that collector and storage air leakage is accompanied by lower collector outlet and house supply temperatures, higher collector array operating efficiency, and increased auxiliary energy use.

19729. Greenberg, J., **The solar demonstration program: Technical issues and constraints,** *ASHRAE J.* **22,** No. 8, 30-31 (Aug. 1980).

Key words: building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy.

This paper is based on a report prepared jointly for the Department of Housing and Urban Development (HUD) and the Department of Energy (DoE) under activities carried out by the National Bureau of Standards (NBS) relative to the Solar Heating and Cooling Demonstration Program. Regulatory information was abstracted from HUD contractor-developed questionnaires and analyzed to determine perceived regulatory constraints which might inhibit, impede, or otherwise adversely affect the installation and use of solar hot water and space and/or cooling systems. The paper documents and analyzes building regulatory information gathered by HUD Contractor personnel during the course of the Solar Residential Demonstration Program—from inception of the program (late 1975) through September 30, 1978. The paper concludes that existing codes do not present a barrier to the installation and acceptance of solar systems; however, code officials need additional training and better back-up material to properly evaluate solar systems.

19754. Glass, R. A., Kaetzel, L. J., Smith, G. R., **A computer data base system for indexing research papers,** *Behav. Res. Methods Instrum. Lett.* **12,** No. 5, 547-548 (1980).

Key words: data base; information retrieval; interactive processing.

The KGS data base system allows the indexing and retrieval of scientific research papers through the use of a minicomputer system in an interactive mode. Criteria are entered through the user's computer terminal which produces subsets of the data base in a report format as well as statistical summaries of data base elements.

19813. Hill, J. E., **Standard procedures for collector performance testing,** Chapter 15 in *Solar Energy Technology Handbook. Part A. Engineering Fundamentals. Energy, Power and Environment* **6,** W. C. Dickinson and P. N. Cheremisinoff, Eds., pp. 457-480 (Marcel Dekker, Inc., New York, NY, 1980).

Key words: solar collector; solar heating and cooling; standards; testing.

The use of solar energy for space heating, cooling, and supplying domestic hot water to buildings has received considerable attention over the past several years. As a result, a solar heating and cooling industry has emerged, and with it a need for both performance and testing standards. This paper reviews the basic concepts used in testing solar collectors for thermal performance and then describes in detail the adopted consensus standard test method, ASHRAE Standard 93-77. It presents typical results obtained for flat-plate collectors using the Standard, how the method can be used for concentrating collectors, how to calculate "cooling" performance for a collector using the test results, and some recent developments in the collector testing field

19815. Kennish, W., Ahmed, M., McCabe, M., McKinstry, M., **Determination of thermal performance characteristics of modular passive solar storage walls,** *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980,* pp. 975-979 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: finite-difference computer model; passive solar energy; responsive coefficients; solar storage walls; testing procedures; thermal performance.

A conceptual study of testing procedures to determine thermal performance characteristics of Trombe-Wall type passive solar storage wall systems has been performed. In the study, a finite-difference thermal model of a passive solar storage wall in a test facility was used to predict the wall thermal performance in a particular climatic location. The simulated test results were used in a multiple regression analysis to charaoterize the thermal performance of test wall. These characteristics were then used in a simplified calculation procedurc to predict the thermal performance of the solar storage wall in different climatic regions. A comparison of these predictions with detailed computer simulation results for these other climatic regions show that the test procedure and data reduction technique provides a simple method of characterizing the passive solar storage wall and has potential wide scale applications for modular passive components.

19819. McKinstry, M., Richtmyer, T., Ducas, W., **Performance evaluation of passive/hybrid solar heating and cooling,** *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980,* pp. 346-350 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: building heat transfer; energy conservation; passive solar heating, cooling, and performance monitoring.

Two levels of passive/hybrid solar heating and cooling performance evaluation are discussed. They have been reviewed and accepted by coordinating committees drawn from government organizations and universities, as technical appendices to the U.S. DoE Program Area Plan, "Performance Evaluation of Passive/Hybrid Solar Heating and Cooling," and will be used in the U.S. DoE passive performance monitoring program. Both levels use a subtractive calculation for passive heating or cooling used by the building, although, with the more detailed method, heat flux to or from primary storage elements is monitored so that an approximate additive calculation can be done.

19820. Ducas, W., McCabe, M., DeCorte, K., **Review of thermal performance test procedures for testing passive/hybrid solar components,** *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980,* pp. 970-974 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: passive product types; solar calorimeter tests; solar-optical properties tests; solar simulation; thermal performance test procedures; thermal transmission tests; thin-film resistance heaters.

Existing test methods have been reviewed for their application as thermal performance test procedures for modular passive/hybrid solar components. These methods cover the thermal performance of building envelope assemblies such as walls and windows, and tests developed for thermal storage assemblies.

A classification of passive components is identified, recommendations are made for testing several types of passive components, and recommendations for new test procedures are identified.

19823. Sabatiuk, P. A., McCabe, M., **Development of thermal performance criteria for residential passive solar buildings,** *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980,* pp. 621-624 (American Section, ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: depletable energy; HUD Demonstration Program; passive solar buildings; performance criteria; statistical evaluation; thermal analysis.

In support of the development of thermal performance criteria for residential passive solar buildings, thermal design characteristics and anticipated performance for 266 projects in the HUD Passive Residential Design Competition and the HUD Cycle 5 Demonstration Program were analyzed. These passive residences are located in all regions of the United States requir-

ing space heating, and they represent a variety of passive solar system types including direct gain, indirect gain, and solarium (isolated gain) systems. The results of this statistical analysis are being used to develop proposed minimum acceptable levels of thermal performance for passive solar buildings for the residential performance criteria.

A number of performance measures were examined, including net solar contribution, solar fraction, and auxiliary energy use. These and other design and climate-related parameters were statistically correlated using the DATAPLOT computer program and standard statistical analysis techniques.

19835. Batts, M. E., Russell, L. R., Simiu, E., **Hurricane wind speeds in the United States,** *ASCE J. Structural Div.* **106,** No. ST10, 2001-2016 (Oct. 1980).

Key words: buildings (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology).

A Monte Carlo simulation technique is used to obtain estimates of hurricane wind speeds in the Gulf and East Coasts of the United States. The paper describes the sources of data, the probabilistic models for the climatological characteristics of hurricanes, and the physical models for the hurricane wind speed field used in the estimations. Estimated values of fastest-mile hurricane wind speeds at 10 m above ground in open terrain at the coastline and at 200 km inland are given for various mean recurrence intervals. The estimated hurricane wind speeds were found to be best fitted by Weibull distributions with tail length parameters $\gamma \geqslant 4$. Estimates are given of various errors inherent in the estimated values of the hurricane wind speeds. Owing to uncertainties with respect to the applicability of the physical models used in this work to locations north of Cape Hatteras, estimated hurricane wind speeds given for these locations should be viewed with caution.

19844. Salomone, L. A., **The effect of organization culture on managers,** *Proc. ASCE Convention and Exposition, Hollywood, FL, Oct. 27-31, 1980,* pp. 1-13 (American Society of Civil Engineers, New York, NY, 1980).

Key words: management theory; managers; organizational development; organization culture; strategic model; theories of behavior.

Systematic examination of management, with few exceptions, is the product of the present century and especially of the past several decades although most students of management would agree that problems of management have existed since the dawn of organized life. Changes in the size, diversity and complexity of projects have reemphasized the need for developing better and more effective techniques in project management. In addition, the unsettled economic environment has reduced the number of new projects, and as a result, has increased the competition in private industry for those projects which are funded. Likewise, in government, similar pressures have been created because of efforts to decrease or hold down government spending.

The management theory which is assisting the National Engineering Laboratory of the National Bureau of Standards in Washington, D.C. and its managers in their search for excellence is presented, and the effect of organization culture on managers is discussed. Using the Managerial Grid developed by Robert R. Blake and Jane S. Mouton, the perceptions of some government employees and corporate managers regarding the soundest organization culture are investigated. Also, results of an experiment in which government employees were asked to rank the alternatives to questions, designed to evaluate organization culture, based on how their organization actually operates are presented.

19862. Kusuda, T., Silberstein, S., McNall, P. E., Jr., **Modeling of radon and its daughter concentrations in ventilated spaces,** *J. Air Pollut. Control. Assoc.* **30,** No. 11, 1201-1207 (Nov. 1980).

Key words: energy conservation; indoor air quality; radioactivity; radon; ventilation.

In order to predict indoor radiation levels due to radon daughters at low building ventilation and air leakage rates, differential equations governing the decay and venting of radon (Rn-222) and its daughters were used. A computer program based on the equations was written to predict radon and daughter concentrations, total potential alpha energy concentration and equilibrium factor. The program can account for time dependence of ventilation and emanation rates and is readily used by building designers.

Sample calculations using the program showed that potential alpha energy levels in tightened buildings can commonly reach about 0.01 working level (WL), a level more than twice as high as concentrations currently found in most houses.

19870. Overton, R. L., Cassel, D. E., McCabe, M. E., **Evaluation of a proposed modification to the f-chart method to include collector array air leakage,** *Proc. Winter Annual Meeting Solar Energy Division, American Society of Mechanical Engineers, Chicago, IL, Nov. 16-21, 1980, Paper 80 WA/Sol-12,* pp. 1-10 (American Society of Mechanical Engineers, New York, NY, 1980).

Key words: air leakage; f-chart method; flat-plate solar collectors; solar energy system; TRNSYS computer program.

Field measurements of air leakage reported for a number of residential and commercial solar air heating systems suggests that air leakage occurs in most collector arrays. However, standard analytical techniques to predict solar energy system performance such as the f-chart method do not consider the effects of air leakage on system thermal performance. A proposed method for incorporating collector array leakage considerations into the f-chart method of system evaluation was determined to be effective. Using modified collector parameters accounting for collector array leakage and the FCHART computer program, the annual thermal performance of a solar space heating system in Madison, Wisconsin was compared with detailed TRNSYS computer program results based on explicit modeling of system air leakage. The modified f-chart method produced annual thermal performance predictions that agreed within five percent of the TRNSYS simulation results when air leakage rates were less than 50 percent of the collector design flow rate.

19872. Reinhold, T. A., Sparks, P. R., **The influence of wind direction on the response of a square-section tall building,** *Proc. Fifth Int. Conf. on Wind Engineering, Ft. Collins, CO, July 8-14, 1979,* **I,** Sessions I-V, VI-3-1—VI-3-14 (Pergamon Press, Elmsford, NY, 1980).

Key words: aerodynamics; boundary layers; dynamic response; influence of wind-direction; tall buildings; wind loads; wind tunnels.

This paper describes a wind-tunnel study to determine the effect of wind-direction on the response of a square-section tall building with an 8.33 to 1 aspect ratio. Rigid models instrumented with pressure transducers were used to determine the modal forces for the fundamental translational and torsional modes of the building. Using these forces and typical stiffness and damping values, the influence of wind-direction on the response of a 500:1 scale prototype building was estimated. The maximum response was generally found to occur when the wind was blowing onto a face of the building. Comparisons are made between predicted response levels of the prototype building, based on experimental results on the one hand, and on current design procedures on the other hand.

19923. Arens, E., Gonzales, R., Berglund, L., McNall, P. E., Zeren, L., **A new bioclimatic chart for passive solar design,** *Proc. American Society of the Int. Solar Energy Society and 5th Natl. Passive Solar Conf. Annual Tech. Conf. Passive Systems Div., University of Massachusetts, Amherst, MA, Oct. 19-26, 1980,* pp. 1202-1206 (American Section ISES, University of Delaware, Newark, DE 19711, Oct. 1980).

Key words: bioclimatic chart; human comfort; indoor environment; outdoor environment; thermal comfort.

This paper presents a substantially revised version of the original bioclimatic chart developed by Olgyay and Yaglou in the 1950s, incorporating recent research results. A thermophysiological model developed at the J. B. Pierce Foundation Laboratory was used to simulate the thermal behavior and resulting comfort sensation of an individual at two clothing levels, and a rate of activity typical of office work, house work, or shopping. The criteria for the boundaries of the comfort zone are based on the ASHRAE Standard 55-74, as currently being proposed for revision. Examples of the chart are presented, in both the original format and in the format of the psychrometric chart.

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Buffeting; buildings; buildings (codes); deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; *19121.*

Building; building codes; building design; disaster mitigation; earthquakes; engineering; standards; *NBSIR 80-2111-9.*

Building; building codes; building design; earthquakes; engineering; standards; structural engineering; *NBSIR 80-2111-2.*

Building; ice; load; roof; roof load; snow; solar collector; structural engineering; *NBS-GCR-79-180.*

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Building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; *NBSIR 80-2065.*

Building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy; *SP586,* pp. 181-185 (June 1980).

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Building code; code official; demonstration program; institutional constraints; solar builder/developer; solar energy; *19729.*

Building code enforcement; buildings; design; energy conservation; housing codes; regulatory approaches; *SP586.*

Building codes; building design; disaster mitigation; earthquakes; engineering; standards; building; *NBSIR 80-2111-9.*

Building codes; building design; earthquakes; engineering; standards; structural engineering; building; *NBSIR 80-2111-2.*

Building codes; building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; *BSS129.*

Building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation; applied economics; *NBSIR 79-1902.*

Building codes; building evaluation; elderly; fire safety; handicapped occupants; health care facilities; nursing homes; user needs; *NBSIR 79-1906.*

Building codes; building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation; *SP586,* pp. 205-224 (June 1980).

Building codes; building inspectors; code enforcement; course development; educational requirements; inspection; licensing; testing; training code officials; *SP586,* pp. 71-83 (June 1980).

Building codes; building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology; *NBS-GCR-80-286.*

Building codes; building regulations; building technology; economics; rehabilitation; *19160.*

Building codes; building standards; dimensional coordination; metrication; regulatory coordination; standardization and international harmonization; *19518.*

Building (codes); climatology; hurricanes; statistical analysis; structural engineering; tropical cyclones; wind (meteorology); *BSS124.*

Building codes; conversion strategies; harmonization; metrication; metric transition; *SP586,* pp. 227-251 (June 1980).

Building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation; applied economics; *NBSIR 79-1929.*

Building collapse; ice; snow; wind; *SP586,* pp. 259-270 (June 1980).

Building components; building materials; durability; life testing; prediction; recommended practice; reliability service life; accelerated aging tests; *TN1120.*

Building controls; building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; *NBSIR 80-2065.*

Building departments; building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments; *SP586,* pp. 33-42 (June 1980).

Building design; building energy performance standards; building standards; component performance standards; energy conservation; housing; *NBSIR 80-2161.*

Building design; computer analysis; energy conservation; HVAC loads; thermal insulation; thermal performance; *NBSIR 80-2076.*

Building design; construction economics; discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; *SP544.*

Building design; disaster mitigation; earthquakes; engineering; standards; building; building codes; *NBSIR 80-2111-9.*

Building design; earthquakes; engineering; standards; structural engineering; building; building codes; *NBSIR 80-2111-2.*

Building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; *NBSIR 79-1948.*

Building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning; applied economics; *NBSIR 80-1977.*

Building economics; buildings; building systems standard; cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; *NBSIR 80-2040.*

Building economics; commercial buildings; economic feasibility; economic optimization; solar energy systems; active solar energy; break-even analysis; *19350.*

Building economics; commercial buildings; investment analysis; life-cycle cost analysis; passive solar energy; retrofit; revitalization; solar energy systems; benefit-cost analysis; *BSS125.*

Building economics; construction; cost estimation; econometric models; economic analysis; engineering economics; mathematical models; program planning; *NBS-GCR-80-197.*

Building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; *NBSIR 80-2167.*

Building economics; cost estimation; economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; *BSS129.*

Building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; *H132.*

Building economics; economic analysis; energy conservation; windows; *19073.*

Building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation; applied economics; building codes; *NBSIR 79-1902.*

Building energy; computerized climate data; *BSS126.*

Building energy calculations; hourly climate date; test reference (TRY); *19224.*

Building energy management systems; chiller controls; distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; building controls; *NBSIR 80-2065.*

Building energy performance standards; building standards; component performance standards; energy conservation; housing; building design; *NBSIR 80-2161.*

Building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating; *19235.*

Building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; *NBSIR 79-1948.*

Building evaluation; design process; man/environment research; post-occupancy evaluation; questionnaire; user needs; *NBSIR 79-1780.*

Building evaluation; elderly; fire safety; handicapped occupants; health care facilities; nursing homes; user needs; building codes; *NBSIR 79-1906.*

Building fires; computer-aided design; computer simulation; fire research; human performance; modeling; regulatory process; simulation; building codes; *SP586,* pp. 205-224 (June 1980).

Building fires; computer-aided design; environmental psychology; fire research; fire safety; human behavior in fires; modeling technique; programming; simulation of human behavior; architectural research; *NBSIR 80-1982.*

Building heat transfer; energy conservation; passive solar heating, cooling, and performance monitoring; *19819.*

Building illumination systems; energy budget; energy conservation; energy performance criteria; illumination; lighting; power budget; *NBSIR 80-2052.*

Building inspection; code administration; Indiana building code enforcement; local government; political appointments; survey of local building departments; building departments; *SP586,* pp. 33-42 (June 1980).

Building inspectors; code enforcement; course development; educational requirements; inspection; licensing; testing; training code officials; building codes; *SP586,* pp. 71-83 (June 1980).

Building laws and regulations; code development; court decisions; legal basis; liability; regulation; regulatory impacts; technology; building codes; *NBS-GCR-80-286.*

Building materials; durability; life testing; prediction; recommended practice; reliability service life; accelerated aging tests; building components; *TN1120.*

Building materials; economic analysis; housing; lead-based paint; lead poisoning; applied economics; building economics; *NBSIR 80-1977.*

Building models; building performance data; computer simulations, building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings; *NBSIR 80-2093.*

Building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; metric building products; modular coordination; *19516.*

Building module; dimensional coordination; metric design and construction; modular coordination; standards; *SP595.*

Building performance data; computer simulations, building; energy conservation in commercial buildings; heat pumps; validation of computer models, buildings; building models; *NBSIR 80-2093.*

Building regulations; building standards development; consensus standards; development of standards; structural design standards; *19091.*

Building regulations; building technology; economics; rehabilitation; building codes; *19160.*

Building regulations; housing policies; housing standards; minimum property standards; *SP586,* pp. 87-102 (June 1980).

Building research; building technology; codes; criteria; project summaries; standards; technical bases; *SP446-3.*

Building research; building technology; codes; criteria; project summaries; standards; technical bases; *SP446-4.*

Buildings; buildings (codes); deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; *19121.*

Buildings; building systems standard; cost; discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; *NBSIR 80-2040.*

Buildings; climatology; hurricanes; structural engineering; tornadoes; winds; *19360.*

Buildings; communication; cost; human characteristics; personal control; physical environment; privacy; architectural psychol-

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ing steels; structural engineering; concrete (reinforced); *19077.*

Criteria; project summaries; standards; technical bases; building research; building technology; codes; *SP446-3.*

Criteria; project summaries; standards; technical bases; building research; building technology; codes; *SP446-4.*

D

Damper leakage; performance criteria; solar heating systems; air corrections; air leakage; computer simulation; *19615.*

Data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; *NBSIR 80-2167.*

Data base; information retrieval; interactive processing; *TN1123.*

Data base; information retrieval; interactive processing; *19754.*

Data base retrieval; residential buildings; solar data base; solar energy system; solar heating and cooling; automatic data processing; computer retrieval; *NBSIR 80-2144.*

Data collection; demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; *NBSIR 80-2167.*

Decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; computer program; *NBS-GCR-80-257.*

Decision table; network; performance requirements; software; specifications; standards; systems analysis/engineering; codes; computer program; *NBS-GCR-80-258.*

Decision theory; editing; networks; specifications standards; systems analysis/engineering; codes; *NBS-GCR-80-259.*

Deflection; dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; buildings; buildings (codes); *19121.*

Demonstration; economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; *NBSIR 80-2167.*

Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *SP586,* pp. 181-185 (June 1980).

Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *NBSIR 79-1957.*

Demonstration program; institutional constraints; solar builder/developer; solar energy; building code; code official; *19729.*

Department; formaldehyde; formaldehyde-based chemicals; formaldehyde level; standards; urea-formaldehyde resins; committee; concentration; *SP586,* pp. 253-258 (June 1980).

Depletable energy; HUD Demonstration Program; passive solar buildings; performance criteria; statistical evaluation; thermal analysis; *19823.*

Design; energy conservation; housing codes; regulatory approaches; building code enforcement; buildings; *SP586.*

Design; loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; *NBSIR 79-1937.*

Design (buildings); limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); *SP577.*

Design criteria; disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; *SP560.*

Design elements; energy performance of windows; window attributes; window design; window design elements; window performance; *SP575.*

Design process; man/environment research; post-occupancy evaluation; questionnaire; user needs; building evaluation; *NBSIR 79-1780.*

Deterioration of stone; preservation; stone; stone consolidation; conservation; consolidating materials; *TN1118.*

Development fee; planning cost; Proposition 13; affordable housing; *SP586,* pp. 13-16 (June 1980).

Development of standards; structural design standards; building regulations; building standards development; consensus standards; *19091.*

Dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; *SP592.*

Dimensional coordination; metrication; regulatory coordination; standardization and international harmonization; building codes; building standards; *19518.*

Dimensional coordination; metric bibliography; metric conversion timetable; metric decision; metric product sizes; metric system (SI); construction industries; *SP598.*

Dimensional coordination; metric building design; metric building products; modular coordination; building module; controlling dimensions; coordinating sizes; *19516.*

Dimensional coordination; metric design and construction; modular coordination; standards; building module; *SP595.*

Dimensions; flat plate collectors; preferred sizes; solar installations; standardization; *NBSIR 80-2116.*

Disaster; earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; *SP560.*

Disaster mitigation; earthquakes; engineering; standards; building; building codes; building design; *NBSIR 80-2111-9.*

Discounting; economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; *H132.*

Discounting; economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; buildings; building systems standard; cost; *NBSIR 80-2040.*

Discounting; economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; building design; construction economics; *SP544.*

Distributed control systems; energy conservation; energy conservation devices; microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; building controls; building energy management systems; chiller controls; *NBSIR 80-2065.*

ΔR effect; BLAST; effective U-value; heat capacity; log home; mass factor; thermal mass; *SP586,* pp. 161-179 (June 1980).

Durability; environmental exposure; materials; polymeric materials; solar collectors; absorber materials; absorptive coatings; accelerated aging; cover plates; *19364.*

Durability; life testing; prediction; recommended practice; reliability service life; accelerated aging tests; building components; building materials; *TN1120.*

Durability/reliability; environmental degradation; materials degradation; solar collector; *19451.*

Durability/reliability; performance criteria; safety; solar collectors; solar energy; standards; thermal performance; buildings; cooling; *SP586,* pp. 151-160 (June 1980).

Dynamic response; influence of wind-direction; tall buildings; wind loads; wind tunnels; aerodynamics; boundary layers; *19872.*

Dynamic response and gust loads; structural engineering; tall buildings; wind forces; wind pressures; acceleration; buffeting; buildings; buildings (codes); deflection; *19121.*

Dynamics; structural engineering; towers; turbulence; wind (meteorology); aerodynamics; buildings (codes); *19143.*

E

Earthquake; engineers; Florida; inspection; legislation; recertification; architects; codes; *SP586,* pp. 197-203 (June 1980).

Earthquakes; engineering; standards; building; building codes; building design; disaster mitigation; *NBSIR 80-2111-9.*

Earthquakes; engineering; standards; structural engineering; building; building codes; building design; *NBSIR 80-2111-2.*

Earthquakes; foreign engineering; geology; highways; housing; landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; dikes; *SP592.*

Earthquakes; ground motion; seismology; standards; storm surge; structural engineering; structural response; tsunami; wind loads; winds; accelerograph; codes; design criteria; disaster; *SP560.*

Econometric models; economic analysis; engineering economics; mathematical models; program planning; building economics; construction; cost estimation; *NBS-GCR-80-197.*

Economic analysis; economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; discounting; *H132.*

Economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; *NBSIR 79-1948.*

Economic analysis; energy conservation; insulation; low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; demonstration; *NBSIR 80-2167.*

Economic analysis; energy conservation; windows; building economics; *19073.*

Economic analysis; enforcement; housing codes; personnel; budgets; *SP586,* pp. 135-148 (June 1980).

Economic analysis; engineering economics; housing; mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; building economics; cost estimation; *BSS129.*

Economic analysis; engineering economics; mathematical models; program planning; building economics; construction; cost estimation; econometric models; *NBS-GCR-80-197.*

Economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; renovation; applied economics; building codes; building economics; *NBSIR 79-1902.*

Economic analysis; fire safety; health care facilities; hospitals; life safety; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; *NBSIR 79-1929.*

Economic analysis; furnaces; incremental savings; life-cycle costs; minimum efficiency levels; minimum efficiency standards; boilers; central heating equipment; *NBSIR 80-2079.*

Economic analysis; housing; lead-based paint; lead poisoning; applied economics; building economics; building materials; *NBSIR 80-1977.*

Economic analysis; incremental savings; life-cycle costs; minimum efficiency standards; minimum energy-efficiency levels; central air conditioners; *NBSIR 80-1993.*

Economic analysis; inflation; life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; buildings; building systems standard; cost; discounting; *NBSIR 80-2040.*

Economic analysis; life cycle cost; value management; value study; *SP586,* pp. 189-196 (June 1980).

Economic efficiency; energy conservation; incentives; life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; discounting; economic analysis; *H132.*

Economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; economic analysis; *NBSIR 79-1948.*

Economic feasibility; economic optimization; solar energy systems; active solar energy; break-even analysis; building economics; commercial buildings; *19350.*

Economic optimization; solar energy systems; active solar energy; break-even analysis; building economics; commercial buildings; economic feasibility; *19350.*

Economics; energy conservation; internal rate of return; life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating; building envelope; cost effectiveness; *19235.*

Economics; energy conservation; life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; building design; construction economics; discounting; *SP544.*

Economics; evaluation; literature search; regulation; standardization; standards; benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; *NBSIR 80-2015.*

Economics; government policy; product certification; standardization research needs; standards; accreditation of testing laboratories; certification; certification industry; *NBSIR 80-2001.*

Economics; rehabilitation; building codes; building regulations; building technology; *19160.*

Editing; networks; specifications standards; systems analysis/engineering; codes; decision theory; *NBS-GCR-80-259.*

Educational requirements; inspection; licensing; testing; training code officials; building codes; building inspectors; code enforcement; course development; *SP586,* pp. 71-83 (June 1980).

Effective U-value; heat capacity; log home; mass factor; thermal mass; ΔR effect; BLAST; *SP586,* pp. 161-179 (June 1980).

Effect of moisture on heat transmission; moisture within wood-frame cavity walls; condensation in walls; *19147.*

Efficiency; flow rate; heat transfer fluid; solar collector; thermal performance; *NBS-GCR-79-184.*

Elderly; fire safety; handicapped occupants; health care facilities; nursing homes; user needs; building codes; building evaluation; *NBSIR 79-1906.*

Electrical codes; fire safety; glowing electrical connections; house wiring; innovative electrical connections; performance testing; contact resistance; *BSS128.*

Elevated temperature; heat transfer; liquid flow rate; solar-heat transfer liquid containment; stagnation; corrosion; *NBSIR 79-1919.*

Employee casualties; environmental hazards; human factors; occupational safety; scaffold failures; scaffolds; accidents; accident statistics; construction regulations; construction safety; *NBSIR 79-1955.*

Energy; energy conservation; process efficiency; Second Law of Thermodynamics; system efficiency; availability analysis; *TN1115.*

Energy; field survey; insulation; moisture content; residences; retrofit; thermal resistivity; conservation; *TN1131.*

Energy; heat transfer; hot water; measurement; modeling; solar; testing; computer; *19375.*

Energy; heat transfer; hot water; measurement; modeling; solar; testing; computer; *19459.*

Energy; heat transfer; hot water; measurement; modeling; solar; testing; computer; *19498.*

Energy; insulation; temperature reduction; usage patterns; water heaters; *19140.*

Energy analysis; energy conservation; calculation procedures; computer simulation; *NBSIR 80-2068.*

Energy analysis calculation; energy retrofit; home audit; thermal time constant; *NBSIR 80-1961.*

Energy budget; energy conservation; energy performance criteria; illumination; lighting; power budget; building illumination systems; *NBSIR 80-2052.*

Energy conservation; calculation procedures; computer simulation; energy analysis; *NBSIR 80-2068.*

F

G

H

I

cost analysis; building economics; commercial buildings; *BSS125.*

Investment problems; life-cycle costing; buildings; cost-effective; energy conservation; *19102.*

K

Key words; publications; abstracts; Center for Building Technology; *SP457-4.*

L

Landslides; liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; *SP592.*

Latent heat storage; pebble-bed; phase-change unit; solar energy storage; thermal storage device; ASHRAE standard 94-77; Glauber's salt; *19175.*

Lead-based paint; lead poisoning; applied economics; building economics; building materials; economic analysis; housing; *NBSIR 80-1977.*

Lead chromate pigments; storm water runoff; toxicity; water pollution; air pollution; chromate ore; environmental effects; *NBSIR 80-1974.*

Lead poisoning; applied economics; building economics; building materials; economic analysis; housing; lead-based paint; *NBSIR 80-1977.*

Legal basis; liability; regulation; regulatory impacts; technology; building codes; building laws and regulations; code development; court decisions; *NBS-GCR-80-286.*

Legislation; recertification; architects; codes; earthquake; engineers; Florida; inspection; *SP586,* pp. 197-203 (June 1980).

Liability; regulation; regulatory impacts; technology; building codes; building laws and regulations; code development; court decisions; legal basis; *NBS-GCR-80-286.*

Licensing; testing; training code officials; building codes; building inspectors; code enforcement; course development; educational requirements; inspection; *SP586,* pp. 71-83 (June 1980).

Life-cycle cost; payback; rate-of-return; savings-to-investment ratio; benefit-cost; building design; construction economics; discounting; economics; energy conservation; *SP544.*

Life-cycle cost; payback; rate of return; solar economics; windows; benefit cost; building economics; discounting; economic analysis; economic efficiency; energy conservation; incentives; *H132.*

Life-cycle cost; present worth analysis; recommended practice; benefit-cost analysis; building economics; buildings; building systems standard; cost; discounting; economic analysis; inflation; *NBSIR 80-2040.*

Life cycle cost; value management; value study; economic analysis; *SP586,* pp. 189-196 (June 1980).

Life-cycle cost analysis; passive solar energy; retrofit; revitalization; solar energy systems; benefit-cost analysis; building economics; commercial buildings; investment analysis; *BSS125.*

Life-cycle costing; buildings; cost-effective; energy conservation; investment problems; *19102.*

Life-cycle costing; marginal analysis; optimal design; residential buildings; space cooling; space heating; building envelope; cost effectiveness; economics; energy conservation; internal rate of return; *19235.*

Life-cycle costing; solar energy; energy conservation; federal buildings; *19067.*

Life-cycle costs; low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; *NBSIR 79-1948.*

Life-cycle costs; minimum efficiency levels; minimum efficiency standards; boilers; central heating equipment; economic analysis; furnaces; incremental savings; *NBSIR 80-2079.*

Life-cycle costs; minimum efficiency standards; minimum energy-efficiency levels; central air conditioners; economic analysis; incremental savings; *NBSIR 80-1993.*

Life safety; mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; economic analysis; fire safety; health care facilities; hospitals; *NBSIR 79-1929.*

Life safety; mathematical programming; nursing homes; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; *NBSIR 79-1902.*

Life testing; prediction; recommended practice; reliability service life; accelerated aging tests; building components; building materials; durability; *TN1120.*

Lighting; lighting design; lighting education; lighting research; post-occupancy evaluation; power budget; task lighting; visual performance; biological effects of lighting; energy conservation; illumination levels; *SP587.*

Lighting; power budget; building illumination systems; energy budget; energy conservation; energy performance criteria; illumination; *NBSIR 80-2052.*

Lighting; suprathreshold seeing; visibility; vision; conspicuity; contrast; energy conservation; illumination; illumination levels; *NBSIR 79-1925.*

Lighting design; lighting education; lighting research; post-occupancy evaluation; power budget; task lighting; visual performance; biological effects of lighting; energy conservation; illumination levels; lighting; *SP587.*

Lighting education; lighting research; post-occupancy evaluation; power budget; task lighting; visual performance; biological effects of lighting; energy conservation; illumination levels; lighting; lighting design; *SP587.*

Lighting research; post-occupancy evaluation; power budget; task lighting; visual performance; biological effects of lighting; energy conservation; illumination levels; lighting; lighting design; lighting education; *SP587.*

Limit states; loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); *SP577.*

Liquefaction; power plants; railroads; rock slides; seismicity; structural engineering; bridges; buildings; dikes; earthquakes; foreign engineering; geology; highways; housing; landslides; *SP592.*

Liquid flow rate; solar-heat transfer liquid containment; stagnation; corrosion; elevated temperature; heat transfer; *NBSIR 79-1919.*

Literature search; regulation; standardization; standards; benefit-cost analysis; benefit-risk analysis; benefits; bibliography; costs; economics; evaluation; *NBSIR 80-2015.*

Load; roof; roof load; snow; solar collector; structural engineering; building; ice; *NBS-GCR-79-180.*

Loads; maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; design; *NBSIR 79-1937.*

Loads (forces); masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; *SP577.*

Local government; political appointments; survey of local building departments; building departments; building inspection; code administration; Indiana building code enforcement; *SP586,* pp. 33-42 (June 1980).

Log home; mass factor; thermal mass; ΔR effect; BLAST; effective U-value; heat capacity; *SP586,* pp. 161-179 (June 1980).

Loss prevention; risk; safety; accidents; fault trees; *19320.*

Low-income housing; marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; *NBSIR 79-1948.*

Low-income housing; statistics; unit costs; weatherization; building economics; cost components; data analysis; data collection; demonstration; economic analysis; energy conservation; insulation; *NBSIR 80-2167.*

Low-sloped roofs; roofing performance; solar collectors; collector installation; field survey; guidelines; *TN1134.*

Low temperature collectors; manufacturing activity; medium temperature collector; solar energy; special collectors; energy estimates; geographical distribution; *19527.*

Lumber grading; shoring; softwood; timber engineering; trench bracing; trenching; construction lumber; construction safety; excavation; hardwood; *BSS122.*

M

Maintenance; occupational hazards; scaffolds; stiffness; strength; structural safety; work surfaces; codes and standards; construction safety; design; loads; *NBSIR 79-1937.*

Management theory; managers; organizational development; organization culture; strategic model; theories of behavior; *19844.*

Managers; organizational development; organization culture; strategic model; theories of behavior; management theory; *19844.*

Man/environment research; post-occupancy evaluation; questionnaire; user needs; building evaluation; design process; *NBSIR 79-1780.*

Manufacturing activity; medium temperature collector; solar energy; special collectors; energy estimates; geographical distribution; low temperature collectors; *19527.*

Marginal analysis; optimal design; residential buildings; space cooling; space heating; building envelope; cost effectiveness; economics; energy conservation; internal rate of return; life-cycle costing; *19235.*

Marginal analysis; thermal efficiency; weatherization; benefit-cost analysis; building economics; building envelope; economic analysis; economic efficiency; energy conservation; insulation; life-cycle costs; low-income housing; *NBSIR 79-1948.*

Masonry; probability theory; reliability; safety; specifications; standards; statistical analysis; steel; structural engineering; timber; aluminum; buildings (codes); concrete (prestressed); concrete (reinforced); design (buildings); limit states; loads (forces); *SP577.*

Mass factor; thermal mass; ΔR effect; BLAST; effective U-value; heat capacity; log home; *SP586,* pp. 161-179 (June 1980).

Materials; polymeric materials; solar collectors; absorber materials; absorptive coatings; accelerated aging; cover plates; durability; environmental exposure; *19364.*

Materials degradation; solar collector; durability/reliability; environmental degradation; *19451.*

Mathematical modeling; tricalcium silicate; cement; hydration; *19079.*

Mathematical models; program planning; building economics; construction; cost estimation; econometric models; economic analysis; engineering economics; *NBS-GCR-80-197.*

Mathematical programming; nursing homes; optimization; renovation; applied economics; building codes; economic analysis; fire safety; health care facilities; hospitals; life safety; *NBSIR 79-1929.*

Mathematical programming; nursing homes; renovation; applied economics; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; life safety; *NBSIR 79-1902.*

Mathematical programming; optimization; rehabilitation; renovation; applied economics; building codes; building economics; cost estimation; economic analysis; engineering economics; housing; *BSS129.*

Measurement; color; colorimetry; fluorescent; fluorescent specimens; *NBS-GCR-79-185.*

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19375.*

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19459.*

Measurement; modeling; solar; testing; computer; energy; heat transfer; hot water; *19498.*

Measurements; radiation; radon; radon daughters; ventilation; buildings; environment; health; *SP581.*

Measurement technology; moisture accumulation; nondestructive tests; thermal resistance; built-up roofs; *NBSIR 80-2100.*

Medium temperature collector; solar energy; special collectors; energy estimates; geographical distribution; low temperature collectors; manufacturing activity; *19527.*

Metering; rate structures; water conservation; consumer education; energy conservation; feedback; incentives; *NBSIR 80-2119.*

Metrication; metric transition; building codes; conversion strategies; harmonization; *SP586,* pp. 227-251 (June 1980).

Metrication; regulatory coordination; standardization and international harmonization; building codes; building standards; dimensional coordination; *19518.*

Metric bibliography; metric conversion timetable; metric decision; metric product sizes; metric system (SI); construction industries; dimensional coordination; *SP598.*

Metric building design; metric building products; modular coordination; building module; controlling dimensions; coordinating sizes; dimensional coordination; *19516.*

Metric building products; modular coordination; building module; controlling dimensions; coordinating sizes; dimensional coordination; metric building design; *19516.*

Metric conversion; preferred dimensions; preferred values; SI units for building; convenient values; *19519.*

Metric conversion timetable; metric decision; metric product sizes; metric system (SI); construction industries; dimensional coordination; metric bibliography; *SP598.*

Metric decision; metric product sizes; metric system (SI); construction industries; dimensional coordination; metric bibliography; metric conversion timetable; *SP598.*

Metric design and construction; modular coordination; standards; building module; dimensional coordination; *SP595.*

Metric familiarization; metric products and non-metric buildings; repair and maintenance; adaptation of building materials; *19520.*

Metric products and non-metric buildings; repair and maintenance; adaptation of building materials; metric familiarization; *19520.*

Metric product sizes; metric system (SI); construction industries; dimensional coordination; metric bibliography; metric conversion timetable; metric decision; *SP598.*

Metric system (SI); construction industries; dimensional coordination; metric bibliography; metric conversion timetable; metric decision; metric product sizes; *SP598.*

Metric transition; building codes; conversion strategies; harmonization; metrication; *SP586,* pp. 227-251 (June 1980).

MIUS; on-site utilities; energy conservation; environmental impact; feasibility study; integrated utilities; *NBSIR 79-1787.*

Microclimatic prediction; pedestrian comfort; wind; wind environment; cool environments; *19106.*

Microcomputers and minicomputers; microprocessor applications; programmable controllers; building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy conservation devices; *NBSIR 80-2065.*

Microprocessor applications; programmable controllers; building automation; building controls; building energy management systems; chiller controls; distributed control systems; energy

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Appendix A. 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, Learning Resource Center (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 and State Law Library (1884).
- Auburn University at Montgomery Library (1971)-REGIONAL.

Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
St. Bernard: St. Bernard College, Herman J. Heidrich 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:
- Supreme Court of Alaska Library (1973).
- University of Alaska, Anchorage Library (1961).

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.
- Grand Canyon College, Fleming Library.
- Phoenix Public Library (1917).

Prescott: Yavapai College Library (1976).
Tempe:
- Arizona State University, Matthews Library (1944).
- Arizona State University, College of Law Library (1977).

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 at Pine Bluff, 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:
- California State University, Dominguez Hills, Educational Resources Center (1973).
- Carson Regional Library (1973).

Chico: Chico State University Library (1962).

Claremont: Pomona College Documents Collection, Honnold Library (1913).

Coalingo: West Hills Community College (1978).

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).

Downey: Downey City Library (1963).

Fresno:
- California State University Library (1962).
- Fresno County Free Library (1920).

Fullerton: California State University, 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 University 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, Delmar T. Oviatt 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, Robert A. 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 University 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 State Polytechnic 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 Library (1972).

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:
- Auraria Libraries (1978).
- Colorado State Library (unknown).
- Denver Public Library (1884)-REGIONAL.
- Department of Interior, Bureau of Reclamation Library (1962).
- Regis College, Dayton Memorial Library (1915).
- Supreme Court Library (1978).
- 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).
Grand Junction: Mesa County Public Library (1975).
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, Learning Resources Center (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:
- Post College, Traurig Library (1977).
- 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).
Wilmington:
- Delaware Law School Library (1976).
- New Castle County Law Library (1974).
- Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

Washington:
- Administrative Conference of U.S. Library (1977).
- Advisory Commission on Intergovernmental Relations Library (1972).
- 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).
- Library of Congress, Gift and Exchange Division (1977).
- National Defense University 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).
- Research Library, Board of Governors of the Federal Reserve System (1978).
- Treasury Department Library (1895).
- U.S. Court of Appeals, Judge's Library (1975).
- U.S. Supreme Court Library (1978).
- Veterans' Administration, Central Office Library (1976).

FLORIDA

Boca Raton: Florida Atlantic University Library (1963).
Clearwater: Clearwater Public Library (1972).
Coral Gables: University of Miami Library (1939).
Crestview: Robert F. L. Sikes Public Library (1978).
Daytona Beach: Volusia County Public Libraries (1963).
DeLand: Stetson University, duPont-Ball Library (1887).
Fort Lauderdale:
- Broward County Library System (1967).
- Nova University Law Library (1967).

Fort Pierce: Indian River Community College Library (1975).
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).

North Miami: Florida International University, North Miami Campus Library (1977).
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: County Library System (1973).
St. Petersburg:
St. Petersburg Public Library (1965).
Stetson University College Law Library (1975).
Sarasota: Selby Public Library (1970).
Tallahassee:
Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
Florida State University, R. M. Stozier Library (1941). (1941).
Florida Supreme Court Library (1974).
State Library of Florida (1929).
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)-REGIONAL.
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-Glyn County Regional Library (1965).
Carrollton: West Georgia College, Sanford Library (1962).
Columbus: Columbus College, Simon Schwob Memorial Library (1975).
Dahlonega: North Georgia College Library (1939).
Dalton: Dalton Junior College Library (1978).
Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).
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 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:
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)-REGIONAL.
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 University 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 Memorial 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).
Mt. Prospect: Mt. Prospect Public Library (1977).
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, Walter E. Helmke 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).
State Library Commission of Iowa (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 University, 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: Emporia State University, 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: Pittsburg State University, 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 University, W. Frank Steely 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).
- 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).
- University of New Orleans Library (1963).

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 (1882).
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).
Bethesda: National Library of Medicine Library (1978).
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, Godell 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).
- Middlesex County Law Library (1978).

Chicopee: Our Lady of the Elms College Library (1969).
Lowell: University of Lowell/North Campus, Alumni/Lydon 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 (1973).
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:
Flint Public Library (1967).
University of Michigan, Flint Library (1959).
Grand Rapids:
Calvin College Library (1967).
Grand Rapids Public Library (1876).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson District 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 University, A. C. Clark Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State University 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 University 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 University 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)
Clinton: Mississippi College School of Law Library (1977).
Columbus: Mississippi State University 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 University, 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:
Maryville College Library (1976).
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).
- State Law Library of Montana (1977).

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)–JOINT REGIONAL.

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 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 Brunswick: East Brunswick Public Library (1977).
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 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 Center 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).
Cheektowago: Cheektowago Public Library (1978).
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).
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 Sojourner Truth 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).
- U.S. Court of Appeals Library (1976).

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 Library (1901).
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).
Uniondale: Nassau Library System (1965).
Utica:
- Utica Public Library (1885).
- Utica/Rome State University College Library (1977).

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 Louis Round Wilson 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, Mary Livermore 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:
North Dakota State Law Library (unknown).
State Historical Society of North Dakota (1907).
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).
Ohio State Library (unknown)-REGIONAL.
Ohio State University, William Oxley Thompson Memorial Library (1907).
Ohio Supreme Court Law Library (1973).
The Public Library of Columbus and Franklin County (1885).
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, Gordon Keith Chalmers Memorial Library (1873).
Granville: Denison University, William Howard Doane 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, Leon A. Beeghly Library (1964).
Toledo:
Toledo-Lucas County Public Library (1884).
University of Toledo Library (1965).
Westerville: Otterbein College (1967).
Wooster: College of Wooster, the Andrews Library (1966).
Youngstown:
Public Library of Youngstown and Mahoning County (1923).
Youngstown State University, William F. Maag Library (1971).

OKLAHOMA

Ada: East Central Oklahoma State University, Linscheid Library (1914).
Alva: Northwestern Oklahoma State University Library (1907).
Bartlesville: United States ERDA-BERC Library (1962).
Bethany: Bethany Nazarene College, R. T. Williams Library (1971).
Durant: Southeastern Oklahoma State University 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 Oklahoma State University, John Vaughan Library (1923).
Tulsa:
Tulsa City-County Library Commission (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 Energy, 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).
Allegheny: Alleghany County Law Library (1977).
Altoona: Altoona Public Library (1969).
Bethlehem: Lehigh University, Linderman Library (1876).
Blue Bell: Montgomery County Community College, Learning Resources Center (1975).
Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College, Myrin Library (1963).
Coraopolis: Robert Morris College Library (1978).
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).
- Thomas Jefferson University, Scott Memorial Library (1978).
- 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, D. Leonard 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).
Woonsocket: Woonsocket Harris Public Library (1977).

SOUTH CAROLINA

Charleston:
- Baptist College at Charleston Library (1967).
- College of Charleston, Robert Scott Small Library (1869).
- The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).
Columbia:
- Benedict College, Learning Resources Center (1969).
- Richland County Public Library (1978).
- 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, Hilton M. Briggs 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 (1908).
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).
Vanderbilt University Law Library (1976).
Sewanee: University of the South, Jesse Ball duPont Library (1973).

TEXAS

Abilene: Hardin-Simmons University, Rupert and Pauline Richardson 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 University, 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, Steen 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 Campus 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:
- University of Utah, Spencer S. Eccles Medical Sciences Library (1970).
- University of Utah, Law Library (1966).
- University of Utah, Marriott Library (1893).
- Utah State Library Commission, Documents Library (unknown).
- Utah State Supreme Court Law Library (1975).

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): Florence Augusta Stephens Williams 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 University, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Hampton: Hampton Institute, Huntington Memorial Library (1977).
Harrisonburg: James Madison University, 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 University Library (1962).
Everett: Everett Public Library (1914).
Olympia:
- Evergreen State College (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).
Charleston:
Kanawha County Public Library (1952).
West Virginia College Graduate Studies (1977).
West Virginia Library Commission (unknown).
West Virginia Supreme Court Law Library (1977).
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 Law 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).
Platteville: 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 Law Library (1977).
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. District 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**—Blaine D. Porter, Director, 701 C Street, P.O. Box 32, 99513, Area Code 907 Tel 271-5041, FTS Dial 8 399-0150, Ask for 271-5041

ARIZONA

Phoenix—Donald W. Fry, Director, Suite 2950 Valley Bank Center, 201 North Central Avenue 85073, Area Code 602 Tel 261-3285, FTS 261-3285

ARKANSAS

Little Rock—Robert E. Kistler, Director, Suite 635, Savers Federal Building, 320 W. Capitol Avenue, 72201, Area Code 501 Tel 378-5794, FTS 740-5794

•**Jonesboro**—P.O. Box 2525, ASU State University, Arkansas 72467, Area Code 501 Tel 792-4760, FTS 277-4760

CALIFORNIA

Los Angeles—Paul W. Leinenbach, Director, Room 800, 11777 San Vicente Boulevard 90049, Area Code 213 Tel 824-7591, FTS 799-7591

•**San Diego**—110 West C Street, 92101, Area Code 714 Tel 293-5395

San Francisco—Betty D. Neuhart Director, Federal Building, Box 36013, 450 Golden Gate Avenue 94102, Area Code 415 Tel 556-5860, FTS 556-5868

COLORADO

••**Denver**—Donald L. Schilke, Director, Room 177, U.S. Customhouse, 721-19th Street, 80202, Area Code 303 Tel 837-3246, FTS 327-3246

CONNECTICUT

Hartford—Richard C. Kilbourn, Director, Room 610-B, Federal Office Building, 450 Main Street 06103, Area Code 203 Tel 244-3530, FTS 244-3530

FLORIDA

Miami—Ivan A. Cosimi, Director, Room 821, City National Bank Building, 25 West Flagler Street 33130, Area Code 305 Tel 350-5267, FTS 350-5267

•**Clearwater**—128 North Osceola Avenue 33515, Area Code 813 Tel 461-0011

•**Jacksonville**—815 S. Maine Street, Suite 100, 32207, Area Code 904 Tel 791-2796, FTS 946-2796

•**Tallahassee**—Collins Bldg., Rm. G-20 32304, Area Code 904 Tel 488-6469, FTS 946-4320

GEORGIA

••**Atlanta**—Daniel M. Paul, Director, Suite 600, 1365 Peachtree Street, N.E. 30309, Area Code 404 Tel 881-7000, FTS 257-7000

••**Savannah**—James W. McIntire, Director, 222 U.S. Courthouse & P.Om Box 9746, 125-29 Bull Street, 31412, Area Code 912 Tel 944-4204, FTS 248-4204

HAWAII

Honolulu—H. Tucker Gratz, Director, 4106 Federal Building, P.O. Box 50026, 300 Ala Moana Boulevard 96850, Area Code 808 Tel 546-8694, FTS Dial 8, 556-0220, Ask for 546-8694

ILLINOIS

Chicago—Gerald M. Marks, Director, 1406 Mid Continental Plaza Building, 55 East Monroe Street 60603, Area Code 312 Tel 353-4450, FTS 353-4450

•**Commerce Business Daily** Room 1304, 433 West Van Buren Street 60607, Area Code 312 Tel 353-2950

INDIANA

Indianapolis—Mel R. Sherar, Director, 357 U.S. Courthouse & Federal Office Building, 46 East Ohio Street 46204. Area Code 317 Tel 269-6214, FTS 331-6214

IOWA

Des Moines—Jesse N. Durden, Director, 817 Federal Building, 210 Walnut Street 50309, Area Code 515 Tel 284-4222, FTS 862-4222

KENTUCKY

Louisville—Donald R. Henderson, Director, Room 636B, U.S. Post Office and Court House Building 40202, Area Code 502 Tel 582-5066, FTS 352-5066

LOUISIANA

New Orleans—Raymond E. Eveland, Director, 432 International Trade Mart, No. 2 Canal Street 70130, Area Code 504 Tel 589-6546, FTS 682-6546

MAINE

•**Augusta (Boston, Massachusetts District)**—1 Memorial Circle, Casco Bank Bldg., Area Code 207 Tel 623-2239, FTS 833-6249

MARYLAND

Baltimore—Carroll F. Hopkins, Director, 415 U.S. Customhouse, Gay and Lombard Streets 21202, Area Code 301 Tel 962-3560, FTS 922-3560

MASSACHUSETTS

Boston—Francis J. O'Connor, Director 10th Floor, 441 Stuart Street 02116, Area Code 617 Tel 223-2312, FTS 223-2312

MICHIGAN

Detroit—Raymond R. Riesgo, Director, 445 Federal Building, 231 West Layfayette 48226, Area Code 313 Tel 226-3650, FTS 226-3650

•**Grand Rapids**—350 Ottawa Street N.W. 49503 Area Code 616 Tel 456-2411/33 FTS 372-2411

MINNESOTA

Minneapolis—Glenn A. Matson, Director, 218 Federal Building, 110 South Fourth Street 55401, Area Code 612 Tel 725-2133, FTS 725-2133

MISSISSIPPI

••**Jackson**—Mark E. Spinney, Director, City Center Plaza, Suite 550, 200 East Pascagoula 39201, Area Code 601 Tel 960-4388, FTS 490-4388

MISSOURI

St. Louis—Donald R. Loso, Director, 120 South Central Avenue 63105, Area Code 314 Tel 425-3302-4, FTS 279-3302

Kansas City—James D. Cook, Director, Room 1840, 601 East 12th Street 64106, Area Code 816 Tel 374-3142, FTS 758-3142

NEBRASKA

••**Omaha**—George H. Payne, Director, Empire State Bldg., 1st Floor, 300 South 19th Street, 68102, Area Code 402 Tel 221-3664, FTS 864-3664

NEVADA

Reno—Joseph J. Jeremy, Director, 777 W. 2nd Street, Room 120, 89503, Area Code 702 Tel 784-5203, FTS 470-5203

NEW JERSEY

Newark—Thomas J. Murray, Director, 4th Floor, Gateway Building, Market Street & Penn Plaza 07102, Area Code 201 Tel 645-6214, FTS 341-6214

NEW MEXICO

Albuquerque—William E. Dwyer, Director, 505 Marquette Ave., NW, Suite 1015, 87102, Area Code 505 Tel 766-2386, FTS 474-2386

NEW YORK

Buffalo—Robert F. Magee, Director, 1312 Federal Building, 111 West Huron Street 14202, Area Code 716 Tel 846-4191, FTS 437-4191

••**New York**—Arthur C. Rutzen, Director, Room 3718, Federal Office Building, 26 Federal Plaza, Foley Square 10278, Area Code 212 Tel 264-0634, FTS 264-0600

NORTH CAROLINA

Greensboro—Joel B. New, Director, 203 Federal Building, West Market Street, P.O. Box 1950 27402, Area Code 919 Tel 378-5345, FTS 699-5345

OHIO

Cincinnati—Gordon B. Thomas, Director, 10504 Federal Office Building, 550 Main Street 45202, Area Code 513 Tel 684-2944, FTS 684-2944

Cleveland—Zelda W. Milner, Director, Room 600, 666 Euclid Avenue 44114, Area Code 216 Tel 522-4750, FTS 293-4750

OKLAHOMA

•**Oklahoma City (Dallas, Texas District)**—4024 Lincoln Boulevard 73105, Area Code 405 Tel 231-5302, FTS 736-5302

OREGON

Portland—Lloyd R. Porter, Director, Room 618, 1220 S.W. 3rd Avenue 97204, Area Code 503 Tel 221-3001, FTS 423-3001

PENNSYLVANIA

Philadelphia—Patrick P. McCabe, Director, 9448 Federal Building, 600 Arch Street 19106 Area Code 215 Tel 597-2866

Pittsburgh—William M. Bradley, Director, 2002 Federal Building, 1000 Liberty Avenue 15222, Area Code 412 Tel 644-2850, FTS 722-2850

PUERTO RICO

San Juan (Hato Rey)—J. Enrique Vilella, Director, Room 659-Federal Building 00918, Area Code 809 Tel 753-4555, Ext. 555, FTS Dial 9 472-6620, Ask for 753-4555

RHODE ISLAND

•**Providence (Boston, Massachusetts District)**—7 Jackson Walkway 02903, Area Code 401 Tel 277-2605, ext. 22, FTS 838-4482

SOUTH CAROLINA

••**Columbia**—Margaret A. Patrick Director, Strom Thurmond Fed. Bldg., Suite 172, 1835 Assembly Street 29201 Area Code 803 Tel 765-5345 FTS 677-5345

•**Charleston**—505 Federal Building, 334 Meeting Street 29403, Area Code 803 Tel 677-4361, FTS677-4361

•**Greenville**—P.O. Box 10048, 29603, Area Code 803 235-5919

TENNESSEE

Memphis—Bradford H. Rice, Director, Room 710, 147 Jefferson Avenue 38103, Area Code 901 Tel 521-3213, FTS 222-3213

•**Nashville**—Room 1020, Andrew Jackson Office Building 37219, Area Code 615 Tel 251-5161 FTS 852-5161

TEXAS

Dallas—C. Carmon Stiles, Director, Room 7A5, 1100 Commerce Street 75242 Area Code 214 Tel 767-0542, FTS 729-0542

Houston—Felicito C. Guerrero, Director, 2625 Federal Bldg., Courthouse, 515 Rusk Street 77002, Area Code 713 Tel 226-4231, FTS 527-4231

UTAH

••**Salt Lake City**—Stephen P. Smoot, Director, U.S. Courthouse, 350 S. Main Street 84101, Area Code 801 Tel 524-5116, FTS 588-5116

VIRGINIA

Richmond—Philip A. Ouzts, Director, 8010 Federal Bldg., 400 North 8th Street, 23240, Area Code 804 Tel 771-2246, FTS 925-2246

•**Fairfax**—8550 Arlington Blvd., 22031, Area Code 703 Tel 560-6460, FTS 235-1519

WASHINGTON

••**Seattle**—Eric C. Silberstein, Director, Room 706, Lake Union Building, 1700 Westlake Avenue North 98109, Area Code 206 Tel 442-5616, FTS 399-5615, FOMC 399-5910/11

WEST VIRGINIA

Charleston—Roger L. Fortner, Director, 3000 New Federal Building, 500 Quarrier Street 25301, Area Code 304 Tel 343-6181, ext. 375, FTS 924-1375

WISCONSIN

Milwaukee—Russell H. Leitch, Director, Federal Bldg/U.S. Courthouse, 517 East Wisconsin Avenue 53202, Area Code 414 Tel 291-3473, FTS 362-3473

WYOMING

Cheyenne—Lowell O. Burns, Director, 6022 O'Mahoney Federal Center, 2120 Capitol Avenue 82001, Area Code 307 Tel 778-2220, ext. 2151, FTS 328-2151

•DENOTES TRADE SPECIALIST
••DENOTES CHANGE.

Appendix C.
CBT Publication Order Numbers and Price List

The National Bureau of Standards, Center for Building Technology (CBT) publications are available from the Government Printing Office, (GPO) or the National Technical Information Service (NTIS). The following table lists the CBT publication numbers, the SD Catalog No. (if available from GPO) or the Order No. (if available from NTIS,) and the most recent price of each document. Page iv provides complete instructions on how to obtain publications.

BUILDING SCIENCE SERIES

	Government Printing Office		National Technical Information Service			Government Printing Office		National Technical Information Service	
Publication Number	SD Catalog No.	Price	Order No.	Price	Publication Number	SD Catalog No.	Price	Order No.	Price
121	SN 003-003-02162-8	$3.75			126	SN 003-003-02228-4	$4.50		
122	SN 003-003-02164-4	$6.00			127	SN 003-003-02195-4	$3.75		
123	SN 003-003-02168-7	$3.50			128	SN 003-003-02269-1	$4.00		
124	SN 003-003-02177-6	$3.25			129	SN 003-003-02270-5	$4.50		
125	SN 003-003-02203-9	$4.75							

TECHNICAL NOTES

1113-1	SN 003-003-02169-5	$8.00			1123	SN 003-003-02245-4	$4.25		
1113-2	SN 003-003-02235-7	$6.00			1131	SN 003-003-02243-8	$3.75		
1115	SN 003-003-02231-4	$3.25			1132	SN 003-003-02277-2	$5.50		
1118	SN 003-003-02191-1	$3.50			1134	SN 003-003-02261-6	$4.00		
1120	SN 003-003-02213-6	$2.25							

HANDBOOKS

132	SN 003-003-02192-0	$5.00							

SPECIAL PUBLICATIONS

446-3	SN 003-003-02150-4	$ 4.00			577	SN 003-003-02200-4	$ 6.00		
446-4	SN 003-003-02236-5	$ 4.00			581	SN 003-003-02196-2	$ 3.75		
457-4	SN 003-003-02205-5	$ 3.75			586	SN 003-003-02212-8	$ 7.00		
474	SN 003-003-01803-1	$14.00			587	SN 003-003-02218-7	$ 5.50		
544	SN 003-003-02156-3	$ 3.50			592	SN 003-003-02257-8	$ 6.50		
560	SN 003-003-02252-7	$11.00			595	SN 003-003-02254-3	$ 5.50		
575	SN 003-003-02238-1	$ 2.25			598	SN 003-003-02265-4	$ 5.00		

NBS INTERAGENCY REPORTS

	Government Printing Office		National Technical Information Service			Government Printing Office		National Technical Information Service	
Publication Number	SD Catalog No.	Price	Order No.	Price	Publication Number	SD Catalog No.	Price	Order No.	Price
78-1578			PB 80-192883	$12.00	80-1988			PB 80-167497	$ 9.00
79-1780			PB 80-119712	$ 7.00	80-1993			PB 80-209885	$ 7.00
79-1787			PB 80-154719	$11.00	80-2001			PB 80-160716	$ 7.00
79-1793			PB 300986	$ 4.50	80-2002			PB 80-185622	$ 7.00
79-1902			PB 80-120165	$ 9.00	80-2015			PB 80-186034	$ 8.00
79-1906			PB 80-119530	$ 7.00	80-2040			PB 80-203649	$ 8.00
79-1908			PB 80-132038	$ 6.00	80-2052			PB 80-184229	$ 9.00
79-1917			PB 80-129828	$ 6.00	80-2065			PB 80-207848	$ 6.50
79-1919			PB 80-161748	$ 6.00	80-2068			PB 80-219819	$ 7.00
79-1923			PB 80-119928	$ 7.00	80-2076			PB 80-224330	$ 9.00
79-1925			PB 80-199292	$ 6.00	80-2079			PB 80-212749	$ 7.00
79-1929			PB 80-194798	$10.00	80-2087			PB 81-104770	$ 8.00
79-1935			PB 80-130511	$ 9.00	80-2090			PB 80-223142	$ 6.00
79-1936			PB 80-140817	$ 7.00	80-2093			PB 81-131922	$ 8.00
79-1937			PB 80-184369	$ 7.00	80-2100			PB 81-140063	$ 5.50
79-1948			PB 80-162142	$11.00	80-2105			PB 80-226707	$ 6.00
79-1955			PB 80-161466	$ 7.00	80-2111-2			PB 81-111759	$ 9.50
79-1957			PB 80-153968	$ 3.50	80-2111-9			PB 81-111742	$ 7.00
80-1961			PB 80-213986	$10.00	80-2116			PB 81-106312	$11.00
80-1964			PB 80-170525	$ 6.00	80-2117			PB 81-128431	$ 9.50
80-1974			PB 80-160666	$ 6.00	80-2119			PB 81-115958	$ 6.00
80-1977			PB 80-162886	$ 8.00	80-2144			PB 81-132268	$12.50
80-1980			PB 80-120173	$ 8.00	80-2161			PB 81-135642	$ 6.50
80-1982			PB 80-169949	$ 9.00	80-2167			PB 81-133829	$ 9.50

GOVERNMENT CONTRACT REPORTS

79-180		PB 80-127053	$ 7.00	80-202		PB 80-192800	$ 8.00
79-184		PB 80-125891	$10.00	80-257		PB 80-221112	$ 7.00
79-185		PB 80-165590	$ 6.00	80-258		PB 80-221120	$11.00
79-189		PB 80-120173	$ 8.00	80-259		PB 80-149073	$11.00
80-197		PB 80-160427	$ 8.00	80-286		PB 81-128845	$23.00

NBS-114A (REV. 2-8C)

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5. AUTHOR(S)

Steve Webber, Editor

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NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

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9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

Same as item 6.

10. SUPPLEMENTARY NOTES

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report presents NBS' Center for Building Technology (CBT) publications for 1980. It is the fifth supplement to NBS Special Publication 457, Building Technology Publications, and lists CBT reports issued during January 1 - December 31, 1980. It includes titles and abstracts of each CBT publication and those papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This publication is divided into three main sections. The first, Titles and Abstracts, provides the report title, author(s), date of publication, selected key words, and an abstract of each NBS publication and each paper published in an outside source. The Author Index cites CBT authors and their publication number which is listed in this supplement. The Key Words Index is a subject index, listing word summaries of the building research topics for each publication and paper. By selecting a main word or subject, the user is able to locate reports of interest through these subject-related words.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

abstracts; building technology; Center for Building Technology; key words; publications.

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