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Introduction

This report presents the National Bureau of Standards' Center for Building Technology (CBT) publications for calendar year 1978. It is the third supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975,* and list all CBT documents issued during the period from January 1, 1978 to December 31, 1978. It includes titles and abstracts of each NBS publication and papers published in non-NBS media; key word and other indexes; and general information and instructions on how to order CBT publications.

This report provides the means of communicating the results of CBT research to its various technical audiences, as well as to the general public. Publications constitute a major end product to CBT's efforts and, in 1978, appeared in several NBS publications series (Building Science Series, Technical Notes, Special Publications, Handbooks and NBS Interagency Reports) as well as non—NBS published media such as the technical and trade publications. NBS publication abbreviations are:

BSS - Building Science Series

TN - Technical Note

SP - Special Publication

H - Handbook

NBSIR - National Bureau of Standards Interagency Report

GCR - Government Contract Report

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

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

Obtaining Publications

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

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

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

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

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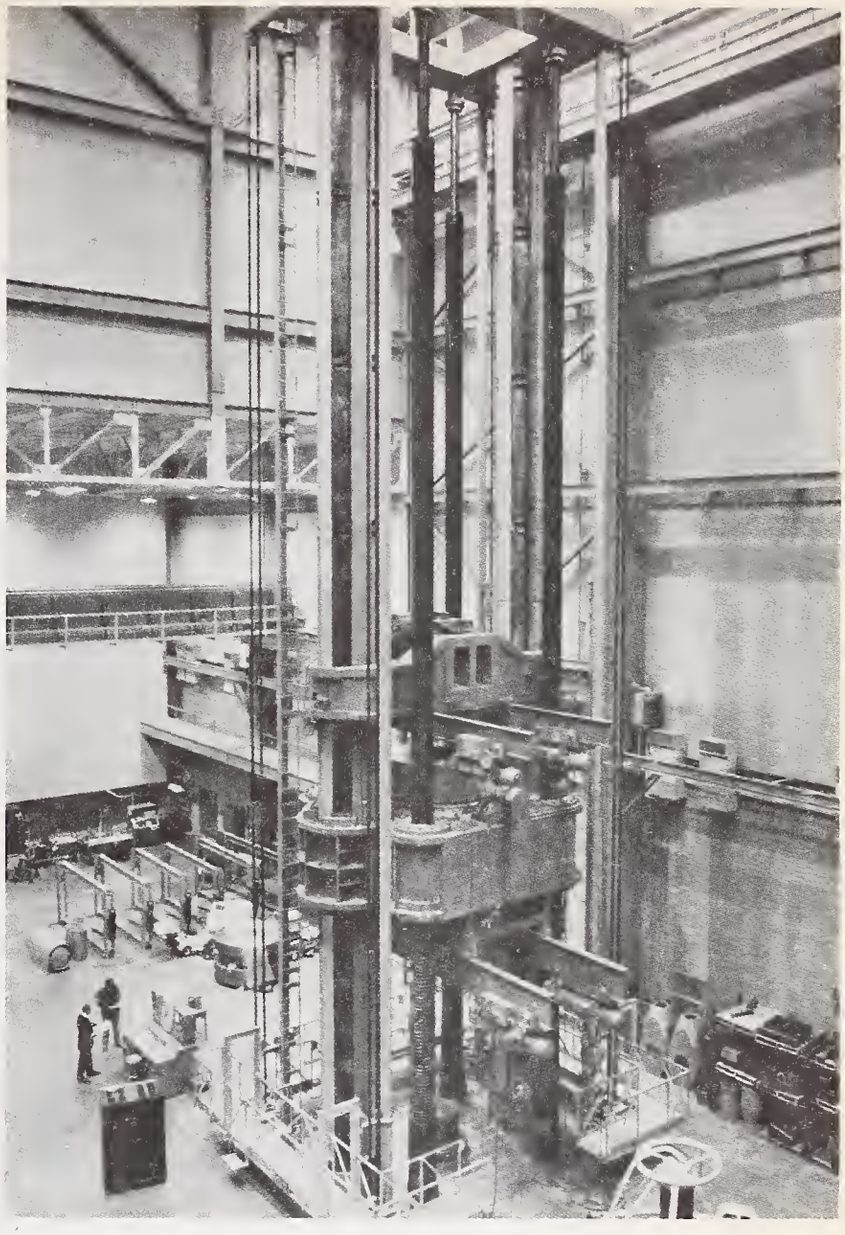
Titles and Abstracts



BUILDING SCIENCE SERIES

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

BSS84. **Design Guide for reducing transportation noise in and around buildings,** D. S. Pallett, R. Wehrli, R. D. Kilmer, and T. L. Quindry, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 84*, 176 pages (Apr. 1978) SN003-003-01687-0.

Key words: acoustics; architectural acoustics; building acoustics; environmental noise; noise; noise control; sound; transportation system noise.

This design guide presents a unified procedure for the selection of noise criteria in and around buildings, for the prediction of exterior and interior noise levels arising as a consequence of transportation systems operations, and for the evaluation of the adequacy of building designs with regard to environmental noise. Noise criteria levels are suggested in terms of equivalent sound levels (Leq). Simplified predictive methods enable the estimation of noise levels arising as a consequence of highway, railway, and aircraft operations. The sound isolation provided by the building shell is estimated by means of a new single-figure rating system. Finally, design manipulations which may make possible the improvement of the acoustic conditions in and around buildings are suggested.

BSS102. **The thermal performance of a two-bedroom mobile home,** G. J. Tietsma and B. A. Peavy, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 102*, 59 pages (Feb. 1978) SN003-003-01863-5.

Key words: air infiltration; energy conservation; mobile home; part-load efficiency; thermography.

Tests were conducted on a mobile home located in an Environmental Climatical Laboratory for the purpose of evaluating its thermal performance. The heating demand greatly affected the part-load efficiency of a gas-fired, forced-air, sealed-combustion furnace system. The practice of installing oversized heating plants was shown to result in low seasonal operating efficiencies. Air leakage measurements were performed using a pressurization technique to quantify the amount of air leakage through the various parts of the mobile home. Separate air infiltration tests using the SF_6 tracer-gas technique showed that somewhat higher air infiltration rates were induced by operation of the mobile home heating plant. A thermographic survey of interior surfaces showed that the technique used to install the wall insulation may allow wrinkles formed in the surface of the insulation to form air paths running the height of the wall cavity. Convective air flow through these paths may create heat leaks on the building surface which can have an impact on the overall heat-loss rate. Separate tests were also conducted to identify places in the mobile home envelope having high condensation potential.

BSS105. **Retrofitting an existing wood-frame residence for energy conservation—An experimental study,** D. M. Burch and C. M. Hunt, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 105*, Supersedes NBSIR 77-1274, 82 pages (July 1978) SN003-003-01885-6.

Key words: air infiltration; condensation in buildings; energy conservation; energy measurements; fuel savings; heat-loss reduction; insulation properties; residential heat loss; retrofitting houses; thermal conductivity; thermal insulation; thermography.

A wood-frame residence having only limited insulation in the attic was retrofitted in three stages to reduce its energy requirements for heating and cooling. The three retrofit stages comprised: reducing air leaks; adding storm windows; and installing insulation in the floor, ceiling, and walls. The house was extensively instrumented to evaluate energy savings and other performance factors. An economic model was used to evaluate the cost effectiveness of the retrofit options and the number of years to pay back their initial investment.

The walls of the test house were insulated with three different types of insulating material: fibrous glass wool, cellulosic fiber, and urea-formaldehyde foam. The thermal performance of those three insulating materials was measured and compared, both in the field and laboratory.

"Recommended good practices" for moisture protection were applied when insulation was installed in the test house. The effectiveness of these measures in preventing damaging moisture accumulation in crawl spaces and attics was evaluated.

Finally, thermographic surveys were performed before and after the retrofit. Based on the results of these surveys, criteria for distinguishing between insulated and uninsulated wood-frame cavity walls were presented.

BSS108. **Safety on stairs,** D. H. Carson, J. C. Archea, S. T. Margulis, and F. E. Carson, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 108,* 122 pages (Nov. 1978) SN003-003-02026-5.

Key words: accidents; architectural psychology; consumer products; environmental factors; home safety; occupant behavior; survey technique.

Stairways are commonplace in U.S. homes. Stairway design and construction standards are based on custom, common sense, and experience. Stairways, however, are hazardous. A large number of stairway accidents have been reported, raising questions about the adequacy of stairway design and construction standards. This study is a first attempt to rationalize stairway standards by applying well established statistical methods to a significant sample of stairways and people using them. A pilot study on a sample of 253 residences in Milwaukee County, Wisconsin, was undertaken. The study included a survey of stairway use and behavior and an inventory of residential stairways. This information was obtained from the total sample. In a subsample of 54 residences, direct field observations and physical measurements of stairways were obtained. The results of the pilot study include a description of existing stairways, inferences about interactions that produce accidents, and guidelines which address reasons for accidents (hence should result in a reduction of accidents). The best strategy for making stairways safer, according to the study, is to remove factors that influence accident rates. Specifically, by systematically reducing hazards, careless stairway habits, and frequency of use, patterns of factors responsible for accidents can be broken and accident rates can be reduced.

BSS109. **Simplified analysis of thermal and lighting characteristics of windows: Two case studies,** T. Kusuda and B. L. Collins, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 109*, 113 pages (Feb. 1978) SN003-003-01892-9.

Key words: daylighting; energy conservation; fenestration design; solar heat gain; window management.

Results of a simplified analysis for annual heating, cooling, and lighting requirements associated with windows are presented. The analysis includes the effects of window size, heat transfer, solar shading, and compass orientation for typical commercial and residential modules located in a climate typical of Washington, D.C. Three different modes of operation with

respect to heating and cooling requirements through windows were assessed: external loads only; external and internal; and external, internal, and daylight. In addition, the effects of selective fenestration heat-transfer management, such as planned employment of thermal shutters and shading devices, and off-hour temperature setback were considered. This analysis assumed that daylight could replace or supplement artificial light whenever it could supply a specified minimum level of illumination. The use of daylight was found to offer the greatest potential for reducing energy costs, particularly when combined with selective fenestration management.

BSS110. **Reliability basis of load and resistance factors for reinforced concrete design,** B. Ellingwood, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 110*, 101 pages (Feb. 1978) SN003-003-01888-1.

Key words: buildings (codes); concrete (reinforced); design (criteria); loads; probability theory; reliability; statistical analysis; structural engineering.

Engineering decisions must be made in the presence of uncertainties which arise as a consequence of imperfect information and knowledge and inherent randomness in many design parameters. It is on account of these uncertainties and potential risks arising therefrom that safety margins provided by load and resistance factors are required in design. Reliability methods are employed in this study to facilitate the selection of criteria for reinforced concrete design. These methods, which are based on probability theory, provide a logical basis for determining the manner in which uncertainties in resistance and loads affect design safety and how their effects should be controlled in building standards. Following a comprehensive analysis of uncertainty measures, safety indices associated with existing reinforced concrete design are evaluated. Design criteria commensurate with levels of uncertainty and required reliability are then presented. Simplification of these leads to practical reliability based criteria which retain the relatively simple characteristics of existing criteria and yet have a well established and documented rationale.

BSS111. **Investigation of standards, performance characteristics and evaluation criteria for thermoplastic piping in residential plumbing systems,** R. S. Wyly, W. J. Parker, E. T. Pierce, D. E. Rorrer, J. R. Shaver, G. C. Sherlin, and M. Tryon, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 111*, 152 pages (May 1978) SN003-003-01934-8.

Key words: acoustical performance (plumbing piping); fire performance (plumbing piping); plumbing performance evaluation (piping); structural performance (thermoplastic plumbing piping); thermoplastic pipe usage (residential plumbing).

The application of the performance concept to the evaluation of piping systems of innovative materials is explored. User needs are considered and several material-related physical parameters are studied that might be used as measures of satisfaction of the user needs.

Information was reviewed on usage, performance characteristics and standards for thermoplastic pipe and fittings, and special laboratory tests were made to study selected characteristics and test methods. A number of performance statements and evaluation methods are recommended or discussed that relate to characteristics associated with polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS) and chlorinated polyvinyl chloride (CPVC). This approach was taken to illustrate the application of performance evaluation methodology to plumbing materials.

The results indicate that PVC, ABS, and CPVC can be used satisfactorily in a number of residential plumbing applications if appropriate attention is given to the selection of the materials, to the design of the piping system and to important installation details. Further research and education are needed for the general application of performance evaluation methodology as a basis for wider and more uniform acceptance of the above-mentioned thermoplastics as well as other materials for plumbing piping. However, the results of this study can be useful in expediting the systematic performance evaluation of future innovative piping materials.

BSS112. **Window blinds as a potential energy saver—A case study,** A. I. Rubin, B. L. Collins, and R. L. Tibbott, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 112*, 85 pages (May 1978) SN003-003-01936-4.

Key words: energy conservation; office buildings; orientation; photographic method; season; venetian blinds; view; windows; window usage.

Window usage at the National Bureau of Standards was studied by photographing venetian blind positions in offices at different times of the day and year. While blind positions were quite stable during the week of each study phase, they were quickly altered by the room occupants when deliberately set at extreme positions by the researchers. Significant differences were observed among blinds depending on compass orientation of the window, view type, season, and nature of experimental treatment. The greatest determinant of blind position was orientation, with blinds on north-facing windows being more open than on the south. The results suggest that energy conservation programs which rely on the activities of building occupants may be feasible. Suggestions are made for improvements in blind use and design.

BSS113. **Life-cycle costing. A guide for selecting energy conservation projects for public buildings,** R. T. Ruegg, J. S. McConnaughey, G. T. Sav, and K. A. Hockenbery, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 113*, 76 pages (Sept. 1978) SN003-003-01980-1.

Key words: building economics; economic analysis; energy conservation; engineering economics; investment analysis; life-cycle cost analysis.

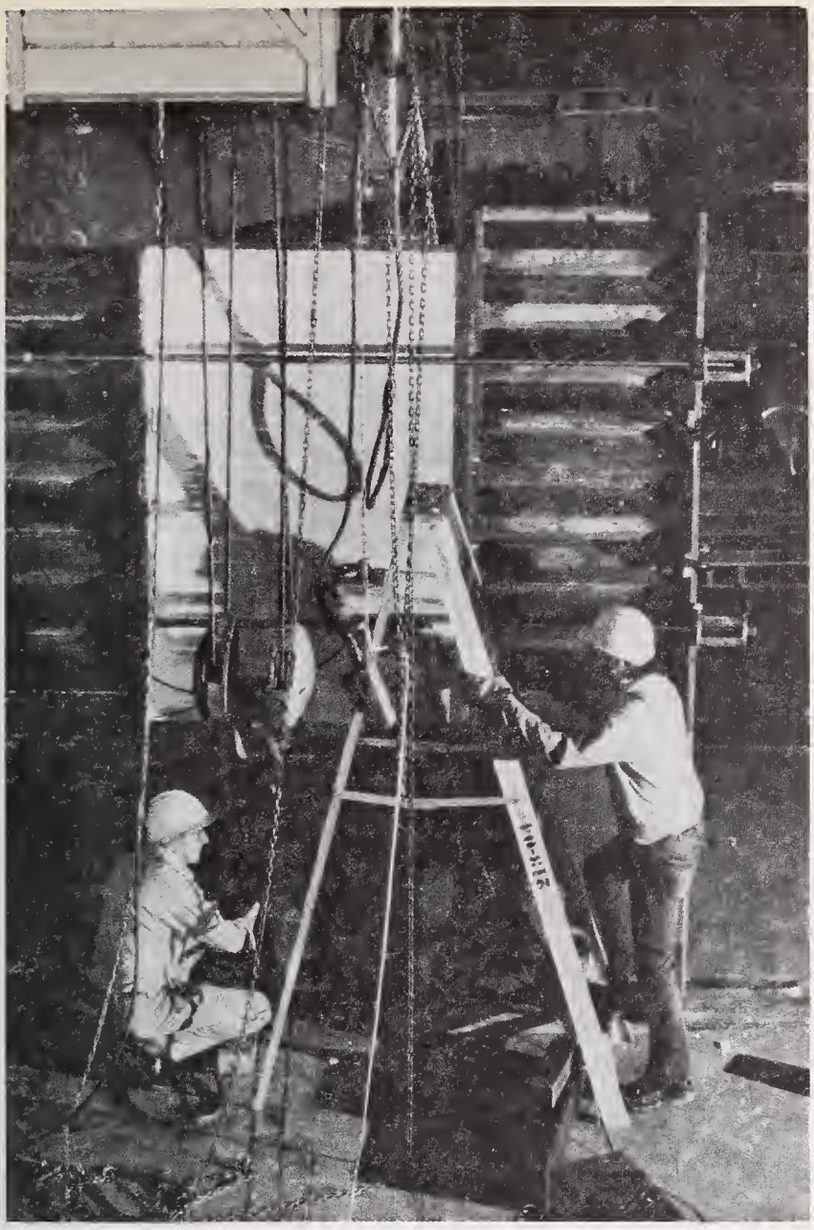
This report provides a step-by-step guide for conducting life-cycle cost evaluations of energy conservation projects for public buildings. It explains the use of life-cycle costing analysis to evaluate and rank the cost effectiveness of alternative energy conservation retrofit projects to existing public buildings, and to select the most cost-effective design for new buildings. Worksheets, illustrated with a realistic example, and a computer program are provided.

This guide is compatible with a life-cycle costing guide prepared for the Department of Energy for use in the Federal Energy Management Program by Federal Agencies. The purpose of this report is to provide a guide to state and local governments for use in their energy conservation programs.

BSS114. **The effect of "resource impact factors" on energy conservation standards for buildings,** S. F. Weber, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 114*, Supersedes NBSIR 77-1199, 55 pages (Sept. 1978) SN003-003-01952-6.

Key words: building economics; economic efficiency; economics; energy; energy conservation; life-cycle cost; optimization; performance standards; resource impact factors; resources; social optimum; standards.

This report addresses the question of the proper price for energy to be used in the development of optimum (i.e., cost-effective) energy conservation performance standards for buildings. This study finds that the appropriate price for energy



is its social value, which should be determined through the development and application of Resource Impact Factors (RIF's). Some guidelines are provided for the formulation and development of RIF's. A life-cycle cost minimization model for determining the optimum conservation standard is employed to show how the use of RIF's would generally lower the maximum allowable energy consumption specified in the standard. Indeed, it is found that the higher the RIF value, the lower the energy consumption allowed by the standard, although this effect steadily diminishes as the RIF value increases. Moreover, the additional energy savings resulting from using RIF's are shown to increase as the severity of the climate increases. When two important restrictive assumptions of the model are relaxed, these same relationships between energy consumption and the RIF value on the one hand, and between the extra energy savings due to RIF's and the climate on the other hand, are both maintained. Finally, geometric and algebraic measures are derived for the net gain in economic efficiency that would result from using RIF's in developing energy conservation performance standards.

BSS116. **Geographical variation in the heating and cooling requirements of a typical single-family house, and correlation of these requirements to degree days,** E. A. Arens and W. L. Carroll, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 116*, 58 pages (Nov. 1978) SN003-003-01992-5.

Key words: building energy conservation; climatic effects on building energy consumption; computer modeling of building energy consumption; energy conservation; geographical variation of building consumption; residential energy consumption.

The report has three main purposes: First, it assesses 'Test Reference Year' (TRY) hourly climate data tapes to determine how well they represent long-term average climate when used for estimating average annual heating and cooling requirements. The report presents a method to adjust heating and cooling requirements that are computed using TRY data, in order to make them represent long-term average heating and cooling requirements.

Second, the report quantifies the geographic variation of annual heating and cooling requirements across the U.S. by computing the heating and cooling requirements of a typical ranch-style residence for the 8760 hours of each of the 60 TRY tapes, and adjusting the results by the method described above.

Third, the effectiveness of 'degree-day' data for predicting these computed annual heating and cooling requirements is examined, and the variability of heating and cooling requirements within degree-day 'zones' of 1000 degree day width is presented.

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.

TN710-8. **Building research translation: French acoustical comfort standards,** S. G. Weber, Translation Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 710-8*, 67 pages (Mar. 1978) SN003-003-01897-0.

Key words: acoustics; codes; CSTB; French compliance techniques; translations.

This report offers methods of providing levels of residential acoustical comfort which meet French specifications contained in the French order of June 1969, and some methods which may facilitate meeting the more stringent requirements of the Acoustical Comfort Standard.

Two levels of solutions are thus identified: first, those which meet the basic French building code regulations; and, second, those which can bring dwelling units up to the French Acoustical Comfort Standard.

Recent advances in acoustical knowledge as applied to residential construction created a need for this revision to the earlier edition to provide new examples of solutions which meet building code requirements as well as solutions qualifying for the Acoustical Comfort Standard Label.

TN710-9. **Building research translation—Discomfort due to wind near buildings: Aerodynamic concepts,** J. Gandemer, *Nat. Bur. Stand. (U.S.), Tech. Note 710-9*, 48 pages (Mar. 1978) SN003-003-01898-8.

Key words: air flow; CSTB; discomfort, wind; France; translations; wind discomfort; wind flow around buildings.

Flow patterns at ground level in groups of buildings result from the complex interaction between the wind (impact, average speed distribution with height, and turbulence) and the buildings themselves (shapes, sizes, arrangements, etc.).

The increase in the number of very tall structures and the more or less arbitrary, with respect to wind, placing of large structures have frequently demonstrated the lack of adaptation of the structural environment to wind phenomena. Manifestation at ground level, such as zones of high speeds or eddies, make the approach to buildings uncomfortable (sometimes even dangerous) for the pedestrian.

Elimination of these problems requires better knowledge of air flows around structures and formulation of practical plans that the architect or city planner can use in designing larger structural units. This report summarizes work carried out at the CSTB institute in Nantes in 1973 and 1974 and gives the main results of the study.

A guide is included which furnishes simple rules or practical advice that can be used by architects and city plannners.

TN710-10. **Building research translation: The behavior of concrete structures in fire—A method for prediction by calculation,** S. G. Weber, Translation Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 710-10*, 83 pages (Mar. 1978) SN003-003-01896-1.

Key words: calculating concrete fire resistance; codes; concrete fire resistance; CSTB; fire; fire codes; France; translations.

This method provides a means for predicting, by calculation, the resistance to fire of a reinforced or prestressed concrete element of construction, in accordance with 1959 French directives.

The method is useful in allowing builders to design structures which show the degree of fire resistance required by the various French construction regulations in force. According to those regulations, only a test furnishes legal proof of fire resistance.

French researchers hope this first step will lead to the acceptance in France of fire resistance calculations as legal proof of satisfactory resistance.

TN965. **Effects of moisture in built-up roofing—A state-of-the art literature survey,** H. W. Busching, R. G. Mathey, W. J. Rossiter, Jr., and W. C. Cullen, *Nat. Bur. Stand. (U.S.), Tech. Note 965*, 78 pages (July 1978) SN003-003-01944-5

Key words: bituminous roof membranes; built-up roofs; moisture; moisture dissipation; nondestructive detection of moisture; performance criteria; roofing moisture.

A literature review of the effects of moisture on built-up roofing was made. Quantitative data were summarized for some properties of membrane roofing including: permeability, absorption, thermal expansion, thermal resistance, tensile strength, modulus, and fungus attack resistance. Example calculations of possible temperature and moisture gradients for two typical roof sections were presented.

Nondestructive evaluative methods to locate moisture in roofing systems were summarized and include gravimetric, nuclear, capacitance, infrared imagery, electrical resistance, and microwave methods. A review of techniques to dissipate moisture in roofing is presented.

TN966. **Performance criteria and plumbing system design,** M. J. Orloski and R. S. Wyly, *Nat. Bur. Stand. (U.S.), Tech. Note 966*, 61 pages (Aug. 1978) SN003-003-01963-1.

Key words: performance; plumbing systems; reduced-size venting.

An overview is presented indicating how the performance approach to plumbing system design can be used to extend traditional methods to innovative systems. Identification of the plumbing performance needed in a built system is used to classify current design criteria intended to furnish this level of performance. Some current design criteria may provide a higher level of performance than is actually needed by the user. In other cases, no standard test method, criterion, or evaluation technique exists. Putting existing knowledge into a performance format increases the utility of this knowledge and facilitates identification of needed research to fill the gaps. Some of the mathematical models now used for system design and pipe sizing in plumbing codes are reviewed in the context of performance-oriented research. The results of experimental work in plumbing systems with reduced-size vents (smaller than allowed by codes) are presented as an example of the use of the performance approach, and illustrate a case where performance criteria permit relaxing of vent design practice. Conceivably the reexamination by plumbing designers of traditional design criteria against measured user needs could be beneficially extended to other areas of plumbing design such as water distribution, storm drainage, and plumbing fixtures. Beyond this, it has been recognized that uniform guidelines for evaluation of innovative systems, based on research tindings, are essential for wide acceptance of performance methods, particularly by the regulatory community.

TN970. **Aseismic design of building service systems: The state-of-the-art,** C. W. C. Yancey and A. A. Camacho, *Nat. Bur. Stand. (U.S.), Tech. Note 970*, 83 pages (Sept. 1978) SN003-003-01974-7.

Key words: aseismic design; building service systems; codes; earthquake; hospitals; standards.

A search for information was conducted to define the state-of-the-art of aseismic design of building service systems and to identify areas of needed research. The study focused primarily on service systems essential to the continuous operation of

hospital facilities in post-earthquake periods. A review of the literature pertaining to seismic performance of nonstructural systems is presented. An evaluation of code and standard regulations applicable to the aseismic design of service system components is also presented. Information obtained from direct contact with several federal agencies, the State of California, and practicing architects and engineers is summarized. The findings from a field visit of two hospitals currently under construction in earthquake-prone areas are reported. Deficiencies in current design/evaluation practice are identified and recommendations for research are presented.

TN972. **Elastomeric roofing: A survey,** W. J. Rossiter, Jr. and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Tech. Note 972*, 54 pages (July 1978) SN003-003-01954-2.

Key words: application guidelines; elastomeric; materials; membranes; performance factors; review; roofing.

In recent years the use of elastomeric roofing sytems in the United States has been increasing. A survey was conducted to ascertain the current state-of-the-art of these roofing systems. The information obtained in the survey was gathered from a literature search complemented by the opinions of people knowledgeable in the field including researchers, contractors, manufacturers and users. A listing of the current elastomeric roofing materials was compiled, along with test methods for determining the properties of membranes fabricated with these materials. The principal materials, available in either liquid or sheet applied systems, included acrylic, butyl, chlorosulphonated polyethylene, EPDM (ethylene propylene diene terpolymer), neoprene, polyvinyl chloride (PVC) and vinyl, silicone and urethane. In addition to these materials some composite membranes were also available.

Factors affecting the performance of the membranes were identified including durability, design of the roofing system, substrate condition at the time of application attachment of the membrane to the substrate and workmanship during application. The performance of elastomeric roofing was discussed based on its advantages, disadvantages and limitations. Guidelines to assist the user in the selection and use of elastomeric roofing were prepared for both new and remedial roofing applications.

Criteria were not available to evaluate or predict the performance of elastomeric roofing. As a first step in the development of criteria, preliminary performance characteristics were suggested.

TN974. **Corrosion of metallic pipes transporting potable water—Laboratory testing methods,** J. N. Andre and J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 974*, 36 pages (June 1978) SN003-003-01945-3.

Key words: copper pipe; corrosion; corrosion measurement; galvanized steel pipe; metal pipes; potable water; resistance polarization.

Many factors affect both the form of and the corrosion of pipes transporting potable water including the composition, temperature and flow rate of the water, type of metal and the physical condition of the pipe. A pipeline was constructed and experimental methods developed to determine the effects of the above factors on the corrosion of pipes. Components of the pipeline were carefully selected or designed to prevent the occurrence of extraneous corrosion.

The rate of corrosion of galvanized steel and copper pipes were measured by direct weight losses measurements and by polarization resistance methods. It appears that the polarization resistance technique is a useful tool which may be used in a variety of corrosion studies of pipe in aqueous media.

TN975. **Results and analysis of a round-robin test program for liquid-heating flat-plate solar collectors,** E. R. Streed, W. C. Thomas, A. G. Dawson III, B. D. Wood, and J. E. Hill, *Nat. Bur. Stand. (U.S.), Tech. Note 975*, 119 pages (Aug. 1978) SN003-003-01959-3.

Key words: measurement; modeling; solar; standards; testing.

A round-robin test program was conducted at 21 United States test facilities, using a common test procedure, to determine the intercomparability of thermal performance data pertaining to two liquid-heating flat-plate solar collectors.

The statistical analysis of the data revealed a relatively large spread in the measured values of collector efficiency. Data from approximately half the facilities were then selected for detailed analysis. A collector analytical model was used to show that less than one-third of the mean-square distance could be attributed to different environmental conditions from facility to facility. It was found that the data showed less scatter for one of the two collectors than for the other. In general, the data were consistent for any single facility; most of the scatter was therefore attributed to systematic uncertainties from facility to facility. When the data from six participants reportedly adhering to the requirements of ASHRAE Standard 93-77 were analyzed, the scatter was found to be within normal limits expected for the test procedure.

TN976. **International trends and developments of importance to the metrication plans of the U.S. construction community,** C. T. Mahaffey, *Nat. Bur. Stand. (U.S.), Tech. Note 976*, 72 pages (June 1978) SN003-003-01937-2.

Key words: international building performance standards; internationally harmonized building regulations; metrication impact on construction.

In 1974 the National Bureau of Standards' Center for Building Technology began an investigation of international developments in the construction field seeking to identify those of importance to U.S. metrication planning. This report identifies and describes a group of related developments selected on the basis of their importance and potential impact on the metric future of the U.S. construction community. The purpose of the report is not to discuss the merits of going metric, but rather to display the trends and developments in the metric building world that the U.S. is preparing to join.

The report suggests that many nations, recognizing unique opportunities in a world that will soon have a common measurement system, have already begun to capitalize on the global adoption of SI—the International System of Units. The report describes the extensive efforts underway to reduce obstacles to trade caused by incompatible national regulations, standards, and certification to standards. It describes the trade implications of the Helsinki international agreements reached at the Helsinki meeting of the Conference on Security and Cooperation in Europe and being advanced in the proposed Standards Code developed by the negotiators involved in the General Agreement on Tariffs and Trade (GATT). It describes the changes in the marketplace for building components brought about by the worldwide adoption of the international standard dimensioning module of 100 mm. It describes the launching and the status of the United Nations project aimed at the international harmonization of national building regulations; the involvement and reorganization of the building standards activity of the International Organization for Standardization (ISO); the significance of the international evaluation mechanisms developed by the European Union of Agreement; and, the initiation of international performance standards developed through ISO Technical Committee 59—Building Construction. All of which should be of special interest to those concerned with the development of a remarkably similar program assigned

to the National Institute of Building Sciences (NIBS).

U.S. metric conversion plans could be designed to take advantage of the opportunities uniquely associated with an SI world or they could treat metrication simply as the adoption of a more modern U.S. measurement system. The report identifies this choice as a major metrication issue for the U.S. construction community. For this reason the report should be of interest to members of the American National Metric Council and of the U.S. Metric Board.

The appendix to this report contains a brief description of 22 international organizations considered to be of future significance to the U.S. as it joins the SI metric building world.

TN977. **Methods for characterizing adobe building materials,** J. R. Clifton, P. W. Brown, and C. R. Robbins, *Nat. Bur. Stand. (U.S.), Tech. Note 977*, 59 pages (June 1978) SN003-003-01940-2.

Key words: adobe building materials; adobe soil; color determination; microfabric analysis; mineralogical analysis; particle size distribution; pH; plastic and liquid limits; soluble salts.

Methods are described for the characterization of those physical properties and mineralogical features of adobe which appear to have the most significant effect on the durabilities of adobes. These methods include determinations of color, pH, soluble salts, particle size distribution, liquid and plastic limits, and the x-ray "fingerprint" of adobe. In addition, methods are given for the identification of the mineralogy of adobe soils and for the examination of the microfabric of adobe.

TN982. **Criteria for retrofit materials and products for weatherization of residences,** W. J. Rossiter, Jr. and R. G. Mathey, Eds., *Nat. Bur. Stand. (U.S.), Tech. Note 982*, 75 pages (Sept. 1978) SN003-003-01976-3.

Key words: caulks and sealants; clock thermostats; energy conservation; insulation; replacement windows; retrofitting; storm doors; storm windows; vapor barriers; weatherization; weatherstripping.

The Department of Energy requested the National Bureau of Standards to develop criteria for materials and products to be included in the DOE Weatherization Assistance Program. This program was established by Congressional legislation and directed toward financially assisting low-income persons in retrofitting residences to conserve energy. For most cases, only energy-saving materials and products for which specifications and/or standards are available are to be included in the Weatherization Assistance Program. Because of statutory requirements labor costs for installing weatherization materials and products are not included in the program.

The report identifies criteria for materials and products eligible under the DOE Weatherization Assistance Program. The materials included are insulation and vapor barriers, storm windows and doors, caulking and weatherstripping, clock thermostats, and replacement windows, and replacement glazing. The retrofit materials are listed by generic type and recommendations are made for their installation.

During the course of the investigation and based upon interactions with industry representatives, materials and products other than those considered eligible under the DOE Weatherization Assistance Program were also given consideration. Those materials and products having energy savings potential but which are considered not eligible are discussed in the Appendices.

TN984. **Evaluation of plastic wallcovering materials,** E. J. Clark and P. G. Campbell, *Nat. Bur. Stand. (U.S.), Tech. Note 984*, 43 pages (Oct. 1978) SN003-003-01982-8.

Key words: abrasion; Federal Specification CCC-W-408A; fungus resistance; stain resistance; surface roughness; vinyl wallcoverings; wallcovering materials; washability.

The suitability of various test methods for measuring performance of plastic wallcovering materials was studied. This report contains the results of performance tests including abrasion resistance, surface texture, fungus resistance, washability and stain resistance. Based on the test results, tentative recommendations for the revision of Federal Specification CCC-W-408A, Wall Covering, Vinyl-Coated, have been developed. These recommendations are based upon the results of tests conducted on seventy-two wallcovering materials from seven manufacturers.

TN990. **The selection of preferred metric values for design and construction,** H. J. Milton, *Nat. Bur. Stand. (U.S.), Tech. Note 990,* 83 pages (Dec. 1978) SN003-003-02001-0.

Key words: convenient numbers; metrication; number systems; preferred numbers; rationalization; selection of metric values; series of numbers; SI.

This Technical Note contains a comprehensive examination of considerations involved in the selection of preferred metric values during the change to SI in the U.S. construction community. It has been prepared to assist those engaged in the conversion and rationalization of technical data for use in design and production to make informed judgments during the selection of metric values.

The adoption of preferred metric values and the concomitant rationalization of the technical data base will be one of the main benefits of the change to metric (SI) units. The principal aim is to encourage the choice of simple, convenient, or preferred metric values and ranges of rational values, rather than exact or marginally rounded soft conversions of existing values which will generally require a second change to more workable numbers at a later stage. The Technical Note has three parts: 1) background information on number systems and properties of numbers, metric impact, and alternative conversion strategies; 2) alternative preferred number concepts for individual values, sets of related values, and series of preferred values; and, 3) a methodology for the determination and selection of preferred metric values in technical information by means of a manual or an automated approach.

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.

SP457-2. **Building technology publications 1977—Supplement 2,** J. R. Debelius, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457-2*, 113 pages (Aug. 1978) SN003-003-01962-3.

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

This report presents the National Bureau of Standards' (NBS) Center for Building Technology (CBT) publications for 1977. It is the second supplement to Special Publication 457, *Building Technology Publications 1965-1975* and covers the period from January 1, 1977 to December 31, 1977. It includes an abstract of each NBS publication, titles and abstracts of papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This report provides the primary means of communicating the results of CBT programs to its varied technical audiences, as well as to the general public. Publications constitute a major end product of CBT's efforts and in 1977 appeared in several NBS publication series (Building Science Series, Technical Note, Special Publication, Handbook and NBS Interagency Report).

SP499. **Noise criteria for buildings: A critical review,** S. L. Yaniv and D. R. Flynn, *Nat. Bur. Stand. (U.S.), Spec. Publ. 499*, 82 pages (Jan. 1978) SN003-003-01870-8.

Key words: building acoustics; building codes; isolation; noise; noise criteria; rating scheme; sound transmission.

A review is given of existing criteria that could be applied to rating the noise environment in dwellings, to rating noise isolation between dwellings, and to rating noise isolation from outside to inside a dwelling. It is concluded that the central problem is to select appropriate criteria for rating the interior noise environment. Once this is done, criteria for noise isolation can be derived directly and these in turn can be used to derive performance requirements for building elements, such as partitions and exterior walls.

SP504. **Metric dimensional coordination—The issues and precedent.** Proceedings of Joint Conference, Washington, DC, June 6, 1977, S. A. Berry and H. J. Milton, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 504*, 77 pages (Feb. 1978) SN003-003-01887-2.

Key words: dimensional coordination in building; international standards for building; metrication; preferred dimensions and sizes.

These edited proceedings are a summary of a Joint Conference of the Design Sector and Construction Products Sector of the Construction Industries Coordinating Committee of the American National Metric Council, which was held in Washington, DC, on June 6, 1977. They may be used as a general reference document dealing with the background of and precedent in metric dimensional coordination.

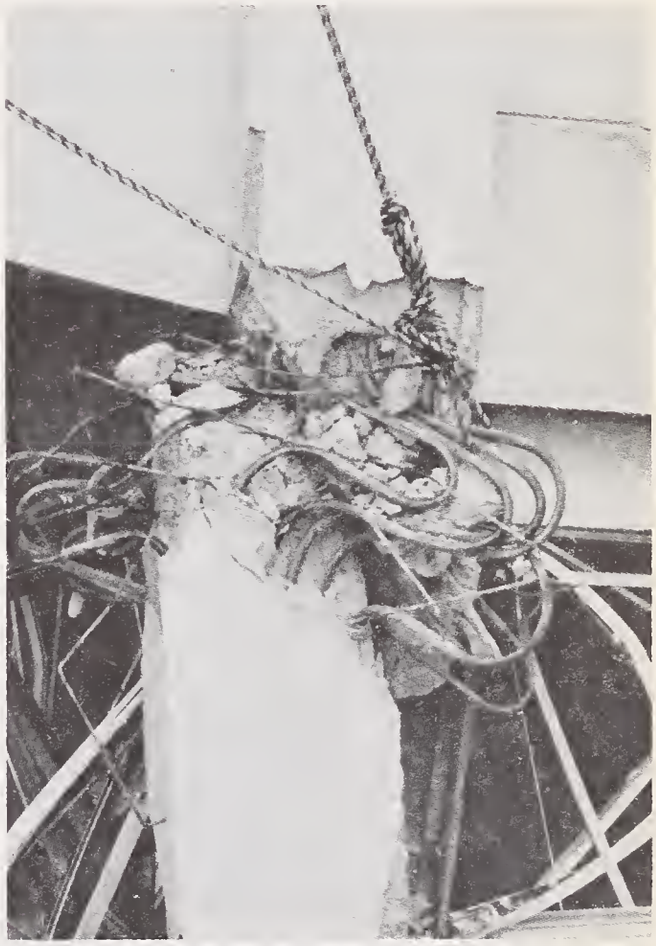
As the United States prepares to join the metric building world, both the issues and relevant precedent in dimensional coordination become significant as a basis for an effective and economical change. To this end, the papers presented at this Joint Conference address the following topics: 1. *Dimensional Coordination—An Industrial Management Tool*, which reviews the issues and application of dimensional coordination; 2. *Building Standards Development in Sweden and in the Metric Building World*, which outlines issues in national and international standardization in the context of building design, production and construction dimensions; and 3. *Metrication—The Opportunity for an Industry-wide System of Dimensional Coordination: Precedents and Issues*, which reviews precedent in metrication and the simultaneous change to preferred building dimensions and preferred sizes in component production.

The questions and answers emanating from the Joint Conference reflect the concerns of the United States' design and production communities at the outset of metrication and dimensional coordination. *These proceedings include the following papers (indented):*

Dimensional coordination—An industrial management tool, L. Bergvall, *SP504*, pp. 5-16 (Feb. 1978).

Building standards development in Sweden and in the metric building world, H. Orlando, *SP504*, pp. 19-30 (Feb. 1978).

Metrication—The opportunity for an industry-wide system of dimensional coordination: Precedent and issues, H. Milton, *SP504*, pp. 33-48 (Feb. 1978).



SP510. **Tentative provisions for the development of seismic regulations for buildings,** *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 510*, 514 pages (June 1978) SN003-003-01939-9.

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

This document contains tentative seismic design provisions for use in the development of seismic code regulations for design and construction of buildings. The provisions represent the result of a concerted effort by a multidisciplinary team of nationally recognized experts in earthquake engineering. Design professionals, researchers, Federal agency representatives, staffs from the model code organizations and representatives from state and local governments from throughout the United States were involved. The provisions are comprehensive in nature and deal with earthquake resistant design of the structural system, architectural and nonstructural elements and mechanical-electrical systems in buildings. Both new and existing buildings are included. They embody several new concepts which are significant departures from existing seismic design provisions. An extensive commentary documenting the basis for the provisions is included.

SP512. **Energy-effective windows.** Proceedings of a Joint DOE (ERDA)/NBS Conference/Round Table on Energy-Effective Windows held in Washington, DC, Apr. 13, 1977, H. R. Trechsel, Technical Coordinator, *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 512*, 53 pages (Apr. 1978) SN003-003-01929-1.

Key words: daylighting; energy conservation; glass; thermal performance; windows.

On April 13, 1977, a Joint DOE/NBS Conference/Round table was held on Energy-Effective Windows. The conference was attended by 30 participants and speakers and auditors representing all major interests in window industry, government, academia, professions, and the media. *These proceedings include the following papers* (*indented*)*:*

An overview of window research at NBS, B. L. Collins, *SP512*, pp. 6-12 (Apr. 1978).

DOE (ERDA)/LBL window research, S. M. Berman, *SP512*, pp. 14-19 (Apr. 1978).

An architect's view of energy-effective windows, H. Taylor, *SP512*, pp. 20-25 (Apr. 1978).

Window research in the United Kingdom and in Europe, D. A. Button, *SP512*, pp. 26-32 (Apr. 1978).

SP515. **International Project Catalog of Modular Integrated Utility Systems,** M. H. Nimmo and C. W. Phillips, *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 515*, 455 pages (July 1978) SN003-003-01953-4.

Key words: catalog; CCMS-MIUS Project Catalog; International Project Catalog; project catalog; project summary forms; reporting system.

The International Project Catalog prepared for the Committee on the Challenges of Modern Society—Rational Use of Energy Pilot Study—Modular Integrated Utility Systems (CCMS-MIUS Project) is a compilation of project descriptions on more than 200 Modular Integrated Utility Systems (MIUS) type of projects being conducted in the participating countries. Each project description includes a description of each project, its status, the approach, expected results, some technical data, the principal investigator, an indication whether or not data is/or will be available and other miscellaneous project information. The catalog is useful to the experts in identifying the various projects being conducted and seeking further technical information on those particular projects in which they are interested.

The catalog is the first of a three level reporting system to report on MIUS type of projects. The second and third level reporting systems, which are expected to be improved and completed in future activities under another international organization, will provide information and guidelines for reporting progress and supplying data. The catalog consists of three parts: an Introduction, list of Projects by Country, and Project Descriptions, one for each project reported.

SP516. **Color in the health care environment.** Proceedings of a Special Workshop held at the National Bureau of Standards, Gaithersburg, MD, Nov. 16, 1976, B. C. Pierman, Ed., *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 516*, 35 pages (Sept. 1978) SN003-003-01957-7.

Key words: architecture; buildings; color; design; hospitals; light.

The proceedings contain invited papers regarding the use of color in Health Care Environments. The subject matter includes the perspective of medical doctors, architects, designers, researchers, and standards writers concerning proper and effective color and light selection and use in all phases of hospitals and medical facilities. Particular problems and cautions are related regarding the use of colors in surgical theaters and pediatric as well psychiatric wards. *These proceedings include the following papers* (*indented*)*:*

Overview of the Center for Building Technology, NBS, R. N. Wright, *SP516*, pp. 1-3 (Sept. 1978).

Hospital light and color from the physician's standpoint, W. C. Beck, *SP516*, pp. 5-7 (Sept. 1978).

Health facilities: Color them caring, M. Graham, *SP516*, pp. 9-12 (Sept. 1978).

Studies of the subjective influence of light and color, J. E. Flynn, *SP516*, pp. 13-18 (Sept. 1978).

Some relationships of color and light to patient care, T. R. C. Sisson, *SP516*, pp. 19-24 (Sept. 1978).

The relationship of color planning in designing a pediatric oncology unit to the symbolic meaning of colors as seen in patients' graphic productions, S. Castelluccio, *SP516*, pp. 25-26 (Sept. 1978).

Lighting and color in health care facilities—From a designer's viewpoint, A. F. Styne, *SP516*, pp. 27-28 (Sept. 1978).

SP518. **Research and innovation in the building regulatory process.** Proceedings of the Second NBS/NCSBCS Joint Conference, held in Bozeman, MT, Sept. 20, 1977, P. W. Cooke, Ed., *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 518*, 406 pages (Aug. 1978) SN003-003-01960.

Key words: administrative procedures; building codes; building regulations; buildings; economic impacts; environmental considerations; innovative practices; regulatory research; standards development.

The Second NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process was held in Bozeman, Montana on September 20, 1977. The proceedings contain the 25 papers presented at the eight technical sessions. The technical sessions addressed the following issues: implementation of solar and energy conservation building standards; issues in building regulation; considerations in the development of energy conservation building standards; developing new approaches for formulating building regulations; state experiences

in the development of energy conservation building standards; the expanding role of the building official; application and impact of building energy conservation standards; administration of building regulations. *These proceedings include the following papers (indented):*

The National Solar Heating and Cooling Information Center: Meeting the code officials' information needs, G. Mara, *SP518*, pp. 1-8 (Aug. 1978).

Key words: building regulations; data collection; demonstration program; dissemination; information needs; residential construction; solar energy; space heating; technology.

Under the provisions of the Solar Heating and Cooling Demonstration Act of 1974, a National Solar Heating and Cooling Center was established in 1976 by the Department of Housing and Urban Development, in cooperation with the Department of Energy. It is the express mission of the Center to gather information about the practical feasibility of solar heating and cooling systems in homes and buildings and to disseminate this information to the general public and to specialized technical or professional groups including building code officials.

Recent developments are accelerating code officials' need for solar information. Solar homes are being built in all geographic areas of the country. Architects, engineers, designers and contractors are gaining solar experience or showing an interest in solar. In addition, many State legislatures are taking direct or indirect action in the solar area which will affect building codes. Some States include general or specific solar considerations in State building codes. Others are making solar familiar by requiring life-cycle cost estimates of competing forms of energy, including solar, in new or substantially renovated State buildings.

Implementation of energy conservation building standards, T. B. Brown, *SP518*, pp. 9-15 (Aug. 1978).

Key words: building code official; buildings; education level; energy conservation; evaluations; upgrading, certification.

Codes and Standards for Energy Conservation in Buildings are currently being written and adopted by States and model code organizations. These Standards are necessary as one of the means of buying the time required to develop alternate energy sources to continue our life style.

But codes and standards are only as effective as their implementation. Who will enforce them in new buildings and monitor them in existing buildings? The logical person for this immense task is the local building code enforcement officer, who in most cases has neither the training nor the background to deal with the terms and concepts involved. He must be upgraded if our nation is to gain time to become energy self-sufficient.

This paper deals with what the code enforcement officer has to know and how he can attain the required level of knowledge to competently enforce energy conservation standards.

A proposal for the implementation of energy conservation building standards and codes, J. R. Groves, Jr., *SP518*, pp. 17-24 (Aug. 1978).

Key words: built environment; education and training; energy conservation; enforcement; legislation; promulgation; regulation; standards.

This paper deals with the mechanics of application, monitoring, and enforcement of State adopted energy conservation standards. It will be presumed that the administrative or legislative process has mandated an energy code for the respective State.

The issues to be examined are: (1) the complexity of the energy standard and its appropriateness for the (a) climatic factors of the respective State and (b) general level and magnitude of building construction within the State; (2) the process of educating and informing the various design professional groups who will integrate the code requirements into new and existing structures, on both an initial and continuing education basis; (3) the process of training and educating the enforcing agency's personnel and the factors to consider in first choosing the appropriate State agency; (4) the necessity for prescriptive and performance components of the code itself and enforcement implications; and (5) the impact of energy standards on (a) architectural design flexibility and (b) building costs, including "tradeoff" possibilities.

Research on natural and man-made hazards: Impacts on building regulations, D. L. Schodek, *SP518*, pp. 25-47 (Aug. 1978).

Key words: building design; building regulatory system; decision processes; hazards-related phenomena; innovations; research findings; scientific methods; socio-political system; technical expertise.

A crucial problem facing the building regulatory system in the United States today is the question of how the results of current technical engineering and scientific research into different natural and man-made hazards that are dealt with by building regulations are to be specifically reflected or incorporated into codes or standards. Ad hoc responses of the building regulatory system to pressures from different research groups, albeit well-meaning pressures, to incorporate research findings with respect to specific hazards, may lead to piecemeal implementation in which there is no underlying logic which attempts to bring about a fundamentally consistent method of dealing with all of the different hazards involved.

This paper speculates in an argumentative way on the role of the building regulatory system with respect to new research and the emergence of increasingly sophisticated scientific methods of analysis. The paper addresses possible bases on which code structures could be developed with the view of treating all hazard-related measures consistently. Some conceptual difficulties are noted along with more pragmatic concerns. In particular the point is addressed that if regulations become more sophisticated in response to more increasingly sophisticated scientific or engineering methods of analysis, then the possibilities for innovation and creative approaches to reducing hazards are increased, but at the same time the technical expertise of all those charged with enforcing the code must also be increased. Therein lies a basic conflict.

A very fundamental issue raised is that the role of the law on which building regulations are based and what it can or should be in relation to the scientific methods embodied in new research is unclear. It is hypothesized that many of the dilemmas currently facing the building regulatory system in regard to new research can be resolved only by considerations involving a greatly extended socio-political context.

Response to building innovation by building codes and regulations, S. Winter, *SP518*, pp. 49-66 (Aug. 1978).

Key words: building codes; code changes; incentives; innovations; log homes; minimum property standards; model code agencies; regulations.

The major U.S. building codes are updated intermittently (e.g., MPS issues updates as they are processed, BOCA issues supplements annually, etc.). The States and other regulatory bodies which adopt these codes do so sometime after the updates are issued. The result is that there is a considerable time span for the process of: recognition of the need for a code change; adoption of the code change; revision of the code; adoption of the revision by regulatory bodies; and implementation of the revision.

Innovations in the building industry, however, are constantly occurring, and there is frequently no allowance in the language of codes or in their interpretation for items not specifically identified.

The position of the author is that building codes and regulatory agencies must be more responsive to innovative materials and methods in order to foster, rather than hinder, improvements and efficiencies in the building process.

A consulting engineer's view of building code process from conception to adoption, N. J. Kornsand, *SP518*, pp. 67-76 (Aug. 1978).

Key words: building codes, due process; legislation; model codes; promulgation; regulatory process; standards development.

The author has been attending the meetings of the model code groups for the past several years. During that time period, he has observed the process, noted the changes that are taking place in the process, identified forces responsible for the changes, analyzed the problems and has formulated possible areas to refine, streamline and be more efficient in the building code promulgation process.

The paper will present the building code process from the standpoint of the designers and engineers who must work with its provisions. The paper will show a significant trend in the past few years that is complicating the process. This includes more code changes, more complex code changes, expansion of the codes into more areas of control, and attempts to keep pace with the plethora of new products, devices and designs flooding the building materials market.

Standards/codes for energy conservation in lighting design, R. L. Smith, *SP518*, pp. 77-94 (Aug. 1978).

Key words: artificial illumination; buildings; criteria; energy conservation; energy consumption; environmental design; lighting levels; standards.

There is a general agreement on the need to eliminate unnecessary energy use in providing artificial illumination for buildings. However, there is widespread disagreement on the procedure that should be promulgated to achieve that need. This paper suggests a method to evaluate building standards/codes and compares three procedures developed to achieve energy efficient lighting systems. The procedures compared are (1) a standard developed by the Illuminating Engineering Society and published as Section 9 of ASHRAE Standard 90-75; (2) a guideline published by the General Services Administration; and (3) a code being developed by a State building code commission.

The need for a more explicit definition in building regulations of the internal thermal environment in buildings, D. R. Heerwagen, A. F. Emery, C. J. Kippenhan, and G. B. Varey, *SP518*, pp. 95-134 (Aug. 1978).

Key words: building performance simulation; building regulations; computer applications; energy conservation; thermal comfort; thermal performance of buildings.

A survey of several widely-accepted or newly-proposed building codes or standards has been conducted to determine (1) what guidelines for establishing occupant thermal comfort currently exist, and (2) whether these guidelines may inhibit the achievement of energy conservation in building operation. This review has shown that the present requirements pertaining to thermal comfort afford nonoptimal conditions, from the points of view of both the provision of thermal comfort and the achievement of energy conservation. In this essay, the authors have cited results from three groups of researchers who have provided definitive work on human thermal comfort. It is suggested that such results be used in writing future building regulations and that energy conservation will result from their inclusions. Additionally, the authors have also suggested that future regulations require the use of several devices or strategies (for building operation or control) and these are discussed.

A thermal simulation computer program UWENSOL is described and its application is displayed as a means of accurately predicting both heating and cooling loads and thermal conditions within buildings during their design.

Implementation of energy conservation building standards—The verification problem for HVAC systems, D. E. Tonini and T. E. Sluiter, *SP518*, pp. 135-144 (Aug. 1978).

Key words: balancing; building code official; code requirements; energy conservation; performance specifications; testing; verification.

This paper outlines the parameters and procedures which should be considered in the preparation of energy conservation performance specifications and verification for building mechanical systems.

The trend toward implementation of energy conservation standards, particularly for commercial building, carries with it the question of how the building code official is to determine whether or not an energy conservation standard has been met. For prescriptive standards, e.g., insulation thickness requirements, this may be readily ascertainable. For performance standards for HVAC systems, this becomes a very significant problem for the code writer as well as the building code official.

It has been shown that significant energy savings may be achieved by careful balancing and optimization of building mechanical systems for new buildings or retrofit of existing inefficient systems. It is anticipated that code writers concerned with energy conservation standards may wish to address this important subject area in their codes.

Systematic organization of standards and codes, J. R. Harris and R. N. Wright, *SP518*, pp. 145-160 (Aug. 1978).

Key words: building codes; classification; index; organization; outline; standards; systems engineering.

The ease and confidence with which a code or standard can be used depends on how well it is organized. A systematic method for organization of design standards and codes is described and illustrated with an example. The method provides checks on the uniqueness and completeness of the organization, where organization is taken to include both the scope and the arrangement of the provisions. The method promotes the use of technically valid provisions and improves the efficiency of standards generating activities. The illustrative example is the organization of a performance specification for the structure of residential buildings.

The method is based upon objective qualities of an organization. The key element of the method is the systematic classification of provisions. Each provision is related by its syntax and semantics to several classifiers. Requisite properties of uniqueness and completeness are achieved in

the overall organization by requiring them in subsets of the classification and then building the overall organization in a systematic fashion.

Consensus standards formulation, J. V. Tyrrell, *SP518*, pp. 161-164 (Aug. 1978).

Key words: economics; formulation; innovation; market aggregation; performance requirements; prescriptive standards; standards development.

The charge has been made that the existence of standards inhibits innovation and consequently hampers technological advances. On the other hand, standards provide obvious benefits in consumer protection and economics through aggregation of markets. One possible remedy that has been advanced is provisions for accepting nonconforming products by exception. While such procedures would make introduction of new products easier, it would to a large extent destroy the fundamental purpose of a standard.

Another proposed remedy is to base all standards on performance requirements. While performance standards may be satisfactory in some cases, they are not a panacea that will easily solve all standards problems. Adequate definition of performance requirements and equally important acceptance requirements is a major problem. The pure performance standard opens the doors to unwanted features if it is not very carefully constructed.

The concept of standards is not wholly compatible with innovation, but standards provide sufficient benefit to warrant continued use. Their effectiveness depends upon procedures for formulation to make their purpose clear and identify their limitations.

The role of fire prevention and control on building construction and regulations, W. H. McLain, *SP518*, pp. 165-176 (Aug. 1978).

Key words: building codes; control measures; fire codes; fire safety; governmental actions; life safety; regulation; risk assessment; societal goals.

Fire prevention and control is an important feature of the modern building codes. Building set-back limits, structural design, and limitations on interior finish materials are among the building design parameters that reflect the public need for fire safety. Historically, codes have been developed to reduce mass urban fires and to limit property damage from the structural collapse of single building units. For example, a standard time-temperature curve has been developed and widely used (ASTM E119) for classification of building structural components in terms of a fire-time rating. More recently, there has developed an increased concern about life safety. Smoke and toxic gas produced by materials subjected to fire exposures are being evaluated and in some cases form part of a developing set of new regulations. The implementation of these new regulations poses a number of difficult problems to the local code regulatory and enforcement officials. An analysis is made of some of the alternative approaches which may be considered to aid the local building official in this important area of control.

Building regulation in the twenty-first century, H. J. Milton, *SP518*, pp. 177-190 (Aug. 1978).

Key words: building regulations; innovation; international standards; metrication; performance standards; research; technological trends.

Many research papers have been devoted to proposals dealing with innovation and rationalization in the building regulatory process.

This paper has two special features—it takes a broad and uninhibited look at the entire field of building controls, and it does so from an imaginary future date in September 2002, a quarter of a century after the Bozeman, Montana, conference. Instead of proposing changes, the paper takes a novel approach and discusses "retrospectively" the major changes that "have occurred" in the intervening 25 years. It thus provides food for thought without running into the gamut of reasons why changes cannot be made.

The Texas approach to energy conservation building standards, M. N. Hart, J. W. Jones, and W. Bowen, *SP518*, pp. 191-204 (Aug. 1978).

Key words: alternatives; ASHRAE 90-75; building standards; energy conservation; performance standards.

In 1975 the State of Texas Legislature mandated that energy conservation standards be developed for new State Buildings. The legislation called for the development of performance criteria and for guidelines for energy efficient design for different classes of state owned or financed buildings. In complying with the requirements of the law, the State Building Commission sought to minimize any adverse impact of the new standards on the design process.

The State of Texas Building Energy Conservation Standard is divided into sections on the envelope, mechanical equipment, lighting, and service hot water. The standard is similar to ASHRAE 90-75 in the mechanical equipment and service hot water sections, but differs in the lighting and envelope sections. The lighting section specifies watts per square foot for most task areas with foot-candle designations for unusual areas. The building envelope section provides a new approach. It assures a minimal thermal performance of the shell by specifying an Energy Envelope Index which is a function of building size and location. The EEI calculations are similar to standard procedures for estimating loads (such as those published by ASHRAE) and is presented in the State Energy Conservation Manual. These procedures are summarized in this paper.

It is felt that the State of Texas procedure, while innovative, provides a flexible and workable standard acceptable to both the State and the design professionals and introduces a new approach toward performance standards.

The need to implement energy conservative insulation standards based on average energy use rather than peak energy use—The New Mexico experience, W. J. van der Meer and L. W. Bickle, *SP518*, pp. 205-218 (Aug. 1978).

Key words: ASHRAE Standard; climatic conditions; energy conservation; glass area; heat transfer; insulation standards; U-values.

All Federal insulating standards for residence walls, ceiling and glazing are based on steady state U-values which govern the heat transfer rate only under conditions of peak energy use. Even the Component Design section of ASHRAE Standard 90-75 considers only steady state U-values as the basis for their requirements at arriving at stipulated average heat transmission values. Theoretical studies on heat transfer through walls and glazing, and studies of actual energy use for heating for a group of approximately 20 residences of different insulation amounts, made by the authors for the New Mexico Energy Resources Board, indicate that while added insulation may reduce heat transfer during peak energy use periods there is no proof that insulating for peak energy use periods reduces the overall or average energy consumption during the heating season. Quite the contrary, we find that insulation for peak energy use may be counterproductive and

result in a greater amount of energy used for the heating season than if one insulates for average energy use conditions.

A study of the effect of existing energy conservation regulations to assist in the selection of more comprehensive energy conservation standards, C. H. Fafard, *SP518*, pp. 219-250 (Aug. 1978).

Key words: ASHRAE standards; building envelope; building regulations; data collection; energy budget; energy conservation; heat loss; thermal performance.

The State of Wisconsin has had, since 1914, a statewide Administrative Building Code, administered and enforced by the Department of Industry, Labor and Human Relations (DILHR). This code regulates construction of all buildings except one- and two-family residences, farm buildings and temporary buildings. The rules contained in the code carry the stature of law.

An Energy Conservation Advisory Committee was appointed to DILHR by the Division Administrator, John Wenning, in December 1973, at the peak of the energy crisis. The committee made several recommendations, including lowering of inside temperatures and reducing the minimum ventilation from 7.5 c.f.m./person to 5 c.f.m/person. The committee also recommended a thermal performance standard which limited the heat loss through above-grade envelope areas to 13 Btu's per hour per square foot. These recommendations were incorporated into the Wisconsin Administrative Code in stages in 1974 and 1975. The thermal performance requirements generated strong opposition in the glass and masonry industries. These groups convinced a committee within the Wisconsin State Legislature to rescind the thermal performance section (May 1975) after five months of enforcement. The thermal performance requirements were reinstated in April 1976, when the full legislature did not act on the permanent suspension of the rules.

Rehabilitation as an instrument in meeting housing need: Can it really work? J. Heron, *SP518*, pp. 251-257 (Aug. 1978).

Key words: decision criteria; demolition; housing needs; physical condition rehabilitation.

There is an increasing trend in city planning toward rehabilitating older buildings and conserving neighborhoods that might have become slums, but the rehabilitation process is slow and unreliable. Few builders are interested in rehabilitation, most preferring new construction in the suburbs. A major question is: can the rehabilitation process be changed to attract more builders and become a high-volume business?

The suggested answer is that criteria to identify buildings needing rehabilitation and to specify what repairs need to be made must be developed, using the cumulative knowledge of builders who have done such work and the insight of people involved in building regulation. These criteria should deal with the fundamental structural and safety characteristics of buildings, to provide a yardstick for selecting the right buildings and deciding how much work is required.

The National Fire Incident Reporting System: Some uses of fire loss data, H. Tovey, *SP518*, pp. 259-283 (Aug. 1978).

Key words: building codes; data collection; fire hazards; fire protection; National Fire Data Center; regulation; reporting system; scenarios; system design.

The National Fire Data Center of the National Fire Prevention and Control Administration is directed by law to collect, analyze, and disseminate data on the occurrence, control, and results of fires of all types. One of the major objectives of this activity is to provide the building code community with information it needs for writing and updating building codes so that they provide as much protection at as low a cost as possible. The fire experience data collected by the National Fire Incident Reporting System of the Center has a high potential utility for that purpose. However, the initial data collected need significant improvement in completeness and accuracy. This paper describes the basic design of the National Fire Incident Reporting System, and illustrates several ways in which the data collected by the system can be used to identify and rank fire hazards associated with building structures. The current status of the system, including efforts to validate the data, are described.

Proposed draft for noise control abatement for the City of New Orleans, C. C. Mann, *SP518*, pp. 285-295 (Aug. 1978).

Key words: awakening to problems; deceptive sounds; establish legal limits; tolerance level differences.

The everyday sounds of simply existing can be very deceptive to us as individuals. Music, for example, is soothing and refreshing to some persons while to others, the same music may be distracting and unpleasant. The rock-and-roll that brings pleasure to one individual might be found distasteful by another individual. We, as individuals "on the street" do not think of noise unless it becomes irritating to us or "gets on our nerves." It has been said that sound is not a "noise" unless it annoys.

This paper is a search into some of the large cities' approaches to their noise problems, with an added proposal to this same noise problem for the City of New Orleans. Many controls are being generated, developed and perfected, and as a result, future generations should have a quieter environment in which to live and work. Much is yet to be accomplished, however, and efforts toward this goal should not be lessened or allowed to become diminished.

Residential energy conservation building regulations and their impact on the building process, M. Green, *SP518*, pp. 297-312 (Aug. 1978).

Key words: building regulations; enforcement; energy conservation; legislation; standards development; survey findings; training.

In early 1977, a study was conducted under contract to the State of California. This work was a portion of a larger contract from ERDA to document the history problems and success of the California residential energy regulations adopted in February 1974. The resulting report, based on personal interviews with code enforcement officials, architects, developers, contractors, material suppliers and manufacturers, and homeowners, describes the impact and changes caused by these regulations on segments of the building industry. This paper will briefly discuss these impacts within the context of statewide energy conservation building regulations.

In addition, the paper will summarize the procedures of the State to develop and implement residential energy regulations. The paper concludes with procedural recommendations for Federal, State, and local government.

The energy conservation code: Implementation in New Mexico, J. O. Dritt, *SP518*, pp. 313-322 (Aug. 1978).

Key words: building code; code officials; effective "U" values; energy conservation; implementation; professional competence; training program.

Officials of the State of New Mexico agreed in September 1976 to adopt the proposed Chapter 53 of the Uniform Building Code (UBC) published by the International Conference of Building Officials (ICBO) with scheduled implementation of July 1, 1977. This paper describes the key elements of an implementation scheme through the utilization of innovative research, development of code Applications Manual, and the conduct of a formal statewide training program for all building officials.

Impact of State mandated thermal efficiency standards on counties, S. Guenther and A. Twitchell, *SP518*, pp. 323-358 (Aug. 1978).

Key words: buildings; counties; energy conservation; enforcement; insulation; regulations; standards; State legislation; thermal efficiency.

Nineteen States have adopted energy-related building regulations since the 1973 Arab oil embargo, but there is considerable variation among the States according to performance and prescriptive criteria, mandatory and voluntary regulations, etc.

The remaining States will soon be adopting thermal efficiency codes as part of their State Energy Conservation Plans, and the Department of Housing and Urban Development is currently developing a national standard for new buildings.

Hundreds of counties have been required to enforce the existing State-mandated codes, and many hundreds more will become involved in the near future.

The National Association of Counties Research Foundation studied the effects of State-mandated thermal efficiency codes on five counties. We found that those codes requiring only a minimal amount of insulation and double glazing for windows appeared to present no major legal, political, operational, or financial problems for counties. Experience with more sophisticated codes is limited.

Regulatory administration: A function of perceived priorities, costs and benefits, N. S. Remmer, *SP518*, pp. 359-369 (Aug. 1978).

Key words: building codes; cost-benefit; decision making; priorities; regulatory agency; resources; risk.

This paper discusses the problems of building regulatory agencies in facing rapid advances in the technology and scope of building regulation and the implied increase in volume of work. The paper attempts to identify distinct classes of obligation for the regulatory agency based on a range of requirements starting with those proven critical to life safety and those mandated by legislation and highly visible to the public to those which represent the possibility of applying wide discretion in judging risk and assigning a priority based on community benefits. The paper gives examples of how decisions affecting risks versus benefit

might be implicitly applied in every day operations of an agency and the significance of these judgments in terms of an acceptable risk level. As workloads increase and technology and mandatory legislation increase in scope and volume, local regulatory agencies, faced with limited resources, must make decisions which reflect a systematic prioritization of functions based on judgments of risk, costs, and benefits.

Development of interface between the regulator and the manufacturer's quality control personnel, E. Starostovic, *SP518*, pp. 369-379 (Aug. 1978).

Key words: certification; compliance assurance programs; industrialized building construction; inspection; personnel qualifications; quality control manual; regulations; third party agencies; training.

The subject of this paper encompasses the manufacturer's commitment to quality control including designation of inspectors who are held accountable. Other aspects will include coverage of: development of inspection aids; regular monitoring of both product and inspection personnel; training of personnel in a formal classroom environment including required annual recertification; classroom written examination, grading process, and PFS Quality Assurance Council review; progress reports after classroom training and as a prerequisite for final written certification; maintenance of year-to-year certification; decertification procedures; case histories of decertification; impact on product quality.

Legal aspects of the building regulatory process, P. J. Moriarty, *SP518*, pp. 381-390 (Aug. 1978).

Key words: building official; building regulations; code enforcement; construction; court decisions; disasters; economics; legal approach; regulatory process; violations.

Building regulations had a beginning, a middle and will have no end. Since the time man first built a shelter which in some way affected the shelter of another, building and housing regulations out of necessity arose. As man progressed and his needs improved, laws were enacted to control his activities and a few of these laws regulated the use and construction of his shelter. It will be attempted here to briefly illustrate the ways in which this shelter has been regulated and misregulated and to show that in several years we have not yet reached an atomic age in the building regulatory process. As the building regulatory process becomes more complex and technical, the building official must become more knowledgeable and technical. It will also be seen how the courts have reminded the building official that the public need not tolerate a building code requirement simply because it is so written.

SP523. **Wind and seismic effects.** Proceedings of the Ninth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, May 24-27, 1977, Tokyo, Japan, H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 523*, 518 pages (Sept. 1978) SN003-003-01979-8.

Key words: accelerograph; codes; design criteria; disaster; earthquake hazards; earthquakes; ground failures; seismicity; solids; standards; structural engineering; structural responses; wind loads; winds.

The Ninth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Tokyo, Japan on May 24-27, 1977. The proceedings of the Joint Meeting include the program, the formal resolutions, and the technical papers. The subjects covered in the paper include (1) characteristics of strong winds; (2) wind loads on structures and design criteria; (3) earthquake prediction; (4) earthquake ground motions and soil failures; (5) seismic loads on structures and design criteria; (6) design of special structures; (7) earthquake hazard reduction program; and (8) quantitative evaluation of damages caused by winds and earthquakes. *These proceedings include the following papers (indented):*

Distribution models of pressure and wind over stationary typhoon fields, S. Fujiwhara and K. Kurashige, *SP523*, pp. I-1—I-9 (Sept. 1978).

Key words: distribution models; pressures; sea surface; stationary typhoon.

For pressure and wind distributions on the sea surface over typhoon and hurricane area, many trials have been proposed in order to adapt distribution models for observational data. These models have been utilized widely in many scientific and technical applications. For example, theoretical analysis, storm surge, disaster evaluation, protective measurement against typhoon damage, and so on.

The above models proposed are simple models. Unfortunately, however, the better adaptation for observed data requires more complicated models. However, the advent of the electronic computer has brought about the methods which can shorten the computational time tremendously. Therefore, the models no longer have to be simple.

In this paper, several new models are introduced and their characteristics are discussed. Then, basic differences between the formulas by various models are pointed out clearly. In order to increase the accuracy of model adaptation, a technique of revising the formulas is discussed. Taking into account the computation time of the electronic computer, a new model formula is presented and examined by comparing it with other formulas.

Extreme winds in the United States, T. D. Potter and M. Changery, *SP523*, pp. I-10—I-15 (Sept. 1978).

Key words: design requirements; design standards; extreme winds; hurricanes; property damage.

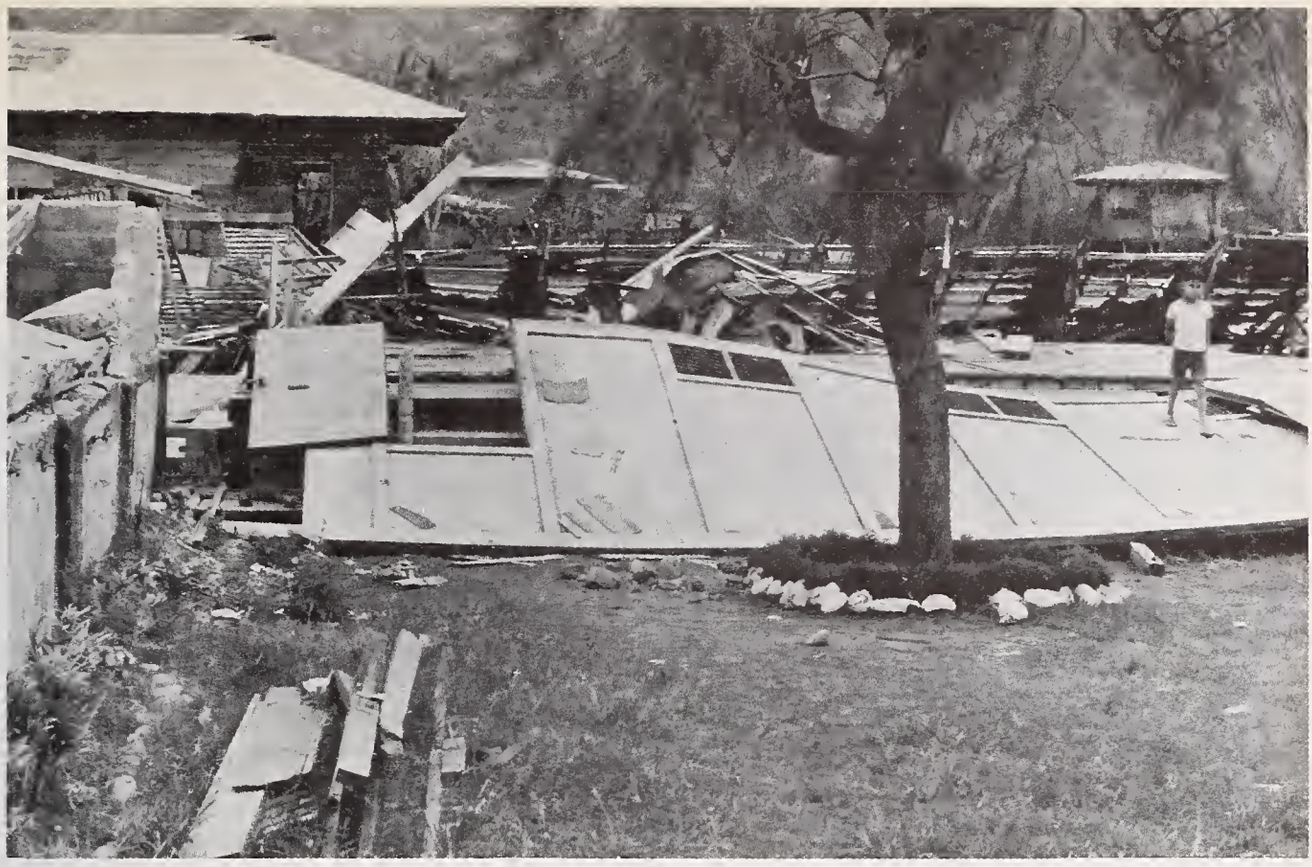
Each year extreme winds in the U.S. cause extensive property damage and occasionally the loss of lives. This paper will first review the patterns of extreme winds in the U.S. and the associated wind damage. The types of maximum wind speed data currently available are then discussed. Finally, problems associated with using these maximum wind speed data in U.S. design standards are considered.

Aerodynamic stability of a long-span suspension bridge at construction stage, T. Kunihiro, N. Narita, and K. Yokoyama, *SP523*, pp. II-1—II-19 (Sept. 1978).

Key words: aerodynamic stability; construction stages; suspension bridge.

Wind accidents on bridge structures have so far occurred at their construction stage, and this necessitates confirming the safety of a structure under construction as well as after completion. The aerodynamic safety of a suspension bridge at construction stage is especially important, because the rigidity and the relevant dynamic characteristics of the stucture alter gradually as the construction work proceeds.

The aerodynamic stability of suspension bridges at construction stages for the Seven Bridge (1), the Kanmon Bridge (2), the Honshu-Shikoku Bridge (3,4) and the Narrows Bridge (5) has already been examined by others. These studies demonstrated the importance of the problem.



However, the erection method of a bridge depends largely on the conditions that, how much clearance is necessary for navigation during construction period and what kinds of erection machines are available, etc. Therefore, the results of this study cannot be applied directly to other bridges.

This paper describes the design wind speed and the aerodynamic stability of suspended structure of the Hirado Ohashi Bridge.

Present situation of earthquake prediction research in Japan, K. Hamada, H. Takahashi, H. Sato, and A. Suwa, *SP523*, pp. III-1—III-19 (Sept. 1978).

Key words: earthquake prediction; Japan National Program; present state.

An outline of the Japanese National Program of Earthquake Prediction is introduced here. First, the progress up to date of the national program of earthquake prediction; second, the organizations related to the prediction, their main roles, and the organizational structure; third, the strategy of earthquake prediction by the coordinating Committee for Earthquake Prediction (CCEP); fourth, the activities of the CEEP; fifth, the present state of earthquake prediction; sixth, the promotion of the prediction program, including the authors' points of view and finally, the following items of research and observations are introduced: 1. Geodetic survey; 2. Tidal observation; 3. Continuous observation of crustal movement; 4. Seismic observation; 5. Velocity change of seismic waves; 6. Active faults and folding; 7. Geomagnetic and geoelectric observations; 8. Laboratory experiments; 9. Works related to ground water; 10. Data processing and monitoring system.

The complementary importance of earthquake prediction and structural response estimation in seismic design and planning decisions, R. K. McGuire, *SP523*, pp. III-20—III-29 (Sept. 1978).

Key words: design decisions; minimum cost; seismic risk.

The present uncertainty in estimating the responses of manmade and natural structures to earthquake threats is translated into cost penalties reflecting costs associated with possible failure of the structure due to underestimated response, and costs associated with overdesign of the structure (or over-conservative reaction to a hazard) due to overestimated levels of motion. The important uncertainties for seismic design and planning decisions are those associated with the size, location, and time of future earthquakes, and those associated with estimating ground motion and structural response during these events. It is shown that reducing the uncertainties in one part of the problem has only a minor effect on reducing the (social and economic) cost of earthquakes unless significant and complementary advances are also made in reducing the uncertainties of the other part.

Research and development of permanent ocean-bottom seismograph observation system off the Pacific Coast to central Honshu, Japan, A. Suwa, N. Yamakawa, and T. Iinuma, *SP523*, pp. III-30—III-43 (Sept. 1978).

Key words: cables; development of submarine equipment; earthquake prediction; ocean-bottom seismograph.

Eighty to ninety percent of all the earthquakes in the world occur in the sea area. However, there is not a single permanent ocean-bottom seismograph yet; this is the weakest point in seismic activity monitoring and earthquake prediction. The Seismology and Volcanology Division of the Meteorological Research Institute has been engaged in the development of a permanent ocean-bottom seismograph observation system off the Pacific coast of Tokai District, central Honshu, which is one of the major items included in the 3rd Five-Year Plan of the National Program of Earthquake Prediction Research in Japan (1974-1978).

The observation system being developed consists of the combination of submarine and land equipment. The submarine equipment consists of one terminal apparatus and several intermediate apparatus, i.e., pressure vessels containing seismograph and tsunami-meter sensors, and signal transmitters, which are connected in series by a submarine co-axial cable. This equipment is laid one hundred and twenty kilometers off Omaezaki, Shizuoka Prefecture, at the ocean-bottom down to 3,000 m below sea level. On the other hand, the land equipment consists of receiving and repeating apparatus in the shore station (Omaezaki Weather Station), and receiving and data processing apparatus at the Earthquake and Tsunami Center (Japan Meteorological Agency in Tokyo).

This development project has been progressively implemented. Trial layings of the submarine equipment have been carried out already and actual layings are planned in 1978.

Vertical distribution of the seismic S-wave velocities at the site of the Iwatsuki Deep Borehole Observatory of Crustal Activities, F. Yamamizu and H. Takahashi, *SP523*, pp. III-44—III-54 (Sept. 1978).

Key words: deep borehole; earthquake, in-situ velocity measurement; S-wave; vertical distribution of seismic wave.

From the earthquake engineering point of view, in-situ velocity measurement of the seismic S-wave was carried out down to a depth of 3500 meters at the site of the Iwatsuki Deep Borehole Observatory constructed by the National Research Center for Disaster Prevention.

S-waves were produced mainly by ordinary small chemical explosions in a shallow borehole and supplementarily by an SH-wave generator (an S gun) firmly pressed on the ground surface. A set of three-component seismometers of moving-coil type with natural frequency of 4.5 Hz was installed in a capsule which could be fixed at any depth in the borehole. Repeated measurements were made at 16 different depths from the surface to the bottom. The S-wave by the S gun was clearly recorded down to the depth of 1500 m. Identification of the S-wave onset on the record of the explosion was unexpectedly easy, even for depths deeper than 1500 m, because very good phase correspondence between the S phase from the S gun and the S phase from the explosion was obtained. Therefore, the reading of the S-wave onset was most reliable.

The estimated S-wave velocity structure was 0.44, 0.76, 1.3, 1.6 and 2.6 km/sec with the boundary depths of 300, 1000, 2000 and 2800 m, respectively, from the surface to the bottom of the borehole. The boundary at 2000-m depth was uncertain unlike the other three boundaries. This boundary may not exist, or the velocity may change gradually with depth.

The P-wave velocity structure was estimated at the same time, and the velocity values were 1.8, 2.1, 2.9 and 4.7 km/sec with the boundaries very close to those of S-wave velocity. But the 2000-m depth boundary was not found.

Research on active faults in the metropolitan area, H. Sato and T. Kakimi, *SP523*, pp. III-55—III-62 (Sept. 1978).

Key words: detection of active faults; earthquake prediction; research on active fault.

The present state of research on active faults in the metropolitan area is discussed. The paper describes the discovery of two active faults, the Tachikawa Fault and the

Arakawa Fault, in the Kanto plain. The paper also points out that at present there is no definitive method(s) to detect active faults covered by thick sediment. The geophysical methods commonly employed in underground research work present problems when the methods are used for research on active faults in urban areas. Geochemical methods should be considered.

Characteristics of vertical components of strong-motion accelerograms, T. Uwabe, S. Noda, E. Kurata, and S. Hayashi, *SP523*, pp. IV-1—IV-19 (Sept. 1978).

Key words: design; horizontal acceleration; seismic coefficients; stability; strong-motion accelerogram; structures; vertical acceleration.

Characteristics of vertical components of the 574 strong-motion accelerograms were studied in order to determine the effects of vertical ground motions on dynamic stability of structures. The following were made clear.

1)According to accelerograms with the maximum acceleration of over 50 gals the ratio of the maximum acceleration on the vertical component to that on the horizontal component was less than 1/2.

2)The occurrence time of the maximum acceleration on the horizontal component was different from that on the vertical component. At the time when the safety factors against sliding and overturning were the smallest, the ratio of the vertical acceleration to the horizontal acceleration was less than 1/3.

3)The stability analysis of the gravity type quaywalls based on a current design method of port facilities was performed considering the vertical seismic coefficient. Consequently, the vertical seismic coefficient was found to have little influence on the safety factor for gravity type quaywalls.

Developments in strong-motion data management, A. G. Brady, *SP523*, pp. IV-20—IV-27 (Sept. 1978).

Key words: accelerograms; digitization; high frequencies; low frequencies.

Some recent developments in the procedures for digitization and subsequent analysis of strong-motion earthquake accelerograph records are described. The standard digitizing and analysis procedures of the California Institute of Technology's Earthquake Engineering Research Laboratory have been well documented for several years now and apply well to the long-duration, high-amplitude recordings that were the main content of the project. This paper provides further descriptive material dealing with the care needed in using standard analysis procedures on records which cannot be described as standard. In particular, short duration records, where except for a few peaks the amplitudes are low, have noise problems that can only be reduced by considerable reduction of the frequency range containing valid data. The Seismic Engineering Branch of the U.S. Geological Survey, in continuing the digitization and analysis of significant records, has modified the standard procedures where experience has shown such adjustments are necessary, and plans to make further modification where appropriate.

On a method for synthesizing the artificial earthquake waves by using the prediction error filter, K. Ohtani and S. Kinoshita, *SP523*, pp. IV-28—IV-47 (Sept. 1978).

Key words: accelerogram; artificial earthquake; covariance; filter; finite Fourier expansion; prediction error; random variables; synthesis; wave.

Several methods for synthesizing the artificial earthquake waves have been reported for the purpose of dynamic analysis and earthquake-resistant design of structures. In the present report, the authors discuss a method by using "the prediction error filter," in which there are less numbers of the required parameters than those in other methods and also these parameters are more easily estimated. This method is based on the linear prediction model for the earthquake wave in the time domain. Therefore, parameters by which the prediction error filter is constructed are computed from the sequence of covariance matrices that represent the characteristics of earthquake waves in the time domain.

As compared with the methods using the finite Fourier expansion by harmonic functions, this method uses the finite Fourier expansion by uncorrelated random variables, and the filter is designed in the time domain. Also, the number of terms of this expansion is automatically determined by using "An Information Criterion" (AIC) proposed by Akaike. The relationship introduced by the authors for synthesizing correlated multi-dimensional waves show an example of synthesis by using an observed strong-motion accelerogram.

Statistical analysis of strong-motion acceleration records, M. Ohashi, T. Iwasaki, S. Wakabayashi, and K. Takida, *SP523*, pp. IV-48—IV-77 (Sept. 1978).

Key words: design; earthquake magnitude; epicentral distance; statistical analysis; strong-motion acceleration records.

This paper briefly discusses the present status of strong-motion observation for engineering structures in Japan. Next, it presents the results of the multiple regression analysis of 301 strong-motion acceleration records to evaluate the effects of earthquake magnitude, epicentral distance and subsoil condition on characteristic variables of ground accelerations such as maximum horizontal acceleration, time duration of major motion, ratio of vertical to horizontal accelerations, etc. The paper also shows the results of a quantification analysis of average response accelerations obtained from 277-component horizontal acceleration records to clarify the effects of seismic and subsoil conditions on average response spectra.

From the analysis performed, empirical formulas which can statistically estimate maximum horizontal acceleration, duration of major motion, and number of zero-crossing in terms of earthquake magnitude, epicentral distance, and subsoil condition, are proposed. Frequency characteristics of horizontal motions and ratios of vertical to horizontal accelerations are evaluated and averaged depending on subsoil conditions. Furthermore, various average response spectrum curves for a linear single-degree-of-freedom system are proposed in terms of earthquake magnitude, epicentral distance, and subsoil condition.

Research on design earthquake, M. Watabe, *SP523*, pp. IV-78—IV-95 (Sept. 1978).

Key words: design earthquake; deterministic intensity function; historical data; maximum values; random characteristics; seismic zoning; spectral shapes; theoretical analysis.

The maximum values of accelerations, velocities and displacements of the ground motions due to earthquakes are first discussed utilizing the historical data as well as some theoretical approaches. Then, duration time and the deterministic intensity function of the accelerograms are introduced. The predominant periods and spectral shapes of the strong motion accelerograms are also reported. Historical earthquake data were utilized to assess the earthquake risks in Japan. Finally the explanation of proposed "design earthquake" concludes this report.

Determination of wave propagation velocities in subsurface soil layers, Y. Shioi and T. Iwasaki, *SP523*, pp. IV-96—IV-114 (Sept. 1978).

Key words: harmonic wave; Love waves; model structure; Rayleigh waves; soil-structure interaction; vibrator.

Activities of the Committee on Earthquake Observation on Soil-Structure Interaction have been described. One of the committee's research activities is the research involving the construction of a model structure, soil investigations, dynamic tests and analysis of dynamic soil-structure interaction.

This paper discusses the results of forced vibration tests conducted on a model structure with a vibrator which generated harmonic waves. These waves were then compared with the Rayleigh and Love waves.

Studies on soil liquefaction related to earthquake resistant design of structures, M. Ohashi, T. Iwasaki, and F. Tatsuoka, *SP523*, pp. IV-115—IV-157 (Sept. 1978).

Key words: bridge foundations; dynamic triaxial tests; liquefaction; model tests; pile foundations; sand; shake table; standard penetration test.

In order to evaluate dynamic behavior of structural foundations and embedded structures during earthquakes, it is essential to estimate the effects of the sorrounding soils on these structures. The authors have conducted a literature survey on the effects of liquefied soils on bridge foundations and also conducted laboratory experiments using models of pile foundations including surrounding soils.

Furthermore, a simplified method to evaluate liquefaction potential of sand deposits was investigated on the basis of numbers of blows (so called N-values) by the standard penetration test. Proposed herein are the critical N-values which can be used in determining liquefaction potential. This method can estimate whether the sand deposit may likely liquefy or not during future severe earthquakes by means of comparing N-values measured at the site of interest with the critical values proposed. These critical values were determined on the basis of dynamic triaxial tests on undisturbed sand samples and N-values measured at the points where the undisturbed samples were obtained.

These studies are to clarify the effects of liquefied soils on pile foundations and to establish design methodology of pile foundations considering the effects of soil liquefaction.

Earthquake resistant design based on ground motions at base-rock, E. Kuribayashi and K. Kawashima, *SP523*, pp. IV-158—IV-179 (Sept. 1978).

Key words: analytical method; base-rock; bridge foundations; deconvolution procedure; earthquake records; ground conditions; ground transfer functions; shear wave.

It is generally known that dynamic behaviors of structures are influenced by their ground conditions and that earthquake ground motions recorded are dependent on their ground conditions. In order to specify common input earthquake motions for design of every structure on and under ground, it is useful to select base-rocks in ground, where effects of grounds near surface are small enough to be ignored, as an input terminal where earthquake motions are to be specified. In order to improve such seismic designs, discussions on necessary conditions of base-rock and on accuracies of base-rock motions estimated by theoretical calculations are presented. Earthquake responses of bridges are also presented as a numerical example.

Basic earthquake for dam design, J. S. Dodd, *SP523*, pp. V-1—V-13 (Sept. 1978).

Key words: earthquakes; dams; dynamic analysis.

Modern computational techniques permit mathematical dynamic analysis of concrete and embankment dams. Steps in the analysis are: (1) specify location, depth, and magnitude of critical specifically located earthquakes, (2) attenuate seismic waves to site, (3) determine site response to seismic waves, (4) analyze response of structure, (5) evaluate results. This discussion addresses the first step and proposes the establishment of a minimum earthquake—the basic earthquake—for damsites in the western United States.

Study on regional distribution of maximum earthquake motions in Japan, M. Ozaki, Y. Kitagawa, and S. Hattori, *SP523*, pp. V-14—V-44 (Sept. 1978).

Key words: earthquake danger; Gumbel's theory of extremes, literature review; regional seismic coefficient map; statistical analysis.

Research activities in the earthquake danger have been critically reviewed. Many researchers concentrated on the study of the past earthquake data and statistical analyses of these data.

This paper presents an application of Gumbel's theory of extremes for the prediction of the intensity of future earthquakes. The paper concludes with a new regional seismic coefficient map of Japan.

Treatments on seismic force in designing earth structures, K. Sawada, *SP523*, pp. V-45—V-52 (Sept. 1978).

Key words: culverts; design principle; earth structure; earthwork manual; fill slope; priority; retaining wall; seismic forces.

Treatment of earthquake forces in the design of retaining walls and of embankment slopes is discussed. The discussion centers around the philosophy and considerations given when Japan Road Association revised its Earth Work Manual in Road Construction.

Studies on the aseismic properties of underground pipes, K. Ohtani, N. Ogawa, and C. Minowa, *SP523*, pp. V-53—V-68 (Sept. 1978).

Key words: dynamic water pressure; shaking table; underground pipes; vibration experiments.

This paper describes the experiments of underground pipes by using the large-scale shaking table of the National Research Center for Disaster Prevention, the analysis results of dynamic water pressure on pipelines caused by earthquake motions, and the problem of the slip between the surface of pipe and the soil.

Two kinds of experiments were executed. In the first experiment a linear pipeline (steel) was buried in the ground at the vicinity of this shaking table. The test pipeline was excited by the waves which were generated from the shaking table and transmitted through the ground. The behaviors of this pipeline and the ground would not always be similar because of the differences in the rigidities between pipe and soil and in the boundary conditions of pipeline ending. In this experiment, slight differences were measured between the behaviors of the test pipeline and the ground.

In the second experiment, a steel pipeline with a branch pipe was set on this shaking table and one end of the main pipe was clumped in the shaking table foundation. And this pipeline was buried in the sand pit. The bending strains and restoring forces of this pipeline were measured. The dynamic strains had the values similar to those of static strains for the same displacements. The hysteresis loops, drawn by the restoring force and displacement at the clumped end, had the energy absorption. The necessity for the second experiment was based on the slip which had grown around the pipe surface in disastrous earthquakes. The slip values of the infinite length pipeline with a branch pipe were calculated for sinusoidal ground waves.

In addition to these problems concerning water supply plpelines, etc., the water pressure in the pipelines has to be considered. In this paper, the procedure for estimating the distributions of dynamic water pressures caused by earthquakes without the so-called water hammer has been developed. For example, the dynamic water pressures for model pipelines are calculated.

Observation of dynamic behavior of Kinuura Submerged Tunnel during earthquakes, S. Nakayama, O. Kiyomiya, and H. Tsuchida, *SP523*, pp. V-69—V-79 (Sept. 1978).

Key words: accelerometer; axial force; bar stress transducer; bending moment; displacement meter; dynamic behavior of tunnel; power spectrum; strain meter; submerged tunnel.

Kinuura Submerged Tunnel, which is located at Kinuura Port and Aichi Prefecture, is equipped with a number of instruments comprising of accelerometers, strain meters, bar stress transducers, and a displacement meter, which are intended to serve the purpose of the tunnel maintenance and to provide data for studying the behavior of the submerged tunnel during earthquakes.

The measurement of earthquake response of the tunnel has been carried out since August, 1973 when the tunnel was opened to traffic. Fifteen earthquakes have been recorded up to January, 1977. A part of the data thus obtained and its analysis have already been reported by the authors. This paper describes the analysis of the data and the result of earthquake response calculations carried out by using these earthquake records.

A proposal for earthquake resistant design methods, K. Nakano and M. Ohashi, *SP523*, pp. V-80—V-101 (Sept. 1978).

Key words: coefficients in aseismic design; design method; proposed earthquake resistant design method; seismic hazard zoning map.

This paper describes the outline of a Proposal for Earthquake Resistant Design Methods, which was completed by the Ministry of Construction in March, 1977.

The earthquake response of hysteretic structures, W. D. Iwan and N. C. Gates, *SP523*, pp. VI-1—VI-14 (Sept. 1978).

Key words: ductility; earthquake response; empirical formula; hysteretic structures; inelastic response spectra.

The earthquake response of a broad class of hysteretic structures is investigated. Inelastic response spectra are determined. Based on these spectra, an effective linear period and damping are defined for each type of hysteretic structure as a function of ductility. A simple empirical formula is presented which may be used to estimate the response of a general hysteretic structure given the linear response spectrum of the excitation. The predictions obtained from this formula are compared with those of another frequently used scheme for estimating the response of hysteretic structures.

On the object postulate for earthquake-resistant code, K. Nakano, Y. Ishiyama, Y. Aoki, and K. Watanabe, *SP523*, pp. V-102—V-116 (Sept. 1978).

Key words: acceptable level of human risk; construction costs; earthquake resistant code; expected seismic force; object postulate; reliability theory; social utility.

What the object of the earthquake-resistant code should be and how to define the object are the concerns of the object postulate. Since the seismic forces and the earthquake-resistant capacity of the buildings have certain dispersions, it is necessary to introduce the concept of the reliability to define the object postulate. This report deals with research on 1) dispersions, 2) relation between the earthquake-resistant capacity and the construction cost, 3) acceptable level of human risk, and 4) principle of social utility to optimize the importance factor, in order to define the object postulate for the earthquake-resistant code.

Earthquake resistant design of high-rise buildings in Japan, K. Ohtani, *SP523*, pp. VI-15—VI-24 (Sept. 1978).

Key words: building height limitation; building volume limitation; earthquake resistant design; flexural-shear model; high-rise buildings; histogram for building uses; shear model.

In January, 1964, the building height limitation which had been stipulated in the Structural Standard Law of Japan since 1921 was replaced with the building volume limitation. Number of high-rise buildings exceeding 45 meters in height came out to be about 300 cases. These buildings are examined thoroughly for the aseismic safety by dynamic analysis instead of static analysis, and received judge-and-rating as to the propriety of structural design from the committee consisting of specialists.

In this report, I discuss the present state of design, especially of dynamic analysis, using the design specification presented to the above committee. The number of data used in this report is 78 for SRC (composite steel and reinforced concrete structure) and 160 for S (steel structure) omitting special type structures such as high chimneys, towers, etc. As this study is the research of materials based on the actual design specification, I refer to the problems of aseismic design or the future subjects of research and development by considering the trend of design.

Racking strength of wood-frame walls, R. L. Tuomi, *SP523*, pp. VI-25—VI-34 (Sept. 1978).

Key words: corner brace; inplane shear forces; racking stiffness; racking strength; windloads.

Evaluation of the racking strength of wall systems has generaliy been limited to performance testing. Acceptance criteria for ultimate racking strength of sheathed walls are based on the strength of a wall with a let-in corner brace and horizontal board sheathing.

An analytical method for predicting racking performance has been developed that appears promising. It is independent of panel size, and small-scale tests can be used to augment the more costly standard tests. A small-scale loading apparatus was designed for rapid testing of wall sections.

Let-in corner braces using today's construction methods and materials no longer meet even the minimum level of acceptance. This is due to the elimination of horizontal board sheathing and the reduction in actual lumber sizes which took place since the racking performance standards were established.

Racking stiffness is an important performance consideration that has not been investigated. New testing apparatus has been designed that will make possible future evaluations of racking stiffness.

Examination for an evaluation method of damage to existing wooden houses caused by earthquakes, K. Ichihara, E. Kuribayashi, T. Tazaki, and T. Hadate, *SP523*, pp. VII-1—VII-15 (Sept. 1978).

Key words: damages of structure by earthquake; disaster mitigation; probability theory; ratio of razed houses; wooden houses.

In an effort to help draft an earthquake disaster mitigation program, an evaluation method for damages of structures by earthquakes is proposed. Concepts of the ratios of razed houses and probability theories with number of razed houses have been employed in the method.

Relationship between modified Mercalli intensity and wood frame dwelling earthquake insurance, K. V. Steinbrugge and S. T. Algermissen, *SP523*, pp. VII-16—VII-28 (Sept. 1978).

Key words: earthquake insurance; earthquake losses; intensity-loss relationships; loss simulation.

Traditionally, earthquake insurance rates have been based on business judgment tempered by engineering input obtained from analyses of observed earthquake damage. The development of loss simulation techniques has provided important new input for improvement of the basis for earthquake insurance rates. Some important loss simulation results are reviewed. Modified Mercalli intensity can be directly related to dwelling loss and is an important parameter in dwelling loss simulation studies. Careful additional study of existing dwelling loss data (such as is available for the 1971 San Fernando, California, earthquake) together with well planned damage studies after future earthquakes will lead to greatly improved loss estimates. Probabilistic loss models should also be developed for dwelling loss studies and the effects of parameter uncertainties taken into account.

Warrants for retrofitting highway bridges, A. Longinow, E. Bergmann, and J. D. Cooper, *SP523*, pp. VIII-1—VIII-21 (Sept. 1978).

Key words: bridges; earthquake; retrofit decision.

A methodology for determining whether or not to seismically retrofit an existing bridge is presented. The method is based on the concept of identifying and comparing the importance of the bridge to its structural integrity. Criticality factors which are expressed in terms of bridge classification and its importance to the social, medical, economic, and security needs of a geographical area following a natural disaster are developed. Structural factors, which estimate a bridge's ability to withstand an earthquake, are determined analytically or by inspection. The criticality and structural factors are compared to determine if a bridge warrants retrofitting. The method is demonstrated by example.

Criterion on the evaluation of seismic safety of existing reinforced concrete buildings, K. Nakano, M. Hirosawa, and S. Okamoto, *SP523*, pp. VIII-22—VIII-41 (Sept. 1978).

Key words: evaluation method of seismic safety; nonstructural elements; reinforced concrete buildings; seismic safety index; structural elements.

The outline of "Criterion on the Evaluation of Seismic Safety of Existing Reinforced Concrete Buildings" by the Ministry of Construction is discussed in detail. The evaluation method consists of three steps with use of various seismic indices.

Transferring the technology for wind-resistant buildings to developing countries, N. J. Raufaste, Jr., *SP523*, pp. VIII-42—VIII-46 (Sept. 1978).

Key words: buildings; design criteria; developing countries; technology transfer; windloads.

The National Bureau of Standards project to develop improved design criteria for low-rise buildings to better resist high winds was recently completed. It contained two essential parts. The first included developing technology to reduce wind damage to buildings through improved building practices. The second part centered around making sure these improved building practices actually reached the individuals who construct and live in buildings. The latter has traditionally received minimum attention. This paper presents a method for getting the results of the NBS wind research to the building community which includes building owners and users who need it most. A 3-level approach to this method is described. The method used can be a model for other research projects aimed at technical, semi-technical, or even semi-literate audiences.

SP524. **Assessment of current building regulatory methods as applied to the needs of historic preservation projects,** R. V. Keune, *Nat. Bur. Stand. (U.S.), Spec. Publ. 524*, 87 pages (Oct. 1978) SN003-003-01990-9.

Key words: architecture; building regulatory system; codes; health and safety; historic buildings; historic preservation; impacts; performance-based standards; research.

To meet contemporary health and safety requirements as defined by the building regulatory system, conflicts frequently occur with the needs of historic building preservation projects. This project: (1) identified, evaluated and proposed historic preservation categorical definitions as applied to buildings; (2) developed performance objectives, requirements, criteria and tests for each definition category; and (3) identified and assessed those current methods most commonly used by regulatory jurisdictions to mitigate adverse impacts on building preservation projects.

SP530. **Metrication in building design, production, and construction—A compendium of 10 papers,** H. J. Milton, *Nat. Bur. Stand. (U.S.), Spec. Publ. 530*, 188 pages (Sept. 1978) SN003-003-01971-2.

Key words: economics of metric conversion; harmonization; management of change; metrication; metric familiarization; rationalization; SI; standardization; transitional period.

This publication is a compendium of ten papers prepared by Hans J. Milton, Technical Consultant on metrication and dimensional coordination to the NBS Center for Building Technology. It may be used as an information and general reference document in the metric subject area.

International experience has enabled the author to refer to precedent in other English-speaking countries which have preceded the United States in the change to metric (SI). The papers are directed at the disciplines of building design, production, and construction. However, they contain much information which could be adapted for use in other sectors of the economy.

Some of the subject areas addressed are: management and economics of metrication; specific product metrication; public construction sector role in metrication; building standards and codes in metrication; graphic design in metrication; and, United States' opportunities in metrication.

A subject index has been included for ready reference to specific metric topics. *This compendium includes the following papers (indented):*

More efficient technology, research, industry and commerce—The metric opportunity, H. J. Milton, *SP530*, pp. 1-9 (Sept. 1978).

Metrication in the construction community—The role of the Federal agencies and the public construction sector, H. J. Milton, *SP530*, pp. 11-20 (Sept. 1978).

The principal management considerations in metrication of construction standards and codes, H. J. Milton, *SP530*, pp. 21-37 (Sept. 1978).

Managerial and economic considerations in the change to a metric production environment, H. J. Milton, *SP530*, pp. 39-60 (Sept. 1978).

Metrication and the contracting community, H. J. Milton, *SP530*, pp. 61-80 (Sept. 1978).

Metrication—A concrete opportunity, H. J. Milton, *SP530*, pp. 81-99 (Sept. 1978).

Metric sizes for building lumber and other wood products: The issues, international precedent, and suggestions for the U.S. wood products industry, H. J. Milton, *SP530*, pp. 101-133 (Sept. 1978).

New measures in graphic design and publications—The advance of the metric system, H. J. Milton, *SP530*, pp. 135-146 (Sept. 1978).

Metric training and familiarization of personnel, H. J. Milton, *SP530*, pp. 147-163 (Sept. 1978).

Guidelines for the metric transitional period in building design and construction, H. J. Milton, *SP530*, pp. 165-181 (Sept. 1978).

HANDBOOKS

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

H124. **Energy management for furnaces, kilns, and ovens,** L. A. Wood, J. F. Ward, and K. G. Kreider, *Nat. Bur. Stand. (U.S.), Handb. 124*, 44 pages (Jan. 1978) SN003-003-01811-2.

Key words: energy conservation, industrial; furnaces, energy conservation; heat balance; industrial energy conservation; kilns, energy conservation; ovens, energy conservation.

This handbook, part of the EPIC Energy Management Series, is directed to the user of direct-fired heating equipment in light industry. Other publications in this series outline steps to plan and establish an energy conservation program in a business or industry. This handbook is a guide to making decisions as to just what actions are appropriate and effective for energy savings in equipment such as furnaces, kilns, and ovens. The major technique described is the heat balance. Examples of heat balances are used to identify energy losses on a batch furnace, a continuous paint dryer oven, and a slot forging furnace. Typical energy conservation opportunities in combustion control, insulation, etc. are discussed. Simplified methods of calculation and measurement are given. Benefit/cost analysis and the time required to recoup investment are described as means of evaluating energy-saving investments.

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 77-1238. **Technical guidelines for energy conservation,** Building Environment Division of NBS, 406 pages (June 1977). Order from NTIS as AD-A041668.

Key words: Air Force facilities; building energy conservation; energy management; evaluation and monitoring; survey of buildings.

This report provides detailed technical material on various energy conservation actions for existing Air Force facilities and utility systems. It is specifically tailored to serve as a working document for Base engineers and technical personnel. The report covers energy conservation for Air Force facilities, including the equipment for providing hot water, space heating and cooling, lighting, and humidification. It also covers central plant systems and underground distribution systems (hot water, steam, and chilled water). It does not cover energy conservation measured for tactical or mission-related equipment such as ground vehicles or fighter aircraft.

NBSIR 77-1247. **Proposed technical data requirements for the National Solar Heating and Cooling Demonstration Program,** 138 pages (Apr. 1977). Order from NTIS as PB280182

Key words: data requirements; noninstrumented data; solar buildings; Solar energy; solar heating and cooling; solar hot water.

Public Law 93-409, the "Solar Heating and Cooling Demonstration Act of 1974" calls for the development of interim performance criteria for solar heating and cooling systems and the buildings in which they will be used. Section 8 of the law provides for the use of data from the demonstration program to develop definitive performance criteria, as well as testing procedures whereby manufacturers can certify that their products conform to definitive performance criteria. Responsibility for the development of these definitive performance criteria has been assigned by the Energy Research and Development Administration and the Department of Housing and Urban Development to the National Bureau of Standards (NBS).

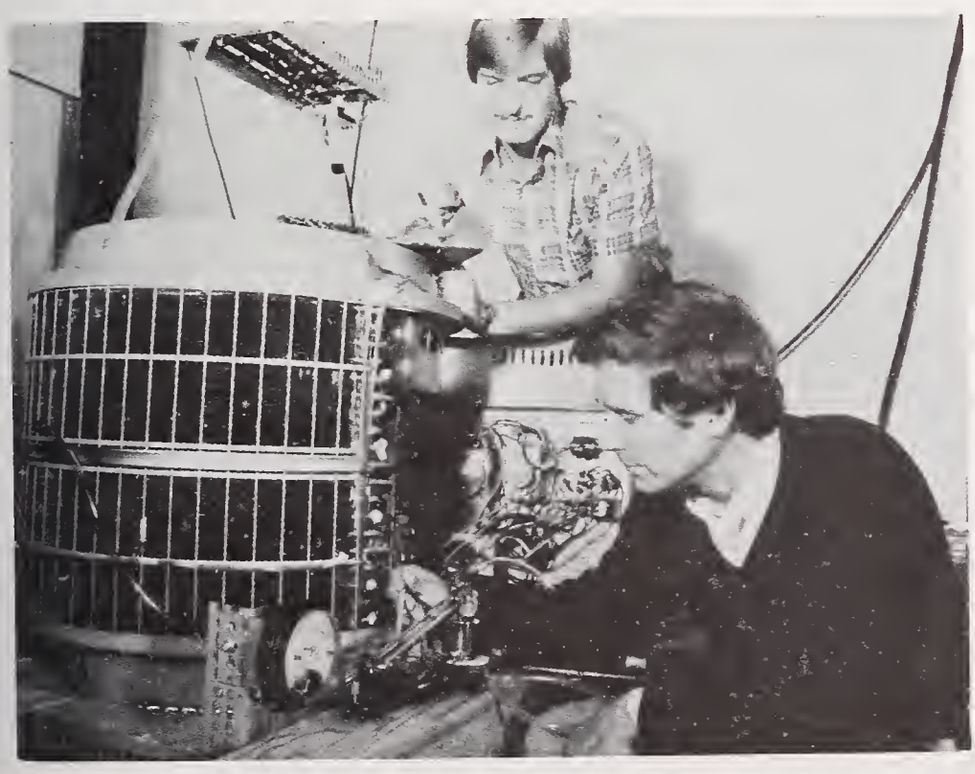
The plan presented in this document was prepared in order to define the technical noninstrumentation (TNI) data required by NBS in order to effectively monitor the residential and commercial demonstration programs, mandated by PL 93-409, for feedback. These data either cannot be collected electronically or can be gathered more effectively by other means.

This plan is intended to be a companion document to a similar plan published by NBS in August 1976 which identified the instrumentation data required by NBS to monitor and evaluate the "thermal effectiveness" and reliability of solar heating, cooling and hot water systems.

NBSIR 77-1271. **Method of testing, rating and estimating the seasonal performance of central air conditioners and heat pumps operating in the cooling mode,** G. E. Kelly and W. H. Parken, Jr., 78 pages (Apr. 1978). Order from NTIS as PB280107.

Key words: central air conditioners; heat pumps; rating procedure; seasonal cost of operation; test method.

The National Bureau of Standards has made a study of the part-load and seasonal performance of residential central air conditioners and heat pumps operating in the cooling mode. This document outlines methods for testing and rating these units which account for the variation in performance due to part-load operation and change in outdoor air temperature. A calculation procedure is presented which can be used to estimate the seasonal performance and seasonal cost of operation of residential central-cooling equipment.



NBSIR 77-1306. **Levels of illumination and legibility,** G. T. Yonemura, W. M. Benson, and R. Tibbott, 31 pages (Nov. 1977). Order from NTIS as PB276531.

Key words: energy conservation; illumination levels; lighting; lighting design; task lighting.

The visibility of tasks encountered in the working world ranges from easy to difficult to see objects. The assumption that experiments performed for threshold targets (difficult to see) can be extrapolated to higher contrast tasks (easy) was tested. The experiments indicate that threshold level studies should not be extrapolated to suprathreshold levels. The performance of the eye is not the same at the two levels. The threshold function is monotonic, that is, contrast required for detection decreases monotonically as luminance is increased, whereas the suprathreshold experiments result in a function with a minimum or optimum luminance level. Recommendations are made to expand the empirical base from which lighting level recommendations are derived to include the more commonly occurring situation involving visual task performance for suprathreshold tasks.

NBSIR 77-1314. **Solar energy systems—Survey of materials performance,** L. F. Skoda and L. W. Masters, 114 pages (Oct. 1977). Order from NTIS as PB273305.

Key words: absorber coatings; absorber plates; cover plates; enclosure; insulation; materials performance; reflective surfaces; seals; selection of materials; solar energy systems; standards.

A study was performed to obtain data regarding the performance of materials in operational solar energy systems, to identify and assess available standards for evaluating materials, to provide recommendations for the development of test method standards for materials and to provide guidelines to aid the selection of materials for use in solar energy systems. During the study, field inspections of approximately twenty-five operational solar energy systems were performed and a questionnaire was sent to 459 manufacturers and installation contractors to obtain materials performance data. This report contains the findings of the study. A primary conclusion is that the process of selecting materials for specific applications within solar energy systems is hindered by the lack of an adequate data base of materials performance under the conditions experienced in solar systems and subsystems. Recommendations are made that would help in establishing an improved data base.

NBSIR 77-1380. **Experimental determinations of temperatures and power losses at the electrical connections of some duplex receptacles,** G. W. Burns, M. G. Scroger, G. A. Evans, R. W. Beausoliel, and W. J. Meese, 65 pages (Apr. 1978). Order from NTIS as PB280071.

Key words: branch circuits; duplex receptacles; electrical connections; power loss; temperatures; thermocouples; wire.

The data presented in this report compare the reliability of power loss determination with the reliability of temperature measurements as a means for determining the quality and adequacy of electrical connections on wiring devices used in branch circuit wiring. The basic premise for the tests presented here is that in the laboratory the determination of power loss is easier, quicker, and not nearly as dependent on environmental factors as temperature. This research indicates that, if power at a specific current level does not exceed some set values(s), temperatures will not be excessive.

This investigation also illustrates the overheating problems associated with copper-wire electrical connections. No. 14 copper wire connections frequently showed significant rises in temperatures and significantly increased power losses when tightened to a torque of only 2 lbf·in, as compared to nominally tight connections (6 lbf·in or more).

NBSIR 77-1388. **A new look at windows,** B. L. Collins, R. T. Ruegg, R. Chapman, and T. Kusuda, 40 pages (Jan. 1978). Order from NTIS as PB276747.

Key words: daylighting; energy conservation; life-cycle costs; residential; solar heat gain; window; window management.

Recent design recommendations have called for reduced window area in buildings to conserve energy. This article presents new information on thermal loads, daylighting, management, and life-cycle costs which indicates that such recommendations may neglect important design and operational aspects of windows which can conserve energy resources and reduce life-cycle building costs. A case example is described in which energy consumption and life-cycle costs are given for windows in a typical house in the Washington, D.C. area. Noticeable reductions in overall energy consumption and life-cycle costs are found if daylight is used, and if the window is managed. It is suggested that lending institutions and builders consider the long-term effects of window design and operation decisions.

NBSIR 77-1399. **Performance of a water-thinned polyurethane seamless flooring system,** M. Godette and P. Campbell, 79 pages (Dec. 1977). Order from NTIS as PB275390.

Key words: field demonstration; high traffic areas; laboratory findings; maintenance engineers; service conditions; solvent-thinned polyurethane system; vinyl title; water-thinned polyurethane system.

This paper summarizes the work of a two-year project to evaluate the performance of a water-thinned polyurethane seamless flooring system. The goals of this project included: 1) To evaluate by laboratory tests and field demonstrations the performance and durability characteristics of a water-thinned polyurethane seamless flooring system; 2) To compare the performance of a water-thinned polyurethane system with solvent-thinned polyurethane systems and other conventional flooring materials; and 3) To recommend performance criteria for the selection of water-thinned polyurethane seamless flooring systems.

The project was divided into two phases, laboratory evaluation and field demonstration. Data obtained from local maintenance engineers at the 20 demonstration sites confirmed laboratory findings that the system did not compare favorably with conventional flooring systems for use in high traffic areas.

NBSIR 77-1402. **The National Cancer Institute's Emergency Virus Isolation Facility: A case study for use in developing a methodology of post-occupancy evaluation,** G. E. Turner, J. Elder, and A. I. Rubin, 72 pages (Dec. 1977). Order from NTIS as PB275410.

Key words: architectural analysis; architectural evaluation; architectural process; architectural research; building evaluation; building research; man and environment relations; people and buildings; post-construction evaluation.

The National Cancer Institute's Emergency Virus Isolation Facility is a laboratory building designed to provide an experimental research environment for all levels of hazardous work related to virus-cancer research. This report represents an attempt to develop a generalizable model for building evaluation through the analysis of the pre-design programming process and the post-construction operation management of the facility.

NBSIR 77-1405. **Determination and verification of thermal response factors for thermal conduction applications,** B. A. Peavy, 33 pages (Apr. 1978). Order from NTIS as PB 283011.

Key words: dynamic conduction heat transfer; heat transfer; thermal response factor; verification.

New formulas for calculating thermal response factors for multiple-layer construction have been developed by a rigorous derivation. A comparison was made of the time for computation between the presently used matrix algebra method and the method given in this paper. Results were obtained using the new method in one-fiftieth to one-half of the computational time necessary to obtain solutions from the matrix algebra method. Comparisons with another analytical method were performed to verify the accuracy of the response-factor technique.

NBSIR 77-1411. **International research—The FY 1977 survey of CBT's international programs,** M. Olmert, Ed., 84 pages (Mar. 1978). Order from NTIS as PB279403.

Key words: building practices; building research; codes and standards; housing; international cooperation; technology transfer.

This report presents the international research activities of the Center for Building Technology during the transition quarter and Fiscal Year 1977. In general, the objectives of this work were to spread the results of building research worldwide in hopes of creating a better built environment. Last year CBT continued working closely with less-developed countries to improve their building practices. The Center also continued cooperative research efforts with a number of countries that have acknowledged expertise in particular areas of building research, such as England, Israel, and France, to name but a few. On such projects, the Center pursued common research goals alongside the building researchers from other nations on studies of critical importance to all nations, such as energy and natural resources conservation.

NBSIR 77-1413. **Proceedings of the 8th Annual Conference of the National Conference of States on Building Codes and Standards,** S. A. Berry, Ed., 146 pages (Jan. 1978). Order from NTIS as PB280113.

Key words: ASHRAE 90-P; building codes; mobile homes; National Conference of States on Building Codes and Standards; NCSBCS; proceedings; 8th Annual Conference.

This document contains the edited proceedings of the 8th Annual Conference of the National Conference of States on Building Codes and Standards (NCSBCS), held in Sante Fe, New Mexico, April 27-May 1, 1975.

In addition, it includes listings of the State Delegates and Committee members for the 8th Annual Conference Year, and the Committee Reports, as finalized, submitted and approved by the State Delegates to NCSBCS, meeting in Annual Session.

NBSIR 77-1437. **Solar energy systems—Standards for rubber seals,** R. D. Stiehler, A. Hockman, E. J. Embree, and L. W. Masters, 64 pages (Mar. 1978). Order from NTIS as PB280114.

Key words: rubber seals; solar collectors; solar energy systems; standards; test methods.

A study was performed to develop standards for rubber seals used in solar systems. Thirty preformed and liquid applied seals were evaluated in the laboratory using modified ASTM standard test methods to obtain data needed to prepare the standards. Also, studies were performed to develop a test method for determining the effects of outgassing on the transmittance of solar collector covers.

The results of the laboratory tests are presented and standards for rubber seals in solar energy systems are proposed.

NBSIR 78-1143A. **Plan for the development and implementation of standards for solar heating and cooling applications,** D. Waksman, J. H. Pielert, R. D. Dikkers, E. R. Streed, and W. J. Niessing, 58 pages (June 1978). Order from NTIS as PB283237.

Key words: buildings; solar energy; standards.

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

NBSIR 78-1305A. **Provisional flat plate solar collector testing procedures: First revision,** D. Waksman, E. R. Streed, T. W. Reichard, and L. E. Cattaneo, 65 pages (June 1978). Supersedes NBSIR 77-1305. Order from NTIS as PB283721.

Key words: durability/reliability; fire safety; rating criteria; solar collectors; structural performance; testing procedures; thermal performance.

This document represents the first revision to NBSIR 77-1305. The test methods contained in this report and the provisional rating criteria presented in an appendix are intended for use in determining the thermal performance, and to aid in the assessment of the safety and durability/reliability of flat plate solar collectors. These test methods and rating criteria have been selected after the review of over 400 accepted industry standards and are consistent with the intent of the U.S. Department of Housing and Urban Development (HUD) Minimum Property Standards (MPS) and the Interim Performance Criteria (IPC) prepared by the National Bureau of Standards (NBS) for the Department of Energy (DoE) and HUD respectively. Many of the test methods and rating criteria contained in this report are preliminary in nature and will be evaluated during a collector testing program being sponsored by DoE. It is, therefore, recommended that regulatory agencies consider the developmental status of these procedures in evaluating their suitability for adoption. It is intended that revisions will be made as more experience is gained and inputs received from appropriate industry representatives, testing laboratories, designers, etc.

NBSIR 78-1395. **Performance guidelines for a modular integrated utility system,** D. J. Mitchell, 92 pages (Nov. 1978). Order from NTIS as PB289783.

Key words: conservation; integrated utilities; performance guidelines; residential utilities; total energy; utilities.

Performance Guidelines for a Modular Integrated Utility System (MIUS) is an aid to construct conceptual, preliminary and final designs for a specific MIUS to be built in a particular geographic location.

This document defines generic performance of a MIUS serving a residential/commercial development. These performance requirements, criteria, and evaluations identify engineering parameters and other constraints associated with electrical service, thermal energy, solid waste management, potable water management, and wastewater management provided by a single, local, integrated source. There are also performance

requirements, criteria, and evaluations for end-use considerations such as environmental impact, health, safety, and subjective acceptability. It is recognized that in view of the many possible combinations of MIUS designs, ownership, methods for implementation, local regulations, a MIUS implementor may wish to omit and/or greatly simplify many of the remaining performance requirements, criteria and evaluations contained herein.

NBSIR 78-1449. **The effects of herbicides on masonry,** J. E. Fearn, 25 pages (May 1978). Order from NTIS as PB281563.

Key words: acidic; alkaline; degradation; herbicide; historic structures; masonry.

In preserving historic structures, the control of obnoxious vegetation is a serious problem. To deal with this problem, a number of organic herbicides have been developed by industry. The efficacy of herbicides in the control of plant life has been studied to a great degree; but heretofore, very little has been reported about the possible effects of these chemical plant killers on the materials they are designed to protect. In this work, an exhaustive survey of pertinent literature has been undertaken. Obtaining very little specific information from literature, a correlation has been drawn between the effects of masonry of materials similar in chemistry to herbicides and the effects that would be expected from the herbicides themselves. Methods for checking the validity of conclusions are suggested.

NBSIR 78-1463. **Studies on the photodegradation of poly(methyl methacrylate),** M. Abouelezz and P. F. Waters, 62 pages (May 1978). Order from NTIS as PB281828.

Key words: degradation; photodegradation; poly(methyl methacrylate); UV.

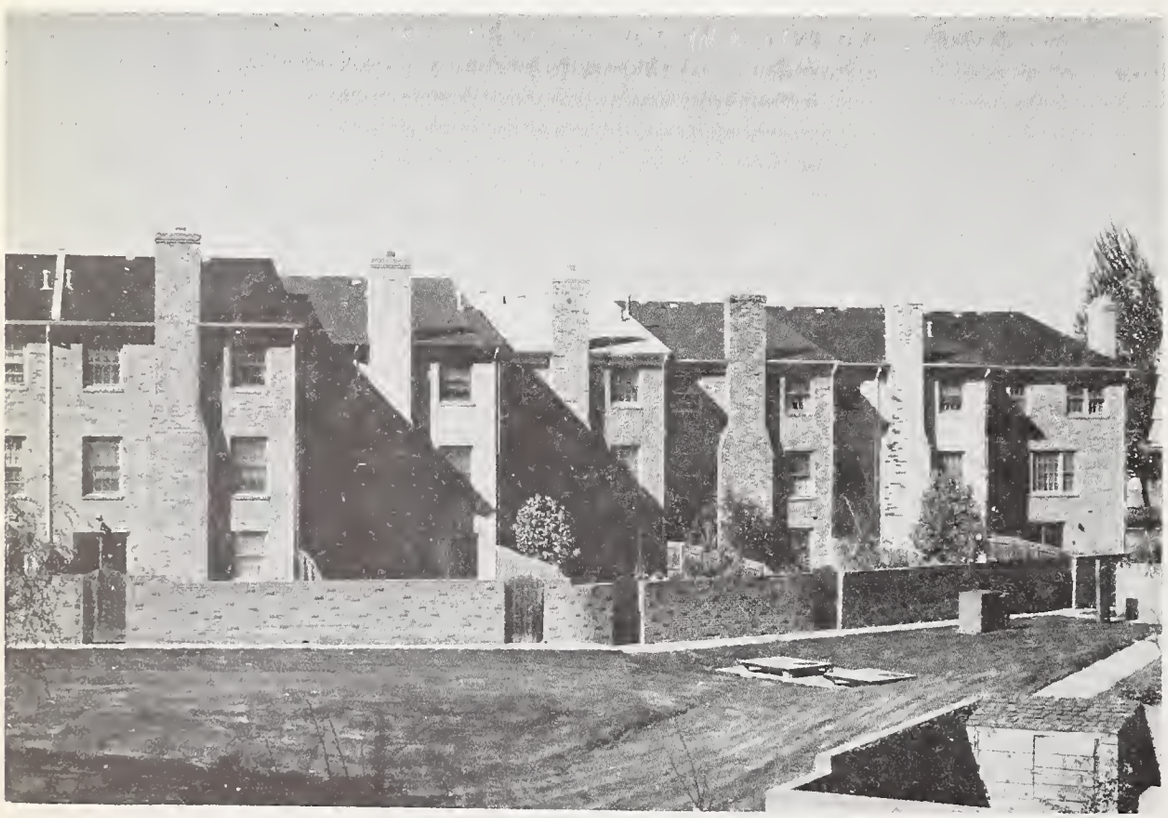
Although poly(methyl methacrylate), PMMA, is known to degrade when exposed to ultraviolet radiation, studies at wavelengths other than 253.7 nm have not been done. The lack of knowledge about the mechanism of degradation of PMMA at wavelengths other than 253.7 nm hinders efforts to develop short-term test methods for predicting the long-term performance of PMMA in applications in which it is exposed to sunlight. This study was performed to determine the effect of ultraviolet radiation on PMMA and to identify mechanisms of degradation induced by radiation.

Thin films of PMMA of two different molecular weights were irradiated with radiation nominally of 253.7 nm and 300 nm. The irradiations were conducted in air and under vacuum. Exposure at 253.7 nm caused a rapid decrease in molecular mass and loss of a small amount of volatile products, which is a characteristic of random chain scission. The quantum yield was greater in air than in vacuum. Changes in the molecular mass and the glass transition temperature as well as weight loss data indicating that wavelengths bands at greater than 253.7 nm also cause degradation. The data further indicate that the degradation at the longer wavelengths may not be completely random scission.

NBSIR 78-1466. **Evaluation of new portable x-ray fluorescent lead analyzers for measuring lead in paint,** A. P. Cramp and H. W. Berger, 59 pages (May 1978). Order from NTIS as PB282254.

Key words: accuracy; calibration; evaluation; lead; paint; poisoning; portable; precision; radiation; references; substrates; x-ray fluorescent.

Portable x-ray fluorescent lead analyzers offer the most cost-effective and adaptable means for the nondestructive detection and measurement of lead in paint in housing. However, commercially available portable lead analyzers have had poor accuracy and precision below lead levels of about 3.0 milligrams of lead per square centimeter of surface area. This is particularly serious because the current operational criteria for lead paint hazard abatement, 1.5 or 2.0 mg/cm of lead maximum (used



in many communities) is in this range. They have also performed relatively unsatisfactorily with regard to serviceability and maintenance. Two new portable lead analyzers based on x-ray fluorescence have been developed under HUD contracts. The prototypes of one of these devices have shown considerable improvement over previously available instruments in terms of accuracy, portability, and user characteristics. This report discusses the performance and operating characteristics of the new lead analyzers.

NBSIR 78-1471. **The role of economic analysis in the development of energy standards for new buildings,** S. R. Petersen, 48 pages (July 1978). Order from NTIS as PB284461.

Key words: benefit-cost analysis; building economics; building standards; energy conservation; life-cycle building costs; performance standards.

The Federal Government and a number of states are currently developing energy conservation standards for new buildings. This report suggests that economic considerations be incorporated directly into the standards development process. A life-cycle benefit-cost approach to standards development can provide a systematic and objective framework for standards specification. Differences in climate, building type, energy cost, and operational requirements can be directly incorporated into the standard as they impact energy-related benefits and costs. It is shown that the life-cycle costs associated with any given overall conservation goal can be reduced by developing an economically balanced standard. In addition, it suggests that a standard which has as its goal the minimization of life-cycle costs will likely lead to greater effective energy savings than alternative approaches. Specific suggestions for the incorporation of economic analysis into the standards development process are made.

NBSIR 78-1475. **Air leakage measurements in three apartment houses in the Chicago area,** C. M. Hunt, J. M. Porterfield, and P. Ondris, 27 pages (June 1978). Order from NTIS as PB283722.

Key words: air infiltration; air leakage; low income housing; sulfur hexafluoride tracer.

Air infiltration measurements were made in three apartment houses in the Chicago area using SF_6 as a tracer gas. Two were in tenement districts and one was suburban. Data were collected in selected apartments in each building, and these data were used to estimate the infiltration rate for the entire building. Whole building estimates of 0.94 and 1.2 air changes per hour were obtained under the conditions of tests in the tenement apartments, and 0.82 air changes per hour in the suburban apartment.

Comparisons of the tightness of individual dwelling units by fan pressurization-depressurization techniques were also made. The suburban apartment was found to be much tighter than the other two apartments. The difference was much greater than predicted by the tracer tests.

An analysis of the ASHRAE Crack Method is also made.

NBSIR 78-1477. **Exploratory study of temperatures produced by self-heating of residential branch circuit wiring when surrounded by thermal insulation,** R. W. Beausoliel, W. J. Meese, and L. S. Galowin, 54 pages (July 1978). Order from NTIS as PB284711.

Key words: branch circuit wiring; electrical fires; heat generation in receptacles; insulated buildings; overheating conductors; residential branch circuit wiring; thermal insulation and electrical wiring.

The purpose of the work presented in this paper was to make preliminary determination under laboratory conditions of temperatures that might develop on residential electrical wiring covered by thermal insulation when carrying rated currents or currents slightly above rated values.

The results show that temperatures on conductors surrounded by thermal insulation can greatly exceed the maximum service temperatures for the wire insulation. Results also show that some types of insulation currently used to retrofit buildings may fill wall outlet boxes and contact the current carrying elements and connections of duplex receptacles.

This study indicates need for a concentrated study of temperatures that might develop on residential electrical wiring covered by thermal insulation.

NBSIR 78-1490. **Standards referenced in the National Building Code,** J. M. Hicks, Jr., Suppl. to NBSIR 76-1140, 43 pages (July 1978). Order from NTIS as PB284819.

Key words: building codes; building regulations; building regulatory systems; model building codes; standards.

This report is a supplement to NBSIR 76-1140, "Standards Referenced in Selected Building Codes," published by the U.S. Department of Commerce, National Bureau of Standards, and is intended to provide a base for assisting the building community in updating, utilizing and maintaining the standards referenced in the 1976 edition of the National Building Code promulgated by the American Insurance Association. In addition to identifying each standard referenced in the code, this publication lists the current date of the standard, its title, the date of the code and the locations within the code where the standard is referenced.

NBSIR 78-1495. **Factors affecting the durability of adobe structures,** P. W. Brown, C. R. Robbins, and J. R. Clifton, 41 pages (July 1978). Order from NTIS as PB286096.

Key words: adobe; clay; particle size distribution; soluble salt analysis; weathering; x-ray analysis.

Adobe samples from three sites of historic interest in the State of Arizona were analyzed to determine their mineral assemblages, particle size distributions, soluble salt contents, and porosities. These analyses were accompanied by microscopic observations of polished sections and thin sections. These data were correlated with the weathering observed and it was found that soluble salt action was responsible for the deterioration of the adobe from one of the sites. The nature of the particle size distribution has resulted in the rapid deterioration of the adobe from a second site. The adobe from a third site was found to be well consolidated due to the presence of large amounts of calcite.

NBSIR 78-1503. **State adopted building regulations for the construction of manufactured buildings—An analysis,** P. W. Cooke and R. M. Eisenhard, 215 pages (July 1978). Order from NTIS as PB284685.

Key words: building regulation; construction; enforcement; inspection; legislation; manufactured building; rules and regulations; standards.

This report summarizes the status and characteristics of State adopted building regulatory programs specific to the construction of manufactured buildings. Included are tabularized data and summary information relative to: technical codes upon which regulations are based; extent to which established technical provisions contained in recognized national model codes have been amended by certain States; differences from a regulatory standpoint between each States treatment of manufactured building construction and conventional construction; occupancy classifications and type of compliance assurance activi-

ties covered by each States' program; definitions for "manufactured building" and related terms as defined in State regulations.

NBSIR 78-1508. **Human response to fire: Three designs for research,** F. I. Stahl, 33 pages (Mar. 20, 1978). Order from NTIS as PB284959.

Key words: architectural psychology; environmental psychology; fire escape; fire safety; human research; research design.

As a group, empirical investigators of the responses of building occupants to emergencies employ idiosyncratic, nonreplicable techniques for research design, data acquisition, and data analysis. As a result, it has been difficult to explain the influence of many, often uncontrolled, variables. This shortcoming has frequently rendered research findings indeterminate and noncumulative. This paper explores three exemplary research design strategies, each aimed at mitigating these problems by introducing a greater degree of rigor into the study of human responses to fires. Both exploratory and experimental designs are considered in various problem contexts.

NBSIR 78-1514. **A computer simulation of human behavior in building fires: Interim report,** F. I. Stahl, 133 (Sept. 1978). Order from NTIS as PB289272.

Key words: architectural psychology; architectural research; building fires; computer-aided design; fire computer program; fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation.

This interim report presents the conceptual development, structure, and function of BFIRES, a computer program designed to simulate human movement behavior during building fires. The basic model underlying BFIRES is derived from a nonstationary, discrete time Markov Process. This model postulates that occupants construct their emergency responses and behavioral decisions dynamically, in response to continually changing social and environmental information fields. The simulation of this process is accomplished through BFIRES, a computer program written in FORTRAN V. Directions for further study are discussed.

NBSIR 78-1525. **Climate data abbreviation for the computerized calculation of heating and cooling requirements in buildings,** E. A. Arens and D. H. Nall, 67 pages (Dec. 1978). Order from NTIS as PB289927.

Key words: climate data; computer; energy; load-calculation; residential; weather.

This paper documents the development of a climate data abbreviation technique for building thermal analysis. The paper first discusses the characteristics of computerized building thermal simulations and the requirements for abbreviated data. The technique is then described together with the statistical analyses used to develop it. A series of tests of the representativeness of the abbreviated climate data are documented. Finally, the limitations and potentials of the abbreviation technique are discussed.

NBSIR 78-1528. **An economic analysis of building code impacts: A suggested approach,** J. S. McConnaughey, Jr., 67 pages (Oct. 1978). Order from NTIS as PB287405.

Key words: benefit-cost analysis; benefit-risk analysis; building codes and standards; building regulations; building safety; economic analysis; economics of safety; electric shock; ground fault circuit interrupters.

This report suggests an evaluation approach which can be used by building officials and legislative bodies faced with making building code decisions. A method to evaluate many of the potential benefit and cost impacts of specific building code provisions is developed. The report also defines and categorizes the economic impacts of building codes. While no approach to classifying building code impacts will be fully appropriate for all uses, the definitions and categories proposed may help to clarify or reconcile some of the differing opinions concerning the impact of building codes. Finally, the report illustrates the suggested approach by evaluating the *1975 National Electrical Code* requirement for the use of Ground Fault Circuit Interrupters (GFCIs) in residences. Based on sensitivity analysis, estimates are made of how much it costs society in order to save one life through the GFCI code provision. This case study concludes that the estimated cost to save a life is nearly $4 million. A lower bound estimate of the cost to save a life is about $2.5 to $3.5 million.

NBSIR 78-1532. **Environmental and safety considerations for solar heating and cooling applications,** D. Waksman and J. Holton, 35 pages (Sept. 1978). Order from NTIS as PB287772.

Key words: fire safety; health; physical hazards; safety; solar heating and cooling; structural performance; toxicity.

The HUD Minimum Property Standards (MPS) and the "residential" and "commercial" interim performance criteria (IPC) prepared by the National Bureau of Standards address many health and safety considerations that need to be considered by solar heating and cooling system designers. For example, factors such as the toxicity and flammability of heat transfer fluids are often not considered in the design of systems. Similarly, attention is seldom paid to the safe disposal of these fluids. These problems are compounded by the lack of clear guidelines as to which fluids constitute hazards that warrant special consideration. This report is intended to create an increased sense of awareness of the health and safety aspects of solar heating and cooling applications by extracting and amalgamating pertinent provisions of the MPS and IPC documents. Some of the areas that are addressed include: structural safety, heat transfer fluid toxicity and flammability considerations including the protection of potable water, effects of solar equipment on the fire resistance of buildings, and protection from physical hazards.

NBSIR 78-1535. **Laboratories technically qualified to test solar collectors in accordance with ASHRAE Standard 93-77: A summary report,** W. J. Niessing, 39 pages (Nov. 1978). Order from NTIS as PB289729.

Key words: collector; evaluation; laboratories; qualification; solar; testing.

In fulfilling its responsibilities under the National Program for Solar Heating and Cooling of Buildings established as a result of the Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) and related legislation, the Energy Research and Development Administration (ERDA) requested the National Bureau of Standards (NBS) to develop criteria for assessing the capabilities of laboratories for testing solar collectors, to identify those laboratories qualified to test solar collectors, and to develop a plan for the certification of solar collectors.

NBS engaged the professional services of ARI Foundation, Inc. (ARIF), a subsidiary of the Air-Conditioning and Refrigeration Institute (ARI), to identify laboratories qualified to test solar collectors and to develop documentation for a solar collector certification program. ARI is a national trade association of manufacturers of air-conditioning and refrigeration equipment with established experience and background in standards development for HVAC equipment and the conduct of certification programs for such equipment.

This summary report covers the identification of qualified solar collector testing laboratories. It discusses the procedures used by ARIF, the results of their evaluation and lists the laboratories evaluated as qualified to test solar collectors in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 93-77.

NBSIR 78-1537. **An exploratory study of dielectric breakdown voltages for residential wiring,** J. E. V. Raduan, R. W. Beausoliel, and W. J. Meese, 34 pages (Oct. 1978). Order from NTIS as PB288857.

Key words: dielectric breakdown voltages; dielectric withstand voltage tests; residential wiring; surge voltages.

Residential electric circuits are subjected to surge voltages resulting from load switching in buildings, and from external causes such as lightning. Laboratory test data are presented on high voltage breakdown values for armored cable (type AC cable), nonmetallic-sheathed cable (type NM), flat conductor cable, and duplex receptacles. Dielectric withstand voltage test requirements in current standards for residential wiring and wiring devices vary over a wide range. In some cases, the standard test voltage values for both wiring and wiring devices are less than surge voltages recorded on wiring in residences. Also, field-recorded voltage wave forms and rates of their application are different from those used in standard withstand voltage tests.

NBSIR 78-1542. **State-of-the-art study of heat exchangers used with solar assisted domestic hot water systems (Potential contamination of potable water supply),** F. E. Metz and M. J. Orloski, 82 pages (July 1978). Order from NTIS as PB287410.

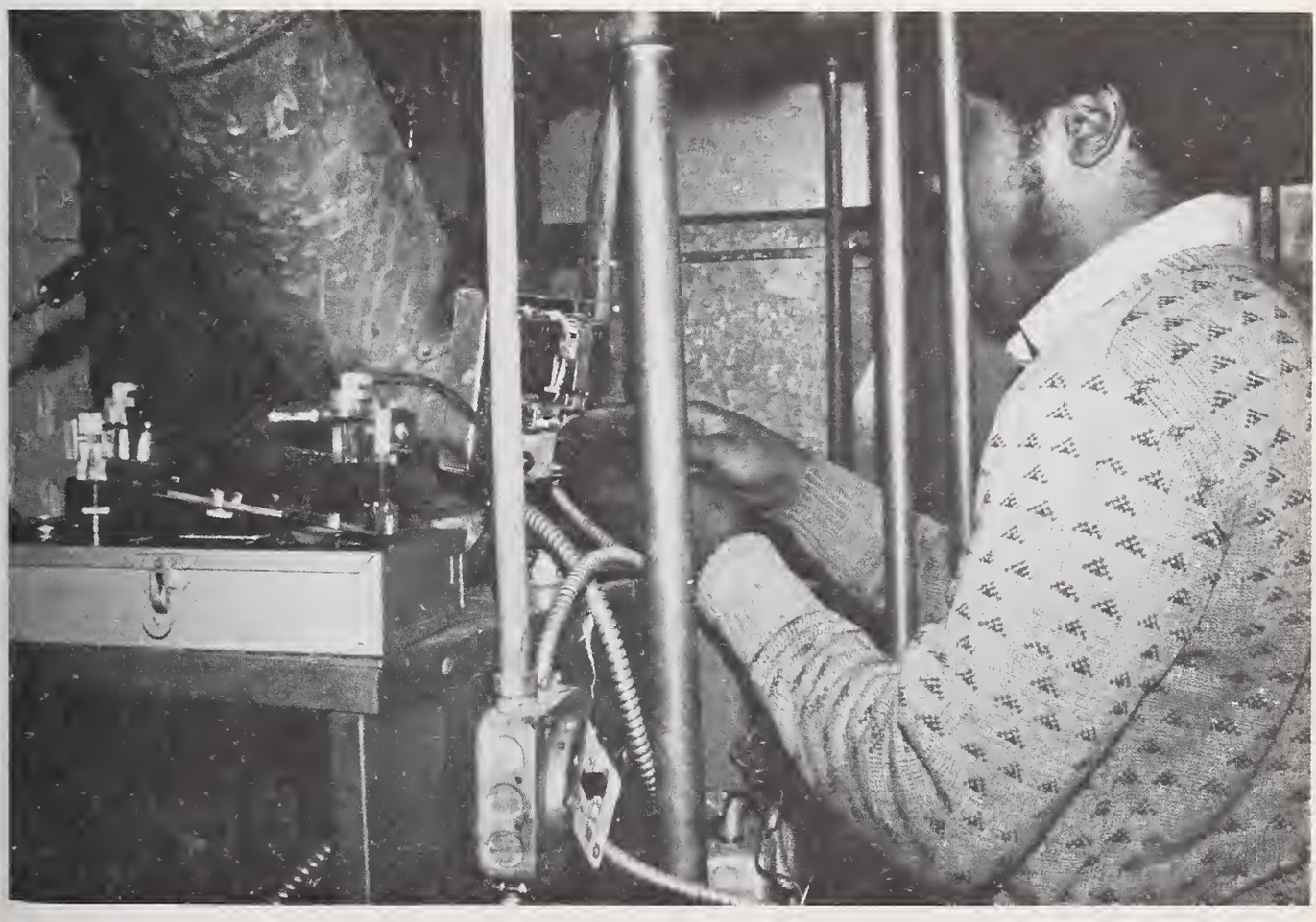
Key words: contamination; corrosion; heat exchanger; heat transfer fluids; potable water; solar energy; standards; toxicity.

This report presents the results of a nonquantitative state-of-the-art study of heat exchangers used with solar assisted domestic hot water systems where a heat exchanger interface exists between the potable water supply and a heat transfer fluid. Emphasis is placed on the potential for contaminating the potable water supply if failures should occur. The study considers (1) characteristics of various heat exchanger types and their relative safety; (2) characteristics of heat exchanger fluids (toxicity, corrosivity, thermal properties, etc.); (3) regulatory considerations; and (4) designs of similar systems with potential for contamination.

NBSIR 78-1543. **Recommended testing and calculation procedures for determining the seasonal performance of residential central furnaces and boilers,** G. E. Kelly, J. Chi, and M. E. Kuklewicz, 110 pages (Oct. 1978). Order from NTIS as PB289484.

Key words: annual operating cost; boilers; fossil fuel heating systems; furnaces; part load performance; rating procedures; seasonal efficiency.

As part of the requirements of the Energy Policy and Conservation Act (PL 94-163) passed by Congress in December 1975, the Department of Energy (formerly Federal Energy Administration) directed the National Bureau of Standards to develop test procedures for certain covered consumer products, including residential central furnaces and boilers. This report summarizes NBS recommendations on how these central heating appliances may be tested in the laboratory and the resulting data used to calculate their annual fuel utilization efficiencies and annual operating costs.



NBSIR 78-1548. **An evaluation of ASHRAE Standard 94-77 for testing water tanks for thermal storage,** B. J. Hunt, T. E. Richtmyer, and J. E. Hill, 75 pages (Oct. 1978). Order from NTIS as PB288793.

Key words: ASHRAE Standards; evaluation of test procedure; solar heating components; standard test procedure; thermal storage tests; water tank thermal storage.

The National Bureau of Standards proposed a standard test procedure for rating thermal storage devices, in mid-1975. Early in 1977, the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) adopted ASHRAE Standard 94-77 Method of Testing Thermal Storage Devices Based on Thermal Performance, which is based substantially on the NBS procedure. In order to evaluate the Standard, NBS has conducted an experiment in which a 1.9 m^3 (500 gal) water tank, built as part of a residential solar heating and cooling system, was tested in accordance with this Standard. A description of the test apparatus, test procedure, and detailed test results are given. It was found that there were no major problems encountered in using the Standard for this kind of thermal storage device. In addition, suggestions are made for minor modifications in the Standard.

NBSIR 78-1549. **Plan for the assessment and implementation of seismic design provisions for buildings,** C. G. Culver, R. E. Chapman, P. W. Cooke, B. R. Ellingwood, S. G. Fattal, J. R. Harris, and E. V. Leyendecker, 31 pages (Nov. 1978). Order from NTIS as PB288762.

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

This plan deals with the assessment and implementation of tentative seismic design provisions developed by the Applied Technology Council as part of the Cooperative Federal Program in Building Practices for Disaster Mitigation of the National Science Foundation and the National Bureau of Standards. The plan was prepared based on comments received from a broad spectrum of representatives of the building community. The National Bureau of Standards invited participation from a broad spectrum of interests to help develop the plan. Trade associations, industry group, professional organizations, the model code organizations, standards organizations and Federal agencies were included; groups with national representation rather than regional or local interest were selected.

The plan includes four phases (1) Review and Refine Tentative Provisions, (2) Trial Designs and Impact Assessment, (3) Consideration and Adoption of Provisions, and (4) Assistance to Facilitate implementation. It can form the basis for the assessment and implementation of the tentative seismic design provisions. As the effort proceeds, it may be necessary to refine the plan. Additional details will need to be specified for the individual tasks. These will be influenced by the procedure adopted to carry out the activities.

NBSIR 78-1554. **An analysis of the behavior of stair users,** J. A. Templer, G. M. Mullet, J. Archea, and S. T. Margulis, 75 pages (Nov. 1978). Order from NTIS as PB291797.

Key words: architectural design; design considerations; dimensional relationships; environmental design; safety; stairs; user needs.

The National Bureau of Standards has conducted research for the Consumer Product Safety Commission the objective of which is to recommend ways to reduce the frequency and severity of stair and landing accidents. One of the several approaches to identifying stair hazards is to videotape stair use in a variety of public settings. About 50 hours of videotape of

stair use have been collected and it has been processed in various ways to provide information on typical human responses to stairs and landings. This report of an analysis of videotape of stair use focuses on the relationship between the occurrence of incidents, including falls, and the stair users' characteristics, user behavior, and environmental conditions. The analysis relies, in part, on a comparison of matched samples of incident and nonincident user groups. Based on the findings of the analysis, a literature review, and other research on stair use by the authors, 44 performance statements are proposed which, if applied to stair design, should substantially reduce the frequency and severity of stair accidents.

NBSIR 78-1562. **Interim performance criteria for solar heating and cooling systems in residential buildings,** J. K. Holton, 114 pages (Nov. 1978). Order from NTIS PB289967.

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

The interim performance criteria, developed for the Department of Housing and Urban Development, is a baseline document for criteria and standards for the design, development, technical evaluation and procurement of the solar heating and cooling systems to be used in residential buildings during the solar heating and cooling demonstration program authorized by Public Law 93-409, the "Solar Heating and Cooling demonstration Act of 1974."

This second edition of the "residential criteria" document, represents the first revision to the "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings" published in January 1975. Its revision draws upon comments received and experience gained in the use of two companion documents, the "Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings," NBSIR 76-1187, and the "HUD Intermediate Minimum Property Standards Supplement, 1977 Edition, Solar Heating and Domestic Hot Water Systems," 4930.2.

These interim criteria are intended primarily for use in the solar residential demonstration program and as a basis for the preparation of definitive performance criteria in accordance with the requirements of Section 8 of PL 93-409.

NBSIR 78-1563. **Guidelines for evaluation of a MIUS demonstration,** R. A. Grot, D. J. Mitchell, J. R. Schaefgen, A. C. Chao, M. E. Kuklewicz, and S. F. Weber, 46 pages (Dec. 1978). Order from NTIS as PB291441.

Key words: co-generation; integrated utility systems; solid waste management; thermal systems; total energy; wastewater treatment.

In order to obtain maximum benefits from a MIUS demonstration facility, a carefully planned evaluation should: assess the technical performance of the MIUS demonstration plant, determine the public benefits of a Modular Integrated Utility System (MIUS); show the viability of private ownership and operation of a MIUS plant, and provide a data base to support future analysis. This document is a guideline for the development of a detailed evaluation plant for a MIUS facility which was planned for demonstration at St. Charles, Maryland. The generic types of technical, institutional, and economic issues are discussed. General performance measures for the total system and each subsystem are indicated. The classes of data that will be required and the types of data analyses to be employed are outlined.

NBSIR 78-1568. **Economic analysis of the Norris Cotton Federal Office Building,** P. T. Chen, 61 pages (Nov. 1978). Order from NTIS as PB289813.

Key words: building; construction cost estimation; discounted payback period; economic analysis; economic evaluation; energy conservation; life-cycle costing; present value analysis.

The Norris Cotton Federal Office Building in Manchester, New Hampshire, has been constructed and occupied by the General Services Administration to demonstrate energy conservation techniques in the design and operations of a contemporary office building. This post-occupancy economic evaluation conducted by the National Bureau of Standards shows that additional construction costs incurred in order to reduce the energy consumption of the building are adequately offset by the present value of the resulting annual energy savings. In the economic model, the actual construction cost and energy consumption of the constructed building are compared with the estimated construction cost and energy consumption of a hypothetical equivalent conventional building. The present value costs of the two buildings are calculated for each year during a 40-year study period.

Grantee/contractor 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-77-104. **Exhaust emission evaluation of three caterpillar tractor D-398 diesel-electric sets,** C. E. Kitson and R. S. Egdall, 73 pages (Nov. 1977). Order from NTIS as PB276102.

Key words: diesel engines; exhaust emissions; MIUS; total energy systems.

Gaseous and particulate emissions testing was conducted on three Caterpillar D-398 600 kW-rated generator sets at varying operating loads which included 0, 20, 40, 59, 79, 100, and 110 percent. These engines were designed to provide the dual functions of electric generation, and heat supply through exhaust heat exchangers. Water jacket cooling water temperatures were maintained at two levels depending on engine load; i.e., ≤200 °F at loads of 100 and 110 percent, and ≤228 °F at 79 percent and below.

Measured parameters included carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter. The measurement techniques and resulting emission data are presented herein.

NBS-GCR-77-107. **Beyond the performance concept,** E. D. Ehrenkrantz, 191 pages (Dec. 1977). Order from NTIS as PB275524.

Key words: building; center for building technology; design; performance concept.

This report of a brief study attempts to identify the knowledge-based problems of those responsible for building design, and to suggest areas in which the Institute for Applied Technology should focus its present and future efforts in order to improve building.

NBS-GCR-77-109. **Analysis of data and results for the roundrobin flat-plate collector test program,** W. C. Thomas and A. G. Dawson, 86 pages (Aug. 31, 1977). Order from NTIS as PB275576.

Key words: flat-plate collectors; measurement; modeling; solar; standards; testing.

A roundrobin test program was conducted in order to determine the inter-comparability of thermal performance experimental data on two liquid-heating solar collectors from 21 test facilities across the United States, using a common test procedure. Data from approximately half the facilities were selected for detailed analysis. A collector analytical model was used to show that less than one third of the spread could be attributed in the measured values of collector efficiency to different environmental conditions from facility to facility. The data for the second collector showed less scatter than data for the first collector. In general, the data from a single facility were consistent, and the majority of scatter was attributed to systematic uncertainties from facility to facility. When the data from six participants reportedly adhering to the requirements of ASHRAE Standard 93-77 were analyzed, the scatter was found to be within normal limits expected for the test procedure.

NBS-GCR-78-123. **Detailed application of a technology for the formulation and expression of standards, Applied to ANSI A58.1-1972,** L. K. Cunningham, J. W. Melin, and R. L. Tavis, 262 pages (Jan. 1978). Order from NTIS as PB279091.

Key words: building codes; computer model; decision table; decision theory; network, specifications; standards; systems engineering.

This investigation applies decision-table and information-network technology in the analysis of the American National Standard Building Code Requirements for Minimum Design Loads in Building and Other Structures (NASI A58.1-1972).

Part I summarizes the logic and technology available for decision-table and information-network analysis. It also sets down a rationale for the attempt to apply this logic at the requisite level of detail and develops the concepts, policies, and procedures that enable such application.

Part II applies the available technology to the ANSI Standard, and in a detailed commentary on each decision table and on the information network, sets down the questions raised by the analysis of each. General questions about the ANSI Standard, classification of data, and potential application of these methods in the expression of standards follow. The analysis concludes by testing the validity of its proposition in the overall findings of the work.

NBS-GCR-78-125. **Report on organization of certification program for solar collectors,** G. R. Munger, R. J. Evans, 99 pages (Nov.30, 1977). Order from NTIS as PB280025.

Key words: certification program; operational manual; rating standard; solar collectors.

Proposed documentation is presented for the operation of a solar collector certification program. The documents included are an Equipment Rating Standard, a Certification Program Operational Manual, a Certification Laboratory Contract, and a Manufacturer's License Agreement. Also provided is a typical calendar for the initiation of a program and an estimate of the first annual budget for a certification program.

NBS-GCR-78-130. **An annotated compilation of the sources of information related to the usage of electricity in nonindustrial application,** B. Reznek, 684 pages (July 1978). Order from NTIS as PB285260.

Key words: abstracts; annotated compilation; electrical usage; government contractor's report; information sources; nonindustrial.

This government contractor's report is a thorough compilation of the sources of information related to the usage of electricity in nonindustrial applications, as available in the open literature and from the U.S. electrical power industry. The report's scope encompasses all aspects of: electric load management; end-use; and the various methods of acquisition, analysis and implementation of electricity usage data. There are over 400 abstracts: 156 from LRC/AEIC reports and 264 from the open literature. The abstracts cover references containing over 12,000 pages plus about 2,500 references and 6,200 graphs and tables pertinent to electricity usage in nonindustrial applications. In addition to the LRC/AEIC abstracts, this document identifies over 100 sources of directly relevant information (in contrast to general interest sources and material of secondary relevance).

NBS-GCR-78-139. **An investigation of regulatory barriers to the re-use of existing buildings**, N. J. Habraken and A. M. Beha, 117 pages (Oct. 1978). Order from NTIS as PB287801.

Key words: building codes; building research; code enforcement; construction; existing buildings; rehabilitation; renovation.

This team investigation focuses on provisions of the regulatory systems which adversely impact re-use of existing buildings. The findings are separated into experientially based team analyses of regulatory systems and data gathered from several Massachusetts sources. A series of recommendations for resolution of specific code problems are made, and a research agenda is presented to identify areas for future study towards the resolution of code-rehab conflicts.

TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA, 1978

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.

17365. Simiu, E., Marshall, R. D., Haber, S., **Estimation of alongwind building response,** *J. Structural Div. ASCE* **103,** ST7, 1325-1338 (July 1977).

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

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

17405. Hill, J. E., Streed, E. R., **Testing and rating of solar collectors,** Paper X in *Applications of Solar Energy for Heating and Cooling of Buildings, Section 2: System Components and Performance*, R. C. Jordan and B. Y. H. Liu, Eds., ASHRAE GRP 170, pp. X-1—X-18 (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., New York, NY, 1977).

Key words: rating solar collectors; solar collector; testing solar collectors.

The use of solar energy for space heating, cooling, and supplying domestic hot water to buildings is receiving serious attention at present due to the mounting public awareness of the shortage of conventional fuels. It is clear that this trend is creating an on-rush of solar collectors of various designs, all claiming a specific efficiency and potentially significant fuel savings if used. It is imperative that standard methods of testing and rating solar collectors be adopted so that the collectors can be evaluated in a meaningful and consistent way.

The purpose of this chapter is to describe the fundamental approach to testing solar collectors, give a brief description of testing activities that have been and are being conducted around the world, and to give the status as of 1975 of efforts being directed toward the adoption of a standard test method for testing and rating collectors. Attention is focused on the flat-plate collector because of its predominant use for space heating, cooling, and domestic water heating. However, it is felt that the basic approach described here is valid for concentrating collectors having a low concentration ratio, that are being considered for solar cooling applications.

17407. Harrje, D. T., Hunt, C. M., Treado, S. J., Malik, N. J., **Automated instrumentation for air infiltration measurements in buildings,** *Princeton University Center for Environmental Studies Report No. 13*, 33 pages (Princeton University, Princeton, NJ, Apr. 1975).

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

Automated instrumentation using sulfur hexafluoride as a tracer gas in residential housing to determine rates of air infiltration in housing is described. The principles of operation, the necessary calibration procedures and the early field data are discussed in detail. Concentration levels of SF_6 are maintained at the parts per billion level in the buildings and are measured by sensitive electron capture detectors in conjunction with a gas chromatograph.

17472. Post, M. A., Godette, M., Campbell, P. G., **Anti-graffiti coatings,** *Mod. Paint Coat.* **68,** No. 2, 28-35 (Feb. 1978).

Key words: graffiti; graffiti-resistant coating; performance characteristics.

Commercially available graffiti-resistant coatings were screened using a graffiti cleanability test. The most easily cleaned coatings were then subjected to additional graffiti removal tests and to other tests designed to measure performance characteristics. Differences in performance characteristics were tabulated. The test results formed the basis for proposed performance criteria for graffiti-resistant coatings. The results show that organic coatings are available which can be used to protect building substrates against defacement by graffiti.

17500. Chapman, R. E., **Lead paint poisoning: A closer look at the costs,** *J. Housing* **33,** No. 10, 489-492 (Nov. 1976).

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

Indecision about how to deal with the lead paint poisoning problem in residential dwellings stems in part from a lack of knowledge about the costs of various abatement methods. This research, sponsored by HUD's Office of Policy Development and Research, provides a procedure for estimating the costs of the alternative abatement methods. Federal and local housing officials can use this procedure and cost information derived from its application to achieve more lead paint abatement per public dollar invested.

17505. Culver, C., **A model for formulating seismic design provisions,** *Proc. CENTO Seminar on Recent Advances in Earthquake Hazard Minimization, Tehran, Iran, Nov. 14-16, 1976*, pp. 536-545 (Technical Research and Standard Bureau, Tehran, Iran, June 1977).

Key words: building codes; earthquakes; structural engineering.

The paper describes a program currently underway in the United States to develop improved seismic design provisions for buildings. Organization of the activity, the form of the provisions and the technical areas included are discussed. Important aspects of the provisions dealing with: (1) design ground motion, (2) structural design, (3) architectural and mechanical-electrical design, and (4) existing buildings are summarized.

17506. Culver, C. G., **Characteristics of fire loads in office buildings,** *Fire Technol.* **14,** No. 1, 51-60 (Feb. 1978).

Key words: buildings; fire loads; load surveys.

A study was made to determine the effects of various parameters on the fire load characteristics of office buildings. This and future studies are expected to form the basis for improving fire resistant design requirements.

17540. Grot, R. A., Galowin, L. S., **Integrated household appliances and utility services for energy conservation in dwellings,** *Proc. ERDA Conf. Div. of Bldgs. and Comm. Services on Technical Opportunities for Energy Conservation in Appliances, Boston, MA, May 11, 1976, CONF ERDA 7605139*, pp. 109-121 (Arthur D. Little, Inc., Cambridge, MA, Mar. 1978).

Key words: appliance combinations; energy conservation in dwellings; ERDA; heat recovery; hot water distribution systems; integrated appliances; utility systems.

The technical feasibility of combining various appliances now constructed separately into integral assemblies which permit more efficient energy design, utilizing waste heat and minimizing the impact of appliance operation on heating and cooling systems is considered. Alternative strategies are suggested to the ways in which energy-consuming services are supplied and utilized in residences. Particular attention is given to the combination of the refrigerator-water heater, air conditioner-water heater and the construction of appliances such as clothes washers and dishwashers which heat only the quantity of water required for their operation from a warm-water house system.

17544. Harrje, D. T., Grot, R. A., **Automated air infiltration measurements and implications for energy conservation,** *Proc. Intl. Conf. on Energy Use Management, Tucson, AZ, Oct. 24-28, 1977*, R. A. Fazzolare and C. B. Smith, Eds., pp. 457-464 (Pergamon Press, New York, NY, 1977).

Key words: air infiltration; automated instrumentation; energy conservation; gas chromatograph; sulphur hexafluoride; tracer gas.

In the average home approximately one third of the energy for space heating is lost through air infiltration. The driving forces for air infiltration often become more severe in larger buildings. Correlation of air infiltration with parameters that are building-related (cracks, seals, porosity, etc.), occupant-related (door, vent, window openings, etc.) weather-related (wind direction, and intensity, outside temperature, etc.) and terrain-related (nearby structures, trees, fences, etc.) has required the development of specialized monitoring equipment. Using sulphur hexafluoride as a tracer gas, using automated procedures for seeding the gas into the building, and measuring the subsequent concentration decay, air infiltration has been measured for a wide range of circumstances. The details of the instrumentation presented here include: injection procedures, sampling methods, detection of the appropriate gas chromatograph concentration peak, and recording the data on magnetic tape for easy retrieval for computer calculations. The data resulting from such air infiltration instrumentation uses are providing the basis for improved energy modeling in buildings, evaluation of energy conserving retrofits, new and old building inspection, and a better evaluation of other air infiltration measurement techniques.

17552. Holton, J. K., **Establishing technical standards for solar installations,** (Proc. on Overcoming Legal Barriers to the Utilization of Solar Energy, Manchester, NH, Apr. 14, 1977), Paper in *IDEA—J. Law Technol.* **19,** No. 1, 25-34 (Capital Offset Co., Inc., Concord, NH, 1977).

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

The Solar Heating and Cooling Demonstration Act of 1974 (PL 93-409) and the National Program for Solar Heating and Cooling (Residential and Commercial Applications), October 1975, recognizes the importance of developing performance criteria and standards to help stimulate the creation of a viable industrial and commercial capability to produce and distribute solar heating and cooling systems. Program activities relating to the development of performance criteria and standards for solar heating and cooling systems, components and materials which are being carried out by the National Bureau of Standards for the Energy Research and Development Administration (ERDA) and the Department of Housing and Urban Development (HUD) are described. Specific activities include the preparation of a standards development plan, establishment of an American National Standards Institute steering committee, the preparation of draft standards for determining the thermal performance of solar components and the performance of various materials used in solar components, and the development of performance criteria to be used in ERDA and HUD solar heating and cooling demonstration programs.

17567. Milton, H. J., **Metrication—A concrete opportunity,** *J. Am. Concr. Inst. No. 11*, pp. N13-N21 (Nov. 1977).

Key words: construction industry metrication; metrication benefits; rationalization; technical issues in metrication.

This paper presents the impending change to metric (SI) measurement in the construction community as an "opportunity" and a once-only chance for review, technical improvement and cost reduction. It deals with the analysis of precedent in the change to SI; defines some new terms, such as "hard conversion" to preferred sizes and descriptions; discusses metrication for benefit; and focuses on the opportunities for rationalization associated with the change.

Four principal opportunities are identified: simplification, rationalization, harmonization and standardization, and each one is illustrated by a number of examples.

The paper recommends that metrication should be regarded as a "worthwhile challenge," rather than as a "problem," so that the appraoch to change is a vigorous and positive one instead of a defensive and negative one.

The benefits from opportunities realized should easily pay for the once only cost of the change.

17574. Petersen, S. R., **Economic optimization in the energy conservation design of single-family housing,** *ASHRAE Trans.* **82,** Pt. 1, 446-458 (1976).

Key words: building economics; economic analysis; energy conservation; engineering economics; housing; insulation; life-cycle cost analysis.

Energy conservation measures appropriate to the design of single-family housing must be utilized to reflect both climatic and economic considerations if life-cycle HVAC costs in housing are to be minimized. This paper examines the economic criteria for minimizing life-cycle costs for both independent and interdependent energy conservation techniques. An index number format with cost data is presented with which the economically optimal use of attic insulation, wall insulation, and storm windows can be estimated for various climatic and economic assumptions, including heating and cooling factors, energy costs, energy conservation costs, discount rates, fuel price increases, and building lifetimes. In general it is shown that the economically optimal use of energy conservation techniques is often considerably greater than currently being observed in most new housing construction.

17581. Quigley, D. F., Kelly, G. E., **Oilburner modification cuts costs,** *Fuel Oil and Oil Heat*, pp. 50, 52 (Sept. 1977).

Key words: heating efficiency; oil-fired furnaces; overfiring of oil-burners.

This paper discusses the results of a field study of residential oil heating systems. The study showed that most oil burners are overfired for the heating load. This overfiring causes low seasonal efficiencies. The article presents a method for optimizing firing rates for improved efficiency.

17592. Masters, L. W., **An approach to the development of predictive service life tests for building components and materials,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977,* **II,** 176-188 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: accelerated aging tests; building components and materials; degradation; methodology; predictive service life tests; service life.

A systematic approach to the development of predictive service life tests and the improvement of existing service life tests for building components and materials is outlined. The approach consists of four parts: Problem Definition, Pre-Testing, Testing and Interpretation and Reporting of DATA. It can be applied to all components and materials comprising a building system. For example, the approach can be applied at the component level to foundations, walls, floors and roofs. It can also be applied to materials comprising components, e.g. coatings, roofing, concrete, sealants, adhesives, metals, wood and others.

Application of the approach to many components and materials is limited, at present, because of the lack of knowledge regarding exposure conditions and mechanisms of failure. Despite these limitations, however, the approach will help in 1) identifying the data needed to develop more definitive tests, 2) ensuring the best possible test is developed and 3) providing a uniform approach to service life prediction and the reporting of results.

17767. Simiu, E., Bietry, J., Filliben, J. J., **Sampling errors in estimation of extreme winds,** *J. Struct. Div. Am. Soc. Civ. Eng.* **104,** No. ST3, 491-501 (Mar. 1978).

Key words: buildings (codes); dynamic response; gust loads; structural engineering; tall buildings; wind forces; wind pressure.

The closure to the paper "Equivalent Static Wind Loads for Tall Building Design" published in April 1976 is presented following four discussions of the paper published in the February 1977, April 1977, June 1977, and October 1977 issues of the ASCE Journal of the Structural Division.

17814. Levy, J., **Efficient equipment maintenance: A tool for energy conservation,** *AACE Bull.* **20,** No. 2, 49-51 (Mar./Apr. 1978).

Key words: dynamic programming; economic analysis; energy conservation; equipment maintenance; Markov decision process; policy improvement algorithm.

A general model of equipment performance as a function of maintenance is developed that permits quantification of the optimal level of maintenance in terms of performance attainment and relative factor costs. The model formulation is that of a finite state, finite action Markov decision process. The model will help persons responsible for making decisions concerning maintenance policies in selecting economically efficient levels of maintenance for elements of building service equipment.

17823. Streed, E. R., **The results of a roundrobin flat-plate collector test program,** *Proc. 1977 Flat-Plate Solar Collector Conf., Orlando, FL, Feb. 28-Mar. 2, 1977,* D. B. Ward, Ed., pp. 267-279 (Florida Solar Energy Center, Publications Auxiliary, 300 State Road 401, Cape Canaveral, FL, Sept. 1977).

Key words: flat-plate collectors; roundrobin test; solar collector; thermal performance testing.

A roundrobin solar energy collector test program has been conducted to evaluate a proposed test method to rate collectors on the basis of thermal performance. Two liquid-type collectors were distributed to 21 organizations in the United States to obtain data in various climatic regions using the prescribed apparatus under allowable ranges of environmental conditions. Plots of the efficiency as a function of the difference in average fluid temperature and ambient temperature divided by the insulation were used to obtain performance curves for each collector. The overall transmittance-absorptance produce ($F'\alpha\tau$) and the overall heat loss coefficient ($F'U_L$) were determined by each participant using a least-squares analysis of the data. The mean and standard deviation for each of these parameters is calculated and the significance with respect to the testing and rating of collectors is discussed.

17852. Sleater, G., **Development of performance criteria for the selection of stone preservatives,** (Proc. American Geological Society, Symp., Miami Beach, FL, Nov. 1974), *Engineering Geology Case Histories No. 11,* pp. 65-71 (1978).

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

This paper describes how test methods and performance criteria for the selection of stone preservatives are being developed. Accelerated aging of stone and of preservative treated stone followed by tests of the aged specimens is used to evaluate both test methods and stone preservatives. The laboratory aging procedure incorporates important causes of stone decay—Chemical Attack, Salt Action, Water Action, Thermal Effects—in a special test chamber (CAD) and test cycle. The effects of the accelerated aging on the weight, appearance, absorption of liquid water, permeability to water vapor, abrasion resistance, and surface hardness of the treated test specimens are used as measures of preservative performance. It is explained how this test data and the test methods employed can be used to set limits of acceptable performance to be used as preliminary performance criteria for the selection of stone preservatives.

17857. Pommersheim, J. M., Mathey, R. G., **Prediction of bitumen slip and sag in roofing systems,** (Proc. First Int. Conf. Math. Modeling, St. Louis, MO, Aug. 29-Sept. 1, 1977), *Eng. Sci.* **III,** 1347-1359 (1977).

Key words: asphalt; bitumen; built-up roofing; coal-tar pitch; roofing; sag; slip.

Mathematical models for slippage of built-up roofing membranes and sag of roofing bitumens were formulated, solved and tested against previously developed experimental data. Bitumens used were coal tar pitch and ASTM Types I, II and III asphalts. Model predictions confirmed the increased slip and sag observed with increased membrane loading, roof slope, interply bitumen film thickness and bitumen temperature. Viscosities were calculated from the models for slip and sag and compared to ones measured independently using a plastometer. Agreement was good for Types II and III asphalts but only fair for coal tar pitch and Type I asphalt. The calculated bitumen viscosities for the slip and sag tests agreed well with one another except for coal tar pitch. Separate calculations showed either Newtonian or pseudoplastic behavior. Design predictions were made for the amount of slip in a built-up roofing membrane subjected to typical summer temperatures and solar radiation intensities. The methods presented in this paper help to quantify the separate and combined effects of the factors influencing roofing performance when slippage and sag occur.

17859. Collins, B. L., **Human response to windows,** *Proc. RILEM/ASTM/CIB Symp. Evaluation Performance External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977,* **1,** 327-338 (1977).

Key words: energy conservation; glare; human factors; psychology; thermal discomfort; window management; windows.

Research into human reaction to windows must consider several different types of response. Windows provide important psychological benefits, including a view out, and dynamic change within a space through continuous variations in external lighting. In addition, another response involves comfort in such areas as temperature, glare, and noise. Finally, it is important to consider the actual use of windows. The way in which people actually use windows and window accessories can be critical to the acceptable performance of glazed areas. Pertinent information from different researchers on human response is reviewed.

17941. Reinhold, T. A., Sparks, P. R., Tielman, H. W., Maher, F. J., **The effect of wind direction on the static and dynamic wind loads on a square-section tall building,** (Proc. 3d Colloq. on Industrial Aerodynamics, Aachen, Germany, June 14-16, 1978), Paper in *Building Aerodynamics, Pt. 1,* pp. 263-279 (Fluid Mechanics Laboratory, Department of Aerodynamics Fachhochschule-Aachen, Germany, May 1978).

Key words: aerodynamics; dynamic loads; dynamic response; structural engineering; tall buildings; wind pressure; wind tunnel tests.

This paper presents the results of a wind-tunnel investigation into the effect of wind direction on the wind loads on a square cross-section building model with sharp corners and an aspect ratio of 8.33 to 1. The studies were carried out in a flow which simulated the mean and turbulent properties expected for an urban boundary layer wind. The static and dynamic wind loads were determined at 6 levels throughout the height of the model. From these loads, local and overall force coefficients were determined for forces normal to the model's faces and for torques about the vertical axis through the geometrical center of the model cross-section. These coefficients are presented together with spectra for the modal forces and modal torques associated with the fundamental translational and modes of the corresponding full structure.

Results indicate that the greatest mean forces do occur when the wind is normal to a building's face but that this is not the case for the mean torques. At certain wind directions mean forces are very sensitive to changes in direction. The dynamic loads suggest that the greatest translational response of the full-scale building would occur in the cross-wind direction with the wind blowing in a direction normal to a face. The greatest dynamic torsional response would also be associated with that direction.

17942. Ruegg, R. T., Chapman, R. E., **Economic analysis of alternative window strategies,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. I,* 395-405 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: buildings costs; economic evaluation; energy conservation; exterior walls; life-cycle costing; windows.

The focus of this paper is the energy and economic performance of the glazed portions of external vertical surfaces in residential buildings. A life-cycle costing technique is used to evaluate the dollar costs of energy, acquisition, maintenance and repair, for windows of alternative design, size, and location, with various accessories and modes of use. The method of evaluation is described briefly and is illustrated in a case study. The results of the case study, based on a "typical" single family dwelling in Portland, Maine, U.S.A. (4173 heating degree days and 131 cooling hours), provide some guidelines for window selection in a moderately cold climate. In general, the economic evaluation of windows indicates that, depending on their design and use, windows can either greatly increase, decrease, or have little impact on energy consumption and total life-time building costs. There is considerable opportunity for the building community to improve both the energy and the economic efficiency of windows while providing for the important psychological benefits which windows often provide.

17943. Sleater, G., **Performance of industrial-type cladding materials,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II,* 302-308 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: abrasion resistance; coatings; color and gloss change; impact resistance; industrial cladding; moisture resistance; salt spray resistance.

The development of performance criteria for the selection of industrial cladding materials is described. These criteria are based upon: 1) laboratory testing of commercial cladding materials, to determine limits of acceptable performance; 2) natural weathering exposure at NBS Exposure Stations, to study weathering effects; 3) field inspection of structures using industrial cladding, to obtain information about cladding durability under use. The performance criteria cover abrasion resistance, impact resistance, color and gloss changes, salt spray resistance, and moisture resistance.

17944. Sleater, G. A., **Preliminary performance criteria for stone preservatives,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces on Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II,* 309, 311-321 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: accelerated stone decay; performance criteria; 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.

17947. Trechsel, H. R., **Test methods for windows and walls—The need for a testing program,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Espoo, Finland, Aug. 28-Sept. 2, 1977, Vol. II,* 374-382 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: buildings; design; test methods; walls and windows.

Despite an advanced state of the art in the design of building walls and windows, and despite the extensive testing on building envelope elements, some rather spectacular failures of such elements have occurred in recent years. The paper discusses several selected factors affecting the reliability of test results: number of specimens to be tested, process for selecting

specimens, and single performance characteristic tests. Based on these factors, it is proposed that testing be considered as an integral part of the design and build process. It is further suggested that the systems approach be used for developing a test program based on the various trade-offs between cost for the testing and the potential risk for failure.

18020. Hastings, S. R., **A comprehensive approach to window design for energy conservation,** *Proc. Second National Conf. on Passive Solar Energy, Philadelphia, PA, Mar. 15-19, 1978*, pp. 321-325 (American Section ICES, University of Delaware, Newark, DE, Aug. 1978).

Key words: building envelope; energy conservation; fenestration; passive solar; windows.

Six categories of design strategies to improve the energy performance of windows are presented. These design strategies are evaluated by their ability to improve one or more of six possible energy control functions windows can perform. An example strategy is selected from each category to illustrate how substantially a window's performance can be improved. In designing and subsequently evaluating a window one should consider the performance of the window in concert with various design strategies and the performance of a given solution should be considered relative to all six possible energy control functions.

18059. Chi, J., **Seasonal operating performance of gas-fired hydronic heating systems with certain energy-saving features,** (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, **1**, 495-504 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: boiler; computer simulation; DEPAB; energy conservation; heating systems; part-load performance; seasonal efficiency.

DEPAB (DEsign and Performance Analysis of Boilers) is an NBS computer program for simulation of fossil-fuel-fired boilers for residential heating systems. It is based upon an analytical model which accounts for cyclic (on-and-off) operation of a boiler fuel burner and water circulating pump. This paper illustrates the use of DEPAB for evaluating quantitatively the effectiveness of several selected energy-saving features for gas-fired hydronic heating systems. Sufficient information is also provided to demonstrate the important factors of the simulation program DEPAB.

18064. Grimes, J. W., Mulroy, W., Shomaker, B. L., **Effect of usage conditions on household refrigerator-freezer and freezer energy consumption,** *ASHRAE Trans.* **83,** Part 1, 818-828 (1977).

Key words: appliance labeling; energy use; household freezers; household refrigerators; refrigerator.

A study was made of an automatic- and a manual-defrost refrigerator/freezer combination, and an upright and a chest freezer to measure the effect on energy consumption of five variable usage conditions: thermostat setting, ambient temperature, food load, door-opening frequency, and relative humidity. No evaluation was made of the effect of frost build-up.

Ambient temperature and thermostat setting were found to have considerably greater effect on energy consumption than door-opening and relative humidity changes for the specimens tested.

18069. Jones, R. R., **Resource impact factor (RIF) approach to optimal use of energy resources,** *ASHRAE J.* **18,** No. 10, 15-18 (Oct. 1976).

Key words: energy sources; fuel selection; institutional factors; social value.

One of the basic objectives of a national energy conservation effort is to optimize use of nonrenewable resources. A careful analysis of the fuel and energy supplied to buildings is especially important since this sector accounts for about 30 percent of energy consumption in the U.S. and since buildings have greater flexibility with regard to energy sources than do motor vehicles and industrial processes. It is the intent of this paper to present the Resource Impact Factor (RIF) concept as a means whereby, in the technical process of developing energy efficient building projects, a quantification could also be given to the social value of our resources in order to obtain wise utilization.

18070. Kusuda, T., **Fundamentals of building heat transfer,** (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, **1**, 321-338 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: air leakage; dynamic heat transfer; energy analysis; heating and cooling loads; heat loss and heat gain; multi-room problems.

Basic problems and unique features of building heat transfer are described in relation to the heating and cooling load calculation, which is a starting point for building energy consumption analysis and equipment sizing. Detailed discussion is given of the relationship between heat loss (heat gain) and heating load (cooling load). Also outlined is a discussion of the multi-space heat transfer problem in which the air and heat exchange equations among adjacent spaces in a building are solved simultaneously with the radiant heat exchange equations for the surfaces of each room.

18084. Orloski, M. J., **All's well that vents well. Pre-occupancy performance of field units with reduced-size vents,** Proc. American Society Sanitary Engineering Annual Meeting, Philadelphia, PA, Oct. 24-27, 1976, pp. 55-64 (1976).

Key words: performance testing; plumbing system design; reduced-size vents; trap-seal retention; venting.

Reduced-size vents were installed in six one- and two-story houses at Andrews Air Force Base, Maryland. Tests were conducted before occupancy to evaluate the performance of the system, principally by measurements of trap-seal retention, under loads believed representative of service conditions. These field test results are a follow on to those of the National Bureau of Standards laboratory work on reduced-size venting which were reported at the ASSE Convention in 1974. Both the laboratory and field test results show the viability of reduced-size venting. This is expected to contribute to the inclusion of reduced-size venting in plumbing codes.

18088. Chi, J., Kelly, G., Didion, D., **Use of computer model to evaluate energy saving potentials for gas-fired furnaces,** *Proc. 1978 ASME International Heat Transfer Conf., Toronto, Canada, Aug. 7-11, 1978, Paper* 4, No. 78-IHTC-77, 143-148 (Hemisphere Publ. Co., Washington, DC, 1978).

Key words: building heating system; computer simulation; DEPAF; energy conservation; furnaces; operating cost; seasonal performance.

DEPAF (DEsign and Performance Analysis of Furnaces) is an NBS computer program for simulation of fossil-fuel-fired furnaces for residential heating systems. It is based upon an analytical model which accounts for cyclic (on-and-off) operation of the burner and air circulating blower. This paper illustrates the use of DEPAF to evaluate quantitatively the effectiveness of 15 combinations of selected energy-saving features

for gas-fired residential heating furnaces. Sufficient information is also provided to demonstrate the important features of the simulation program DEPAF.

18098. Didion, D., Maxwell, B., Ward, D., **A laboratory investigation of a Stirling engine-driven heat pump,** (Proc. Int. Conf. Centre Heat & Mass Transfer, Dubrovnik, Yugoslavia, Aug. 29-Sept. 2, 1977), Paper in *Energy Conservation in Heating, Cooling, and Ventilating Buildings, New Techniques in Heating and Cooling of Buildings*, **2**, 583-596 (Hemisphere Publ. Corp., Washington, DC, 1978).

Key words: air-to-air heat pump; energy conservation heating; engine-driven heat pump; heat engine; heat pump; residential heating; Stirling engine; Stirling engine heat pump.

An experimental investigation was conducted on an air-to-air heat pump powered by a single-cylinder, seven-horsepower, water-cooled Stirling engine. The steady-state part-load performance of the engine-driven heat pump system was determined in both the heating and cooling modes of operation. The unit was operated over a broad range of outdoor temperatures and corresponding coefficients of performance (COP), and seasonal performance factors (SPF) were determined. The energy rejected to the engine's cooling water was measured and included in the heating mode calculations.

18102. Stiehler, R. D., Hockman, A., Embree, E. J., Masters, L. W., **Existing standards inadequate for solar collector use,** *Solar Eng.* **3**, No. 8, 35-37 (Aug. 1978).

Key words: durability; rubber seals; solar energy systems; standards; test methods.

A study was performed to develop standards for rubber seals used in solar energy systems. Thirty-one preformed and liquid applied seals were evaluated in the laboratory using modified ASTM standard test methods to obtain data needed to evaluate those materials and prepare new standards. Also, studies were performed to develop a test method for determining the effects of outgassing on the transmittance of solar collector covers.

This paper is a summary of the findings of NBSIR Solar Energy Systems—Standards for Rubber Seals, in which standards for rubber seals in solar energy systems are proposed.

18107. Holton, J. K., **Updating solar performance criteria and standards,** *Proc. 1978 Ann. Meeting American Society Int. Solar Energy Society, Inc., Denver, CO, Aug. 28-31, 1978*, pp. 514-521 (Amer. Section ISES, McDowell Hall, U. of Delaware, Newark, DE, Sept. 1978).

Key words: solar performance criteria; updating.

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 wide-spread 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, thermo-syphoning, flow balancing, controls, safety, maintenance and check-out procedures; and component performance covering freeze protection, stratification, stagnation, materials deterioration, and heat transfer fluid quality.

18115. Campbell, P. G., Post, M. A., **Nontoxic yellow traffic striping,** *Federal Highway Administration Report FHWA-RD-78-1*, 74 pages (Available from the National Technical Information Service, Springfield, VA 22161, Jan. 1978).

Key words: alkyd traffic paint; chlorinated rubber traffic paint; hot thermoplastic coatings; lead chromate; organic yellow pigments; yellow traffic paint.

A study was carried out to examine the performance characteristics of alternative pigments which might be used in yellow traffic paints if the use of lead chromate were curtailed. Thirty-six yellow traffic paints were prepared using lead chromate and alternative pigments as the yellow color source. Screening tests were used to evaluate the initial color stability and durability characteristics of the paint formulations. The thermal stabilities of selected yellow pigments for use in thermoplastic marking applications were evaluated. Also, outdoor exposures and a small scale field test were used to evaluate the performance of formulations containing lead chromate and alternative pigments. The performance of the alternative organic yellow pigments, as measured by color change under the various exposure conditions, was found to be at least as good as that of lead chromate.

18132. Steihler, R. D., **Getting the right angle,** *Eng. Educ.* **5,** No. 2, 1 page (Aug. 2, 1978).

Key words: plane angle; SI units; torque unit; trigonometric functions.

Confusion exists concerning units for torque, energy, and other quantities involving rotation. This confusion stems from the treatment of plane angle and trigonometric functions in schools.

A plane angle is the divergence between two intersecting straight lines. The magnitude of the divergence can be expressed in a variety of measurement units, such as radian, grad, degree, minute, or second. The magnitude is *not* a number without units. An arc of a circle is frequently expressed in the same unit as plane angle. Actually, an arc of 30 degrees means a length on the circumference subtended by two radii having a divergence of 30 degrees; the length of the arc being 30 kr, where k = 0.01745 per degree. If the arc (s) and radius (r) are expressed in the same unit and angle (Θ) is in radians, k must have the value: 1 rad^{-1}. Since $s/r = k\Theta$, the practice of using the ratio s/r as synonymous with Θ is misleading. It implies that Θ is dimensionless. This practice is the source of the controversy concerning the radian in SI.

Trigonometric functions (sine, cosine, tangent, etc.) are mathematical designations for the ratios of lenghts of sides in a right triangle. The functions are designated in reference to one of the angles other than the right angle in order to specify the two sides involved in a particular function.

18203. Symuleski, R. A., **An evaluation of the applicability of pyrolysis-gas-liquid chromatography for the identification of microorganisms in water and sewage treatment plant effluents,** *Proc. 3d National Conference on Complete Water Reuse, Cincinnati, OH, June 27-30, 1976,* pp. 457-461 (American Institute of Chemical Engineering, United Engineering Center, New York, NY, 1976).

Key words: bacterial identification; gas-liquid chromatography; potable water; pyrolysis; sewage treatment plant effluent; water reuse.

Recent studies have shown pyrolysis-gas-liquid chromatography to be a valuable tool in the rapid identification of bacteria. Most of the work to date has been involved with the detection of anaerobic bacteria in clinical samples. The present study indicates that the technique may also have promise in detecting those facultative bacteria present in samples of environmental origin. This paper describes on-going work in the evaluation of this procedure for the rapid identification of bacteria in water and sewage treatment plant effluents. Preliminary results from the analysis of one species of bacteria are presented along with a discussion of current problems encountered in the analytical procedure.

18230. Yonemura, G. T., **Light and vision,** Paper in *Developments in Lighting-1,* J. A. Lynes, Ed., Chapter 2, 25-45 (Applied Science Publishers Ltd., Essex, England, 1978).

Key words: illumination; illumination levels; lighting; task lighting; vision.

Three levels of visual information needs are defined. The psychological responses associated with these information requirements are identified and correlated with their stimulus counterparts. The criteria for recommending levels of illumination should be 'goodness of seeing' rather than 'just barely able to see'. Blur is introduced as a parameter that has been neglected in task description for lighting. The Modulation Transfer Function is recommended as a technique that analytically describes the classical parameters associated with visual sensory performance as well as blur. The relative contributions of physiological and psychological variables in visual task performance studies are discussed.

18234. Holton, J. K., **Critical performance standards for passive solar buildings,** *Proc. Conf. Second National Passive Solar Buildings, Philadelphia, PA, Mar. 16-18, 1978,* **II,** 294-297 (University of Delaware, Newark, DE, 1978).

Key words: passive solar systems; performance standards; system classification.

An outline of a limited number of performance standards and evaluation criteria for passive solar buildings is presented. Three levels of criteria are described which are intended to categorize these into a few most needed criteria concerning basic thermal performance, health and safety, and two levels of additional criteria that are thought desirable to assess long term usefulness of passive installations. Status of development of the criteria is also discussed.

18254. Ventre, F. T., **Decision-aiding communications in the regulatory agency: The partisan uses of technical information,** *Ind. Forum* **8,** No. 1, 15-28 (1977).

Key words: building codes; decision making; public policy; regulation.

Based on a nationally representative survey of 1 200 municipal building departments, the partisan uses of information in a regulatory setting are described. Each of the surveyed agencies was facing a specific decision to alter its regulations to accommodate innovative building techniques. The agencies identified the various members of the building community—builders, designers, vendors, users, regulators—who came forward to initiate the change, to discuss its advantages or disadvantages, and then to assert a position, either supporting or resisting the agency decision, to modify the regulations. The local building industry—accused by many of being the greatest source of resistance to technical innovation—was found to be the strongest force for change, equalling and sometimes surpassing the positive influence of the model code groups.

18286. Hill, J. E., Jenkins, J. P., Jones, D. E., **Testing of solar collectors according to ASHRAE Standard 93-77,** *ASHRAE Trans.* **84,** Part 2, 107-126 (1978).

Key words: heat transfer; measurement; radiation; rating; solar; standards; testing.

A proposed procedure for testing and rating solar collectors based on thermal performance was published by the National Bureau of Standards (NBS) in 1974. The procedure prescribed that a series of outdoor steady-state tests be conducted to determine the near-solar-noon efficiency of the collector over a range of temperature conditions. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has recently adopted ASHRAE Standard 93-77. It is similar to the original NBS procedure but calls for additional tests to determine the collector time constant as well as an incident angle correction factor that can be applied to the near-solar-noon efficiency to determine collector performance both early in the morning and late in the day.

Two test facilities have been built at NBS in accordance with ASHRAE Standard 93-77, one for modular water-cooled collectors and the other for air heaters. The purpose of this paper is to describe the recently adopted test procedure, provide a description of the facility at NBS, and to give results of a complete series of tests made according to the Standard on several commercially available collectors.

18287. Hill, J. E., Richtmyer, T. E., Jenkins, J. P., **Initial test results for a solar-cooled townhouse in the Mid-Atlantic region,** *ASHRAE Trans.* **82,** Part II, 389-404 (1976).

Key words: absorption; air-cooling; computer; hot-water; measurement; residential; solar; testing.

A factory-produced four-bedroom townhouse unit equipped with a solar heating, cooling, and domestic hot water supply system is currently under test at the National Bureau of Standards in Gaithersburg, Maryland. The test house has approximately 110² (1200 ft²) of floor area. The solar system consists of 45 m² (485 ft²) of double-glazed flat-plate solar collector having a nonselective coating on the absorber, a water-to-air heat exchanger in a forced-air distribution system for space heating, two large water tanks for thermal storage, and a lithium-bromide absorption refrigeration unit. In addition, domestic hot water is preheated from the solar system through a water-to-water heat exchanger.

Results are given for the first summer's cooling tests conducted in 1975. It was found that approximately 20 percent of the required cooling energy was obtained from the sun and approximately 75 percent of the energy for domestic hot water. The test results were compared with predicted results for the same conditions. It was found that solar collector array thermal output was less than one-half of what had been expected based both on manufacturers' published data and previous tests done on one part of the array at NBS. Due to the poor performance of the collector array, it was found that no effective use could be made of thermal storage.

18292. McNall, P. E., Pierce, E. T., Barnett, J. P., **Control strategies for energy conservation in buildings,** *Proc. Symp. Honoring A. Pharo Gagge on Energy Conservation Strategies in Buildings: Comfort, Acceptability, and Health, Hartford, CT, Jan. 25, 1978,* pp. 1-12 (J. B. Pierce Foundation Laboratories, Hartford, CT, 1978).

Key words: comfort conditions in buildings; compared comfort control strategies; energy conservation potential; set point controls; temperature controls.

Three control strategies allowing zone temperatures to "drift" between a minimum and a maximum set point, without energy use, were imposed on two example commercial buildings. Each building was simulated on a different computer load program in several locations in the U.S. Comparisons of the energy demands were made for the various cases, showing significant energy saving potentials while maintaining inside thermal conditions which could probably be made acceptable to the occupants.

18293. Brungraber, R. J., Adler, S. C., **Technical support for a slip-resistance standard,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 649,* pp. 40-48 (1978).

Key words: coefficient of friction; friction; performance standards; safety engineering; slip resistance; test methods.

In the spring of 1975, ASTM Subcommittee F15.03.01 on Specifications and Test Methods for Slip Resistance of Bathing Facilities, requested technical assistance from the Building Safety Section (BSS) of the National Bureau of Standards (NBS) in developing a performance test for establishing quantitatively an acceptable level of slip resistance for bathtubs and shower bases. Close cooperation between the subcommittee members and the BSS staff, coupled with financial support from the Consumer Product Safety Commission (CPSC), resulted in the development of a performance test which approximates the conditions that are likely to occur on bathtub or shower base surfaces, is reliable and repeatable, and discriminates adequately between currently available bathtub and shower base materials.

18294. Ducas, W., Streed, E., Holton, J., Angel, W., **Thermal data requirements and performance evaluation procedures for passive buildings,** *Proc. 2d Natl. Conf. on Passive Solar Heating and Cooling, Philadelphia, PA, Mar. 16-18, 1978,* **2,** 411-430 (Mid-Atlantic Solar Energy Association, Philadelphia, PA, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

A systematic classification of passive solar buildings and performance factors are proposed to standardize evaluation procedures for these buildings. Two measurement levels are described with appropriate sensors and data acquisition systems to obtain either detailed data for complete component and system evaluation or to obtain "critical" data for evaluating the energy saved at many sites.

18296. Hill, J. E., Streed, E. R., **A method of testing for rating solar collectors based on thermal performance,** *Sol. Energy* **18,** 421-429 (1976).

Key words: measurement; radiation; rating; solar; standards; testing.

This paper describes a proposed test method for determining the efficiency of solar collectors under specified outdoor "steady-state" conditions. The prescribed series of tests should provide useful data for the rating of solar collectors based on thermal performance. A study was made of existing theory, measurement practices and a number of collector test procedures in use prior to the publication of the proposed method.

The test apparatuses and major components have been prescribed so a liquid or air can be used as the transfer fluid. The energy of the fluid entering and leaving the collector is determined by making appropriate measurements and these quantities are then compared to the energy incident upon the collector (also determined by measurement) in order to calculate the collector efficiency.

The series of tests to be conducted consists of determining the average efficiency for 15 min periods (integrating the energy quantities) over a range of temperature differences between the average fluid temperature (average of inlet and outlet) and the ambient air. The test apparatuses have been designed so that the temperature of the fluid entering the collector can be controlled to a selected value. This feature is used to obtain the data over the temperature range desired. At least sixteen "data points" are required for a complete test series and they must be taken symmetrical with respect to solar noon (to prevent biased results due to possible transient effects).

18297. Hill, J. E., Jenkins, J. P., **The application of ASHRAE Standard 93-77 to concentrating collectors,** *Proc. ERDA Conf. on Concentrating Solar Collectors, Atlanta, GA, Sept. 26-28, 1977,* pp. 6-1—6-8 (College of Engineering, Georgia Institute of Technology, Atlanta, GA, 1977).

Key words: measurement; radiation; rating; solar; standards; testing.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers, (ASHRAE) has recently adopted ASHRAE Standard 93-77 for testing and rating of solar collectors based on thermal performance. Four separate tests are required to be conducted. This paper will briefly explain the tests and indicate how they might be adapted for use with concentrating collectors.

18298. Jones, D. E., **System performance measurements for a packaged solar space heating system equipped with air-heating collectors,** *Proc. Conf. on Performance Monitoring Techniques for Evaluation of Solar Heating and Cooling Systems, Washington, DC, Apr. 2-5, 1978*, pp. 105-114 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

This paper describes the approach and instrumentation used at the National Bureau of Standards for determining system performance of a packaged solar space heating system equipped with air heating collectors. A method of measuring air flow rate accurately without disturbing system performance through use of the collector as a flow measuring element is the major unique feature of the experimental approach.

18299. Jones, D. E., Hill, J. E., **Testing of flat-plate air heaters according to ASHRAE Standard 93-77,** *Proc. American Section, Int. Solar Energy Society 1977 Annual Meeting, A Solar World, Orlando, FL, June 6-10, 1977*, pp. 2-1—2-4 (American Section of the International Solar Energy Society, Inc., Killeen, TX, 1977).

Key words: measurement; radiation; rating; solar; standards; testing.

A proposed procedure for testing and rating solar collectors was published by the National Bureau of Standards (NBS) in 1975. In early 1977, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) adopted ASHRAE Standard 93-77 which is a modified version of the NBS procedure. A test facility for air heaters has been built at NBS in accordance with this Standard. The purpose of this paper is to briefly explain the recently adopted test procedure, describe the NBS test facility, and to give typical test results for a commercially available air-cooled solar collector.

18300. Kusuda, T., Bean, J. W., McNall, P. E., Jr., **Potential energy savings using comfort-index controls for building heating and cooling systems,** *Proc. Int. Indoor Climate Symp., Copenhagen, Denmark, Aug. 30-Sept. 1, 1978*,

Key words: computer simulation; energy conservation; heating and cooling load calculation; planned heating and cooling; thermal comfort indices.

Significant energy savings are possible through the use of thermal comfort index controls of building heating and cooling systems. In order to study the potential energy saving by comfort index controls, Fanger's Predicted Mean Vote (PMV) and Predicted Percent Dissatisfied (PPD) indices have been incorporated into NBSLD (National Bureau of Standards Heating and Cooling Load Calculation Program) to determine hourly profiles of indoor thermal comfort conditions under various operating conditions which allow inside control points to vary. Discussed in this paper are the potential applications of this computer program (NBSPMV) for the evaluation of selected energy conservation options, from the standpoint of indoor habitability and energy conservation. These options include increased temperature deadband, natural cooling, nighttime thermostat setback, passive solar heating, evaporative cooling, temperature ramp controls, intermittent heating and cooling, and programmed heating and cooling.

18301. Liu, S. T., Shih, K., Wood, B. D., **Experimental validation of the solar simulation program TRNSYS for a solar domestic hot water heating system,** *Proc. DoE Symp. on Systems Simulation and Economic Analysis for Solar Heating and Cooling, San Diego, CA, June 27-29, 1978*, pp. 193-194 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch and Barriers and Incentives Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

TRNSYS, a transient simulation program developed by the University of Wisconsin, is currently the most widely used computer simulation program in the solar heating and cooling field. This program has been used to predict system performance of numerous solar heating and cooling systems. Although it is widely used, the accuracy of the prediction has not yet been sufficiently validated with experimental data.

The primary objective of a project currently underway at the National Bureau of Standards is to carry out experiments to validate the TRNSYS program for solar domestic water heating systems. Two approaches are being taken. One is to use the program to predict the performance of six representative solar water heating systems and then to gather long-term experimental data (12 months) on these systems in actual operation at an outdoor test site in Gaithersburg, Maryland. The second approach is to use a laboratory apparatus which has been designed around the typical components simulated in TRNSYS and to gather detailed short-term experimental data on the performance of these components when subjected to closely controlled experiments. The results are then compared with the predictions of TRNSYS for the same experiments.

This paper presents some of the initial results of comparisons obtained using the laboratory apparatus and associated TRNSYS simulation. The specially-designed indoor test configuration will be described. Comparison of test results for several different combinations of hot water use schedule, piping configuration, and assumed solar collector output with those predicted by the applicable component models in TRNSYS under similar conditions will be shown. Emphasis has been placed on comparing the degree of temperature stratification in the storage tanks and heat loss from the tanks.

18302. Richtmyer, T. E. , **The use of computer-controlled data acquisition systems in determining solar heating and cooling system performance,** *Proc. Monitoring Techniques for Evaluation of Solar Heating and Cooling Systems, Washington, DC, Apr. 2-5, 1978*, pp. 95-104 (U.S. Department of Energy, Conservation and Solar Applications, Solar Heating and Cooling Research and Development Branch, Washington, DC, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

For the past few years, NBS has been conducting a number of solar energy related projects. Two, in particular, are solar heated and cooled buildings that use computer controlled data acquisition systems. This paper describes those buildings, their data acquisition systems and discusses problems that have been experienced. Finally, a list of recommendations and suggestions are offered based on those experiences that should help prevent similar problems on future projects.

18304. Streed, E. R., **A comparison of flat-plate solar collector thermal performance data obtained indoors and outdoors,** *Proc. 1978 Annual Meeting of the International Solar Energy Society, Denver, CO, Aug. 28-31, 1978*, **2.1**, 352-361 (American Section of the International Solar Energy Society, Inc., Killeen, TX, 1978).

Key words: measurement; radiation; rating; solar; standards; testing.

Standard test methods for the determination of the thermal performance of flat-plate solar collectors are needed on an international basis to provide consistent and reproducible data for the world market. Indoor and outdoor test methods have been proposed by a task group of the International Energy Agency. The National Bureau of Standards is assisting in the evaluation of these methods. In this paper, a comparison is made of pertinent data obtained within the United States for the thermal efficiency of several state-of-the-art water-heating flat-plate solar collectors. The data was obtained both outdoors as well as indoors using a solar simulator. In addition, the values of the collector heat loss coefficient obtained indoors and outdoors both under nonirradiated conditions is compared with values indicated from the outdoor tests to determine thermal efficiency (irradiated conditions). The comparisons indicate that relatively good agreement is achieved using the various methods but that some of the environmental parameters may require better control and/or simulation during the tests.

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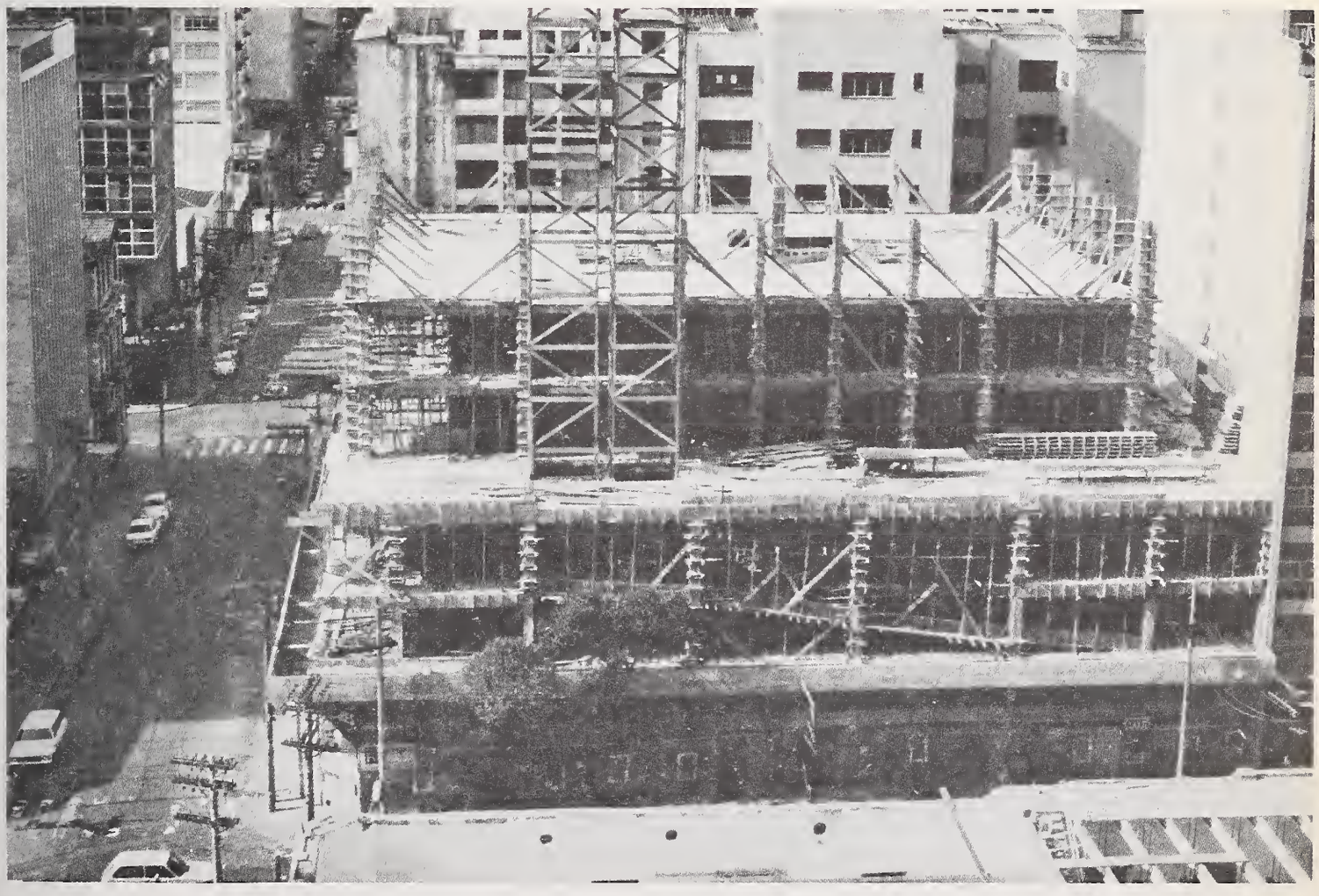
Key Word Index



A

B

Bridges; earthquake; retrofit decision; *SP523*, pp. VIII-1—VIII-21 (Sept. 1978).

Building; building codes; building design; disaster mitigation; earthquakes; engineering; standards; *SP510*.

Building; center for building technology; design; performance concept; *NBS-GCR-77-107*.

Building; construction cost estimation; discounted payback period; economic analysis; economic evaluation; energy conservation; life-cycle costing; present value analysis; *NBSIR 78-1568*.

Building acoustics; building codes; isolation; noise; noise criteria; rating scheme; sound transmission; *SP499*.

Building acoustics; environmental noise; noise; noise control; sound; transportation system noise; acoustics; architectural acoustics; *BSS84*.

Building code; code officials; effective "U" values; energy conservation; implementation; professional competence; training program; *SP518*, pp. 313-322 (Aug. 1978).

Building code official; buildings; education level; energy conservation; evaluations; upgrading, certification; *SP518*, pp. 9-15 (Aug. 1978).

Building code official; code requirements; energy conservation; performance specifications; testing; verification; balancing; *SP518*, pp. 135-144 (Aug. 1978).

Building codes; building design; disaster mitigation; earthquakes; engineering; standards; building; *SP510*.

Building codes; building design; disaster mitigation; earthquakes; engineering; implementation; standards; assessment; *NBSIR 78-1549*.

Building codes; building regulations; buildings; economic impacts; environmental considerations; innovative practices; regulatory research; standards development; administrative procedures; *SP518*.

Building codes; building regulations; building regulatory systems; model building codes; standards; *NBSIR 78-1490*.

Building codes; building research; code enforcement; construction; existing buildings; rehabilitation; renovation; *NBS-GCR-78-139*.

Building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind loads; *17365*.

Building codes; classification; index; organization; outline; standards; systems engineering; *SP518*, pp. 145-160 (Aug. 1978).

Building codes; code changes; incentives; innovations; log homes; minimum property standards; model code agencies; regulations; *SP518*, pp. 49-66 (Aug. 1978).

Building codes; computer model; decision table; decision theory; network, specifications; standards; systems engineering; *NBS-GCR-78-123*.

Building codes; control measures; fire codes; fire safety; governmental actions; life safety; regulation; risk assessment; societal goals; *SP518*, pp. 165-176 (Aug. 1978).

Building codes; cost-benefit; decision making; priorities; regulatory agency; resources; risk; *SP518*, pp. 359-369 (Aug. 1978).

Building codes; data collection; fire hazards; fire protection; National Fire Data Center; regulation; reporting system; scenarios; system design; *SP518*, pp. 259-283 (Aug. 1978).

Building codes; decision making; public policy; regulation; *18254*.

Building codes; earthquakes; structural engineering; *17505*.

Building codes; isolation; noise; noise criteria; rating scheme; sound transmission; building acoustics; *SP499*.

Building codes; mobile homes; National Conference of States on Building Codes and Standards; NCSBCS; proceedings; 8th Annual Conference; ASHRAE 90-P; *NBSIR 77-1413*.

Building codes and standards; building regulations; building safety; economic analysis; economics of safety; electric shock; ground fault circuit interrupters; benefit-cost analysis; benefit-risk analysis; *NBSIR 78-1528*.

Building codes, due process; legislation; model codes; promulgation; regulatory process; standards development; *SP518*, pp. 67-76 (Aug. 1978).

Building components and materials; degradation; methodology; predictive service life tests; service life; accelerated aging tests; *17592*.

Building design; building regulatory system; decision processes; hazards-related phenomena; innovations; research findings; scientific methods; socio-political system; technical expertise; *SP518*, pp. 25-47 (Aug. 1978).

Building design; disaster mitigation; earthquakes; engineering; standards; building; building codes; *SP510*.

Building design; disaster mitigation; earthquakes; engineering; implementation; standards; assessment; building codes; *NBSIR 78-1549*.

Building economics; building standards; energy conservation; life-cycle building costs; performance standards; benefit-cost analysis; *NBSIR 78-1471*.

Building economics; economic analysis; energy conservation; engineering economics; investment analysis; life-cycle cost analysis; *BSS113*.

Building economics; economic analysis; energy conservation; engineering economics; housing; insulation; life-cycle cost analysis; *17574*.

Building economics; economic efficiency; economics; energy; energy conservation; life-cycle cost; optimization; performance standards; resource impact factors; resources; social optimum; standards; *BSS114*.

Building energy conservation; climatic effects on building energy consumption; computer modeling of building energy consumption; energy conservation; geographical variation of building consumption; residential energy consumption; *BSS116*.

Building energy conservation; energy management; evaluation and monitoring; survey of buildings; Air Force facilities; *NBSIR 77-1238*.

Building envelope; building regulations; data collection; energy budget; energy conservation; heat loss; thermal performance; ASHRAE standards; *SP518*, pp. 219-250 (Aug. 1978).

Building envelope; energy conservation; fenestration; passive solar; windows; *18020*.

Building evaluation; building research; man and environment relations; people and buildings; post-construction evaluation; architectural analysis; architectural evaluation; architectural process; architectural research; *NBSIR 77-1402*.

Building fires; computer-aided design; fire computer program; fire research; fire safety; human performance; model documentation; modeling technique; programming; simulation; architectural psychology; architectural research; *NBSIR 78-1514*.

Building heating system; computer simulation; DEPAF; energy conservation; furnaces; operating cost; seasonal performance; *18088*.

Building height limitation; building volume limitation; earthquake resistant design; flexural-shear model; high-rise buildings; histogram for building uses; shear model; *SP523*, pp. VI-15—VI-24 (Sept. 1978).

Building materials; cost; economics; housing; lead-based paint; lead poisoning; abatement; *17500*.

Building official; building regulations; code enforcement; construction; court decisions; disasters; economics; legal approach; regulatory process; violations; *SP518*, pp. 381-390 (Aug. 1978).

Building performance simulation; building regulations; computer applications; energy conservation; thermal comfort; thermal performance of buildings; *SP518*, pp. 95-134 (Aug. 1978).

Building practices; building research; codes and standards; housing; international cooperation; technology transfer; *NBSIR 77-1411*.

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Appendices

APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).
Auburn: Auburn University, Ralph Brown Draughon Library (1907).
Birmingham:
Birmingham Public Library (1895).
Birmingham-Southern College Library (1932).
Jefferson State Junior College, James B. Allen Library (1970).
Samford University, Harwell G. Davis Library (1884).
Enterprise: Enterprise State Junior College Library (1967).
Florence: University of North Alabama, Collier Library (1932).
Gadsden: Gadsden Public Library (1963).
Huntsville: University of Alabama, Huntsville Campus Library (1964).
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
Maxwell A.F. Base: Air University Library (1963).
Mobile:
Mobile Public Library (1963).
Spring Hill College, Thomas Byrne Memorial Library (1937).
University of South Alabama Library (1968).
Montgomery:
Alabama State Department of Archives and History Library (1884).
Alabama Supreme Court Library (1884).
Auburn University at Montgomery Library (1971)—REGIONAL.
Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
St. Bernard: St. Bernard College, 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:
Anchorage Higher Education Consortium Library (1961).
Supreme Court of Alaska Library (1973).
College: University of Alaska, Elmer E. Rasmuson Library (1922).
Juneau: Alaska State Library (1964).
Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).
Flagstaff: Northern Arizona University Library (1937).
Phoenix:
Department of Library and Archives (unknown)—REGIONAL.
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, Watson Memorial Library (1976).
Russellville: Arkansas Tech University, Tomlinson Library (1925).
Searcy: Harding College, Beaumont Memorial Library (1963).
State College: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcadia: Arcadia Public Library (1975).
Arcata: Humboldt State College Library (1963).
Bakersfield:
California State College, Bakersfield Library (1974).
Kern County Library System (1943).
Berkeley:
University of California, General Library (1907).
University of California, Law Library, Earl Warren Legal Center (1963).
Carson: Carson Regional Library (1973).
Chico: Chico State University Library (1962).
Claremont: Pomona College Documents Collection, Honnold Library (1913).
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).
Dominguez Hills: California State College, Dominguez Hills, Educational Resources Center (1973).
Downey: Downey City Library (1963).
Fresno:
Fresno County Free Library (1920).
California State University Library (1962).
Fullerton: California State University at Fullerton Library (1963).
Garden Grove: Garden Grove Regional Library (1963).

Gardena: Gardena Public Library (1966).
Hayward: California State College at Hayward Library (1963).
Huntington Park: Huntington Park Library, San Antonio Region (1970).
Inglewood: Inglewood Public Library (1963).
Irvine: University of California at Irvine Library (1963).
La Jolla: University of California, San Diego, University Library (1963).
Lakewood: Angelo Iacoboni Public Library (1970).
Lancaster: Lancaster Regional Library (1967).
Long Beach:
- California State College at Long Beach Library (1962).
- Long Beach Public Library (1933).

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

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

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

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

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

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

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

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

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

CANAL ZONE

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

COLORADO

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

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

Fort Collins: Colorado State University Library (1907).
Golden: Colorado School of Mines, Arthur Lakes Library (1939).
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 (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).
- Delaware Law School Library (1976).

Wilmington:
- New Castle County Law Library (1974).
- Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

Washington:
- Advisory Commission on Intergovernmental Relations Library.
- Civil Aeronautics Board Library (1975).
- Civil Service Commission Library (1963).
- Department of Commerce Library (1955).
- Department of Health, Education, and Welfare Library (1954).
- Department of Housing and Urban Development Library (1969).
- Department of the Interior Central Library (1895).
- Department of Justice Main Library (1895).
- Department of Labor Library (1976).
- Department of State Library (1895).
- Department of State, Office of Legal Advisor, Law Library (1966).
- Department of Transportation, National Highway Traffic Safety Administration Library (1968).
- District of Columbia Public Library (1943).
- Federal City College Library (1970).
- Federal Deposit Insurance Corporation Library (1972).
- Federal Election Commission Library (1975).
- Federal Reserve System Law Library (1976).
- General Accounting Office Library (1975).
- General Services Administration Library (1975).
- Georgetown University Library (1969).
- Indian Claims Commission Library (1968).
- National War College Library (1895).
- Navy Department Library (1895).
- Navy Department, Office of Judge Advocate General Library (1963).
- Office of Management and Budget Library (1965).
- Office of The Adjutant General, Department of Army Library (1969).
- Postal Service Library (1895).
- 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: Charlotte County Library System (1973).
St. Petersburg:
- St. Petersburg Public Library (1965).
- Stetson University College Law Library (1975).

Sarasota: Sarasota Public Library (1970).
Tallahassee:
- Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
- State Library of Florida (1929).
- Florida State University, R. M. Stozier Library (1941).
- Florida Supreme Court Library (1974).

Tampa:
- Tampa Public Library (1965).
- University of South Florida Library (1962).
- University of Tampa, Merle Kelce Library (1953).

Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

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

Augusta: Augusta College Library (1962).
Brunswick: Brunswick Public Library (1965).
Carrollton: West Georgia College, Sanford Library (1962).
Columbus: Columbus College, Simon Schwob Memorial Library (1975).
Dahlonega: North Georgia College Library (1939).
Dalton: Dalton Junior College Library (1978).
Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).
Gainesville: Chestatee Regional Library (1968).
Macon: Mercer University Library (1964).
Marietta: Kennesaw Junior College Library (1968).
Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
Mount Berry: Berry College, Memorial Library (1970).
Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).
Statesboro: Georgia Southern College, Rosenwald Library (1939).
Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

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

HAWAII

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

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

IDAHO

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

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

ILLINOIS

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

Decatur: Decatur Public Library (1954).
De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).
Edwardsville: Southern Illinois University, Lovejoy Library (1959).
Elsah: Principia College, Marshall Brooks Library (1957).
Evanston: Northwestern University Library (1876).
Freeport: Freeport Public Library (1905).
Galesburg: Galesburg Public Library (1896).
Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).
Kankakee: Olivet Nazarene College, Benner Library and Resource Center (1946).
Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).
Lockport: Lewis University Library (1952).
Macomb: Western Illinois University Memorial Library (1962).
Moline: Black Hawk College, Learning Resources Center (1970).
Monmouth: Monmouth College Library (1860).
Morton Grove: Oakton Community College Library (1976).
Mt. Carmel: Wabash Valley College Library (1975).
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, Regional Campus Library (1965).
Public Library of Fort Wayne and Allen County (1896).
Franklin: Franklin College Library (1976).
Gary:
Gary Public Library (1943).
Indiana University, Northwest Campus Library (1966).
Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
Butler University, Irwin Library (1965).
Indiana State Library (unknown)—REGIONAL.
Indiana Supreme Court Law Library (1975).
Indiana University, Law Library (1967).
Indianapolis-Marion County Public Library (1906).
Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
Ball State University Library (1959).
Muncie Public Library (1906).
New Albany: Indiana University, Southeastern Campus Library (1965).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
Earlham College, Lilly Library (1964).
Morrison-Reeves Library (1906).
South Bend: Indiana University at South Bend Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

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

KANSAS

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

KENTUCKY

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

LOUISIANA

Baton Rouge:
Louisiana State Library (1976).
Louisiana State University Law Library (1929).
Louisiana State University Library (1907)—REGIONAL.
Southern University Library (1952).
Eunice: Louisiana State University at Eunice, Le Doux Library (1969).
Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).

Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State University, Frazar Memorial Library (1941).
Monroe: Northeast Louisiana University, Sandel Library (1963).
Natchitoches: Northwestern State University, Watson Memorial Library (1887).
New Orleans:
- Isaac Delgado College, Moss Technical Library (1968).
- Law Library of Louisiana (unknown).
- University of New Orleans Library (1963).
- Loyola University Library (1942).
- New Orleans Public Library (1883).
- Southern University in New Orleans Library (1962).
- Tulane University, Howard-Tilton Memorial Library (1942).
- Tulane University Law Library (1976).
- U.S. Court of Appeals, Fifth Circuit Library (1973).

Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).
Ruston: Louisiana Technical University Library (1896)—REGIONAL.
Shreveport:
- Louisiana State University at Shreveport Library (1967).
- Shreve Memorial Library (1923).

Thibodaux: Francis T. Nicholls State University, Leonidas Polk Library (1962).

MAINE

Augusta:
- Maine Law and Legislative Reference Library (1973).
- Maine State Library (unknown).

Bangor: Bangor Public Library (1884).
Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).
Castine: Maine Maritime Academy, Nutting Memorial Library (1969).
Lewiston: Bates College Library (1883).
Orono: University of Maine, Raymond H. Fogler Library (1907)—REGIONAL.
Portland:
- Portland Public Library (1884).
- University of Maine Law Library (1964).

Springvale: Nasson College Library (1961).
Waterville: Colby College Library (1884).

MARYLAND

Annapolis:
- Maryland State Library (unknown).
- U.S. Naval Academy, Nimitz Library (1895).

Baltimore:
- Enoch Pratt Free Library (1887).
- Johns Hopkins University, Milton S. Eisenhower Library (1882).
- Morgan State College, Soper Library (1940).
- University of Baltimore, Langsdale Library (1973).
- University of Maryland, Baltimore County Library (1971).
- University of Maryland, School of Law Library (1969).

Bel Air: Harford Community College Library (1967).
Beltsville: Department of Agriculture, National Agricultural Library (1895).
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, Goodell Library (1907).

Belmont: Belmont Memorial Library (1968).
Boston:
- Boston Athenaeum Library (unknown).
- Boston College, Bapst Library (1963).
- Boston Public Library (1859)—REGIONAL.
- Northeastern University, Dodge Library (1962).
- State Library of Massachusetts (unknown).

Brookline: Public Library of Brookline (1925).
Cambridge:
- Harvard College Library (1860).
- Massachusetts Institute of Technology Libraries (1946).
- Middlesex County Law Library (1978).

Chicopee: Our Lady of the Elms College Library (1969).
Lowell: Lowell Technological Institute, Alumni Memorial Library (1952).
Lynn: Lynn Public Library (1953).
Marlborough: Marlborough Public Library (1971).
Medford: Tufts University Library (1899).
Milton: Curry College Library (1972).
New Bedford: New Bedford Free Public Library (1858).
North Dartmouth: Southeastern Massachusetts University Library (1965).
North Easton: Stonehill College, Cushing-Martin Library (1962).
Springfield: Springfield City Library (1966).
Waltham: Brandeis University, Goldfarb Library (1965).
Wellesley: Wellesley College Library (1943).
Wenham: Gordon College, Winn Library (1963).
Williamstown: Williams College Library (unknown).
Worcester:
- American Antiquarian Society Library (1814).
- University of Massachusetts, Medical Center Library (1972).
- Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).
Allendale: Grand Valley State College Library (1963).
Alma: Alma College, Monteith Library (1963).
Ann Arbor:
- Great Lakes Basin Commission Library (1971).
- University of Michigan, Harlan Hatcher Library (1884).

Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Cranbrook Institute of Science Library (1940).
Dearborn:
- Henry Ford Centennial Library (1969).
- Henry Ford Community College Library (1957).

Detroit:
- Detroit Public Library (1868)—REGIONAL.
- Marygrove College Library (1965).
- Mercy College of Detroit Library (1965).
- University of Detroit Library (1884).

Wayne State University Law Library (1971).
Wayne State University, G. Flint Purdy Library (1937).
Dowagiac: Southwestern Michigan College Library (1971).
East Lansing:
Michigan State University, Law Library (1971).
Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).
Flint:
Charles Stewart Mott Library (1959).
Flint Public Library (1967).
Grand Rapids:
Grand Rapids Public Library (1876).
Calvin College Library (1967).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson Public Library (1965).
Kalamazoo:
Kalamazoo Library System (1907).
Western Michigan University, Dwight B. Waldo Library (1963).
Lansing: Michigan State Library (unknown)—REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Monroe: Monroe County Library System (1974).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Olivet: Olivet College Library (1974).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Warren: Warren Public Library, Arthur J. Miller Branch (1973).
Wayne: Wayne Oakland Federated Library System (1957).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

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

MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).
Clinton: Mississippi College School of Law Library (1977).
Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1920).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
Jackson State College Library (1968).
Millsaps College, Millsaps-Wilson Library (1963).
Mississippi Library Commission (1947).
Mississippi State Law Library (unknown).
Lorman: Alcorn Agricultural and Mechanical College Library (1970).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
University of Mississippi Library (1833)—REGIONAL.
University of Mississippi, School of Law Library (1967).

MISSOURI

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

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
Carroll College Library (1974).

Montana Historical Society Library (unknown).
Montana State Library (1966).
Missoula: University of Montana Library (1909)—REGIONAL.

NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
Nebraska Publications Clearinghouse, Nebraska Library Commission (1972)—REGIONAL.
Nebraska State Library (unknown).
University of Nebraska, Don L. Love Memorial Library (1907).
Omaha:
Creighton University, Alumni Library (1964).
Omaha Public Library (1880).
University of Nebraska at Omaha, University Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).
Wayne: Wayne State College, U.S. Conn Library (1970).

NEVADA

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

NEW HAMPSHIRE

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

NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Free Public Library of Bloomfield (1965).
Bridgeton: Cumberland County Library (1966).
Camden: Rutgers University-Camden Library (1966).
Convent Station: College of St. Elizabeth, Mahoney Library (1938).
Dover: County College of Morris Library, Learning Resources Center (1975).
East 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, McLaughlin Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
Toms River: Ocean County College Learning Resources Center (1966).
Trenton:
New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
Trenton Free Public Library (1902).
Union: Kean College of New Jersey, Nancy Thompson Library (1973).
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
Wayne: Wayne Public Library (1972).
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

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

NEW YORK

Albany:
New York State Library (unknown)—REGIONAL.
State University of New York at Albany Library (1964).
Auburn: Seymour Library (1972).
Bayside: Queensborough Community College Library (1972).

Binghamton: State University of New York at Binghamton Library (1962).
Brockport: State University of New York, Drake Memorial Library (1967).
Bronx:
Herbert H. Lehman College Library (1967).
New York Public Library, Mott Haven Branch (1973).
Bronxville: Sarah Lawrence College Library (1969).
Brooklyn:
Brooklyn College Library (1936).
Brooklyn Law School, Law Library (1974).
Brooklyn Public Library (1908).
Polytechnic Institute of Brooklyn, Spicer Library (1963).
Pratt Institute Library (1891).
State University of New York, Downstate Medical Center Library (1958).
Buffalo:
Buffalo and Erie County Public Library (1895).
State University of New York at Buffalo, Lockwood Memorial Library (1963).
Canton: St. Lawrence University, Owen D. Young Library (1920).
Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).
Cortland: State University of New York, College at Cortland, Memorial Library (1964).
Delhi: State University Agricultural and Technical College Library (1970).
Douglaston: Cathedral College Library (1971).
East Islip: East Islip Public Library (1974).
Elmira: Elmira College, Gannett-Tripp Learning Center (1956).
Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).
Flushing: Queens College, Paul Klapper Library (1939).
Garden City:
Adelphi University, Swirbul Library (1966).
Nassau Library System (1965).
Geneseo: State University College, Milne Library (1967).
Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1965).
Hamilton: Colgate University Library (1902).
Hempstead: Hofstra University Library (1964).
Ithaca:
Cornell University Library (1907).
New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).
Jamaica:
Queens Borough Public Library (1926).
St. John's University Library (1956).
Kings Point: U.S. Merchant Marine Academy Library (1962).
Mount Vernon: Mount Vernon Public Library (1962).
New Paltz: State University College Library (1965).
New York City:
City University of New York, City College Library (1884).
College of Insurance, Ecker Library (1965).
Columbia University Libraries (1882).
Cooper Union Library (1930).
Fordham University Library (1937).
Medical Library Center of New York (1976).
New York Law Institute Library (1909).
New York Public Library (Astor Branch) (1907).
New York Public Library (Lenox Branch) (1884).
New York University Libraries (1967).
New York University, Law Library (1973).
State University of New York, Maritime College Library (1947).
Newburgh: Newburgh Free Library (1909).
Niagara Falls: Niagara Falls Public Library (1976).
Oakdale: Dowling College Library (1965).
Oneonta: State University College, James M. Milne Library (1966).
Oswego: State University College, Penfield Library (1966).
Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).
Potsdam:
Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
State University College, Frederick W. Crumb Memorial Library (1964).
Poughkeepsie: Vassar College Library (1943).
Purchase: State University of New York, College at Purchase Library (1969).
Rochester:
Rochester Public Library (1963).
University of Rochester Library (1880).
St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).
Saratoga Springs: Skidmore College Library (1964).
Schenectady: Union College, Schaffer 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).
Utica: Utica Public Library (1885).
West Point: U.S. Military Academy Library (unknown).
Yonkers:
Yonkers Public Library (1910).
Yorktown Heights: Mercy College at Fox Meadow Library.

NORTH CAROLINA

Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).
Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).
Boone: Appalachian State University Library (1963).
Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
Chapel Hill: University of North Carolina Library (1884)—REGIONAL.
Charlotte:
Public Library of Charlotte and Mecklenburg County (1964).
Queens College, Everette Library (1927).
University of North Carolina at Charlotte, Atkins Library (1964).
Cullowhee: Western Carolina University, Hunter Library (1953).
Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).
Durham:
Duke University, William R. Perkins Library (1890).
North Carolina Central University, James E. Shepard Memorial Library (1973).
Elon College: Elon College Library (1971).
Fayetteville: Fayetteville State University, Chesnutt Library (1971).
Greensboro:
North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).
Greenville: East Carolina University, J. Y. Joyner Library (1951).
Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).
Lexington: Davidson County Public Library System (1971).

Mount Olive: Mount Olive College, Moye Library (1971).
Murfreesboro: Chowan College, Whitaker Library (1963).
Pembroke: Pembroke State University Library (1965).
Raleigh:
North Carolina State Library (unknown).
North Carolina State University, D. H. Hill Library (1923).
North Carolina Supreme Court Library (1972).
Wake County Public Libraries (1969).
Rocky Mount: North Carolina Wesleyan College Library (1969).
Salisbury: Catawba College Library (1925).
Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).
Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).
Winston-Salem:
Forsyth County Public Library System (1954).
Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:
State Historical Society of North Dakota (1907).
North Dakota State Law Library (unknown).
State Library Commission Library (1971).
Veterans Memorial Public Library (1967).
Dickinson: Dickinson State College Library (1968).
Fargo:
Fargo Public Library (1964).
North Dakota State University Library (1907)—REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.
Grand Forks: University of North Dakota, Chester Fritz Library (1890).
Minot: Minot State College, Memorial Library (1925).
Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
Akron:
Akron Public Library (1952).
University of Akron Library (1963).
Alliance: Mount Union College Library (1888).
Ashland: Ashland College Library (1938).
Athens: Ohio University Library (1886).
Batavia: Clermont General and Technical College Library (1973).
Bluffton: Bluffton College, Musselman Library (1951).
Bowling Green: Bowling Green State University Library (1933).
Canton: Malone College, Everett L. Cattell Library (1970).
Chardon: Geauga County Public Library (1971).
Cincinnati:
Public Library of Cincinnati and Hamilton County (1884).
University of Cincinnati Library (1929).
Cleveland:
Case Western Reserve University, Freiberger Library (1913).
Cleveland Heights-University Heights Public Library (1970).
Cleveland Public Library (1886).
Cleveland State University Library (1966).
John Carroll University, Grasselli Library (1963).
Municipal Reference Library (1970).
Columbus:
Capital University Library (1968).
Columbus Public Library (1885).
Ohio State Library (unknown)—REGIONAL.
Ohio State University Library (1907).
Ohio Supreme Court Law Library (1973).
Dayton:
Dayton and Montgomery County Public Library (1909).
University of Dayton, Albert Emanuel Library (1969).
Wright State University Library (1965).
Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
Elyria: Elyria Public Library (1966).
Findlay: Findlay College, Shafer Library (1969).
Gambier: Kenyon College Library (1873).
Granville: Denison University Library (1884).
Hiram: Hiram College, Teachout-Price Memorial Library (1874).
Kent: Kent State University Library (1962).
Marietta: Marietta College, Dawes Memorial Library (1884).
Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).
New Concord: Muskingum College Library (1966).
Oberlin: Oberlin College Library (1858).
Oxford: Miami University, Alumni Library (1909).
Portsmouth: Portsmouth Public Library (unknown).
Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).
Springfield: Warder Public Library (1884).
Steubenville:
College of Steubenville, Starvaggi Memorial Library (1971).
Public Library of Steubenville and Jefferson County (1950).
Tiffin: Heidelberg College, Beeghly Library (1964).
Toledo:
Toledo-Lucas County Public Library (1884).
University of Toledo Library (1963).
Westerville: Otterbein College, Centennial Library (1967).
Wooster: College of Wooster, the Andrews Library (1966).
Youngstown:
Public Library of Youngstown and Mahoning County (1923).
Youngstown State University Library (1971).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).
Alva: Northwestern State College Library (1907).
Bartlesville: United States ERDA-BERC Library (1962).
Bethany: Bethany Nazarene College, R. T. Williams Library (1971).
Durant: Southeastern State College Library (1929).
Edmond: Central State University Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Muskogee: Muskogee Public Library (1971).
Norman: University of Oklahoma Libraries (1893).
Oklahoma City:
Oklahoma County Libraries (1974).
Oklahoma City University Library (1963).
Oklahoma Department of Libraries (1893)—REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907).
Tahlequah: Northeastern State College, John Vaughan Library (1923).
Tulsa:
Tulsa City-County Library (1963).
University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene: University of Oregon Library (1883).
Forest Grove: Pacific University Library (1897).
La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Oregon College of Education Library (1967).
Portland:
- Department of the Interior, Bonneville Power Administration Library (1962).
- Lewis and Clark College, Aubrey R. Watzek Library (1967).
- Library Association of Portland (1884).
- Portland State University Library (1963)—REGIONAL.
- Reed College Library (1912).

Salem:
- Oregon State Library (unknown).
- Oregon Supreme Court Library (1974).

Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
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 Library (1975).
Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College, Myrin Library (1963).
Doylestown: Bucks County Free Library, Center County Library (1970).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: State Library of Pennsylvania (unknown)—REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
- Drexel University Library (1963).
- Free Library of Philadelphia (1897).
- St. Joseph's College Library (1974).
- Temple University, Samuel Paley Library (1947).
- U.S. Court of Appeals, Third Circuit (1973).
- University of Pennsylvania, Biddle Law Library (1974).
- University of Pennsylvania Library (1886).

Pittsburgh:
- Bureau of Mines, Pittsburgh Research Center Library (1962).
- Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
- Carnegie Library of Pittsburgh (1895).
- La Roche College, John J. Wright Library (1974).
- University of Pittsburgh, Hillman Library (1910).

Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College, Corgan Library (1949).
Williamsport: Lycoming College Library (1970).
York: York Junior College Library (1963).
Youngwood: Westmoreland County Community College, Learning Resource Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
- Brown University, John D. Rockefeller, Jr. Library (unknown).
- Providence College, Phillips Memorial Library (1969).
- Providence Public Library (1884).
- Rhode Island College Library (1965).
- Rhode Island State Library (before 1895).

Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).
Woonsocket: Woonsocket Harris Public Library (1977).

SOUTH CAROLINA

Charleston:
- Baptist College at Charleston Library (1967).
- College of Charleston Library (1869).
- The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).
Columbia:
- Benedict College, Learning Resources Center (1969).
- 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, Lincoln Memorial Library (1889).
Pierre: South Dakota State Library (1973).
Rapid City:
Rapid City Public Library (1963).
South Dakota School of Mines and Technology Library (1963).
Sioux Falls:
Augustana College, Mikkelsen Library and Learning Resources Center (1969).
Sioux Falls Public Library (1903).
Spearfish: Black Hills State College Library (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

Bristol: King College Library (1970).
Chattanooga:
Chattanooga-Hamilton County Bicentennial Library (1907).
TVA Technical Library (1976).
Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
Cleveland: Cleveland State Community College Library (1973).
Columbia: Columbia State Community College Library (1973).
Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville:
Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).
University of Tennessee Law Library (1971).
University of Tennessee Library (1907).
Martin: University of Tennessee at Martin Library (1957).
Memphis:
Memphis and Shelby County Public Library and Information Center (1896).
Memphis State University, John W. Brister Library (1966).
Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
Nashville:
Fisk University Library (1965).
Joint University Libraries (1884).
Public Library of Nashville and Davidson County (1884).
Tennessee State Law Library (1976).
Tennessee State Library and Archives, State Library Division (unknown).
Tennessee State University, Martha M. Brown Memorial Library (1972).
Vanderbilt University Law Library (1976).
Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene: Hardin-Simmons University Library (1940).
Arlington:
Arlington Public Library (1970).
University of Texas at Arlington Library (1963).
Austin:
Texas State Law Library (1972).
Texas State Library (unknown) – REGIONAL.
University of Texas at Austin Library (1884).
University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
University of Texas, School of Law Library (1965).
Baytown: Lee College Library (1970).
Beaumont: Lamar University Library (1957).
Brownwood: Howard Payne College, Walker Memorial Library (1964).
Canyon: West Texas State University Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
Corsicana: Navarro Junior College Library (1965).
Dallas:
Bishop College, Zale Library (1966).
Dallas Baptist College Library (1967).
Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center Library at Dallas (1975).
Denton: North Texas State University Library (1948).
Edinburg: Pan American University Library (1959).
El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary Couts Burnett Library (1916).
Galveston: Rosenberg Library (1909).
Houston:
Houston Public Library (1884).
North Harris County College, Learning Resource Center (1974).
Rice University, Fondren Library (1967).
University of Houston Library (1957).
Huntsville: Sam Houston State University, Estill Library (1949).
Irving: Irving Municipal Library (1974).
Kingsville: Texas Arts and Industries University Library (1944).
Lake Jackson: Brazosport College Library (1969).
Laredo: Laredo Junior College Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Tech University Library (1935) – REGIONAL.
Marshall: Wiley College, Cole Library (1962).
Mesquite: Mesquite Public Library (1975).
Nacogdoches: Stephen F. Austin State University Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
San Antonio College Library (1972).

San Antonio Public Library, Business and Science Department (1899).
St. Mary's University Library (1964).
Trinity University Library (1964).
University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: University of Houston, Victoria Center Library (1973).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)—REGIONAL.
Ogden: Weber State College Library (1962).
Provo:
Brigham Young University, Lee Library (1908).
Brigham Young University Law Library (1972).
Salt Lake City:
Utah State Supreme Court Law Library (1975).
University of Utah, Eccles Medical Sciences Library (1970).
University of Utah, Law Library (1966).
University of Utah, Marriott Library (1893).
Utah State Library Commission, Documents Library (unknown).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
St. Thomas Public Library (1968).
Christiansted (St. Croix): Christiansted Public Library (1974).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
University of Virginia, Alderman Library (1910)—REGIONAL.
University of Virginia Law Library (1964).
Chesapeake: Chesapeake Public Library System (1970).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College Library (1884).
Fairfax: George Mason University, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Harrisonburg: Madison College, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
Virginia Military Institute, Preston Library (1874).
Washington and Lee University, Cyrus Hall McCormick Library (1910).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
Armed Forces Staff College Library (1963).
Norfolk Public Library (1895).
Old Dominion University Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico:
Federal Bureau of Investigation Academy Library (1970).
Marine Corps Schools, James Carson Breckinridge Library (1967).
Reston: Department of the Interior, Geological Survey Library (1962).
Richmond:
State Law Library (1973).
University of Richmond, Boatwright Memorial Library (1900).
U.S. Court of Appeals, Fourth Circuit Library (1973).
Virginia Commonwealth University, James Branch Cabell Library (1971).
Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia:
Evergreen State College Library (1972).
Washington State Library (unknown)—REGIONAL.
Port Angeles: North Olympic Library System (1965).
Pullman: Washington State University Library (1907).
Seattle:
Seattle Public Library (1908).
University of Washington Library (1890).
University of Washington, School of Law Library (1969).
Spokane: Spokane Public Library (1910).
Tacoma:
Tacoma Public Library (1894).
University of Puget Sound, Collins Memorial Library (1938).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Bluefield: Bluefield State College Library (1972).
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 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).

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Supplement 3: 1978

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J. Debelius, Editor

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

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13. Type of Report & Period Covered: Supplement 1978

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number: 79-600099

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report presents the National Bureau of Standards' (NBS) Center for Building Technology (CBT) publications for 1978. It is a supplement to Special Publication 457, Building Technology Publications 1965-1975, and covers the period from January 1, 1978 to December 31, 1978. It includes an abstract of each NBS publication, titles and abstracts of papers published in non-NBS media, key word and author indexes, and general information and instructions on how to order CBT publications.

This report provides the primary means of communicating the results of CBT programs to its varied technical audiences, as well as to the general public. Publications constitute a major end product of CBT's efforts and in 1978 appeared in several NBS publication series (Building Science Series, Technical Notes, Special Publications, Handbooks, and NBS Interagency Reports).

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Abstracts, Center for Building Technology; key words; publications.

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