Technology Publications supplement 2: 1977

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
Department of Commerce

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

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[1]Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted;
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[2]Some divisions within the center are located at Boulder, Colorado, 80303.

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

BUILDING TECHNOLOGY PUBLICATIONS

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JoAnne R. Debelius, Editor

Center for Building Technology
National Engineering Laboratory
National Bureau of Standards
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Introduction

This report presents the National Bureau of Standards' Center for Building Technology (CBT) publications for calendar year 1977. It is the second supplement to NBS Special Publication 457, *Building Technology Publications 1965-1975*, and lists all CBT documents issued during the period from January 1, 1977 to December 31, 1977. 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 of CBT's efforts and, in 1977, appeared in several NBS publication series (Building Science Series, Technical Notes, Special Publications, Handbooks and NBS Interagency Reports) as well as non—NBS published media such as the technical and trade publications. NBS publication abbreviations are:

BSS - Building Science Series

TN - Technical Note

SP - Special Publication

H - Handbook

NBSIR - National Bureau of Standards Interagency Report

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.

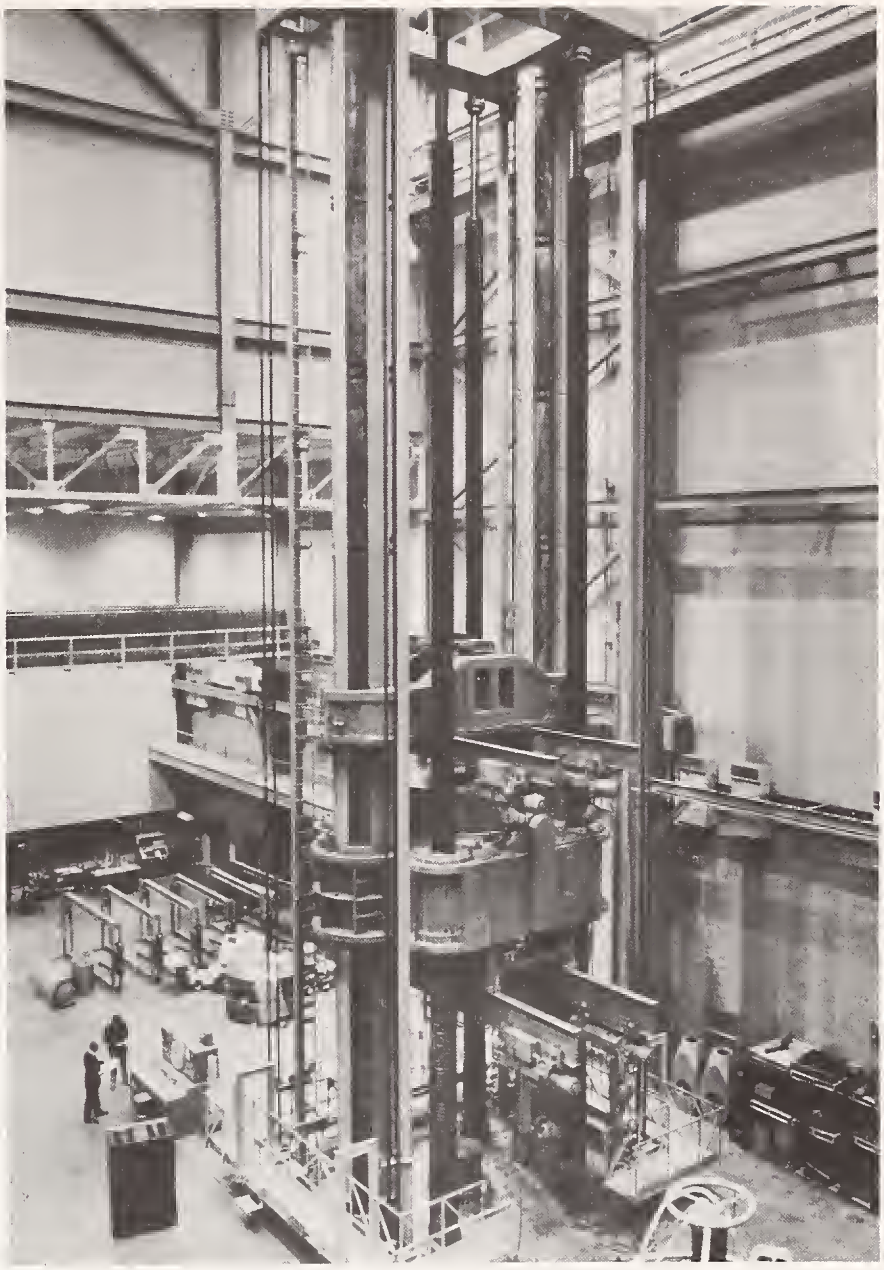
Department of Commerce Field Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access at the local level, to publications, statistical statements, and surveys. Each Field Office serves as an official sales agent of the Superintendent of Documents, U.S. Government 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.

Contents

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.

BSS62. **Evaluation of structural properties of masonry in existing buildings,** S. G. Fattal and L. E. Cattaneo, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 62*, 127 pages (Mar. 1977) SN003-003-01738-8.

Key words: analysis; compressive strength; deflection; design; flexural strength; masonry walls; racking strength; seismic loading; shear strength; shear wall; stiffness.

The current state of knowledge on the structural behavior of masonry is synthesized to develop a methodology for the evaluation of the load capacity of masonry walls in existing buildings. A procedure is described for direct sampling and testing of specimens removed from masonry walls of buildings to determine their strength in shear, flexure and compression, and to measure their load-deformation characteristics. A documentation of strength and stiffness properties obtained from available test data is included to provide an alternate source of information on masonry of comparable construction. Sample calculations of masonry building analysis for seismic forces are given in Appendices A and B.

BSS93. **Dynamic performance of a residential air-to-air heat pump,** G. E. Kelly and J. Bean, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 93*, 18 pages (Mar. 1977) SN003-003-01691-8.

Key words: cooling and heating coefficients of performance; effective seasonal heating COP; heat pumps; heat pumps and energy conservation; part-load performance; seasonal performance factor.

Information is presented on the dynamic performance of a 5-ton air-to-air heat pump, which was installed in a residence in the Washington, D.C. area. The effect of part-load operation on the heat pump's COOLING and HEATING coefficients of performance (COP) was determined. When the pump operated in the heating mode at outdoor temperatures below 40 °F (4.4 °C), a considerable discrepancy was found to exist between the measured performance and the performance data supplied by the manufacturers. This discrepancy is apparently due to the adverse effects of frost buildup and defrosting of the outdoor coil. The seasonal performance factor (SPF) of the heat pump was estimated and then traced back to the power plant to obtain an "EFFECTIVE SPF" which is then compared with the performance which might be expected from fossil-fuel heating equipment.

BSS94. **Investigation of the Skyline Plaza Collapse in Fairfax County, Virginia,** E. V. Leyendecker and S. G. Fattal, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 94*, 91 pages (Feb. 1977) SN003-003-01696-9.

Key words: apartment building; collapse; concrete; concrete strength; construction; flexure; progressive collapse; shear; strength.

The collapse of the Skyline Plaza apartment building A-4 has been studied by using information contained in case records of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor and obtained from on-site inspections by investigators from the National Bureau of Standards.

Noncompliance with OSHA construction standards has been identified with regard to formwork, field-cured concrete specimens and crane installation. Specifically, the construction procedures did not comply with standards for the removal of supporting forms. It is concluded that premature removal of forms was a contributing factor to the collapse in building A-4.

An analysis of the 23rd-floor slab indicates that its most likely mode of failure was in shear around one or more columns in section 3 of the floor slab. The strength of the 23rd-floor slab on the day of collapse has been estimated to be at a level that removal of shoring could have produced shear failure in the slab.

BSS96. **Hourly solar radiation data for vertical and horizontal surfaces on average days in the United States and Canada,** T. Kusuda and K. Ishii, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 96*, 412 pages (Apr. 1977) SN003-003-01698-5.

Key words: computer; energy; radiation; solar.

The majority of the available solar radiation data for the United States and Canada are in the form of either monthly averages of daily total radiation on a horizontal surface or hourly values for cloudless days on horizontal, tilted, and vertical surfaces. Hourly solar radiation data for walls and roofs under "average" solar conditions were computed in order to be able to make estimates of the effect that incident solar radiation has on a building and/or its heating and air conditioning system over a heating and/or cooling season. Calculation procedures developed by Liu and Jordan were modified and hourly solar radiation data were compiled for 80 locations in the United States and Canada. Data were also computed and tabulated for a new parameter called "sol-air temperature for glass."

BSS97. **Evaluation of ventilation requirements and energy consumption in existing New York City school buildings,** S. T. Liu, C. M. Hunt, and F. J. Powell, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 97*, 69 pages (Apr. 1977) SN003-003-01768-0.

Key words: computerized thermal simulation; CO_2 concentration; energy conservation in schools; energy consumption; energy utilization in schools; oxygen content; reduced ventilation rate; school operation schedule; ventilation test.

A study was made, under the sponsorship of the National Science Foundation and in collaboration with the New York City Board of Education, of the energy consumption and ventilation requirements of typical existing urban public schools, for the purpose of determining the pattern of energy usage in such public schools so that effective energy conservation measures can be taken both for existing schools and for future new school design.

Electricity and fuel-oil consumption data from May 1970 through April 1973 on 19 existing schools provided by the New York City Board of Education were analyzed. Analysis showed that the overall energy consumption of 17 of the 19 schools varied by a factor of less than 2. Average yearly consumptions per 1,000 ft^2 (92.9 m^2) gross floor area of 5,250 kWh of electrical energy and 417 gallons of No. 6 fuel oil (2.03×10^8 J and 0.017 m^3 per m^2 of gross floor area), were selected as a norm typical of the existing schools. These figures correspond to 82,400 Btu/year-(gross) ft^2 (29.7 W/m^2) at the building line or an estimated 126,000 Btu/year-(gross) ft^2 (45.4 W/m^2) when calculated in terms of raw fuel at the generating plant. The figures can be used for future comparison purposes with a new energy conservation school. A computerized thermal energy simulation, using the program NBSLD, was performed on one of the schools having an energy consumption close to the norm. The results showed good agreement between the predicted and measured monthly electricity and fuel-oil consumption data. Detailed analysis of the pattern of energy consumption showed that 75 percent of the thermal energy during the heating season was used for the heating of outdoor air for ventilation purposes, and 80 percent of the electrical energy was used for lighting.

A ventilation test was conducted over a 4-day period in a typical classroom. It was found that a reduction of the air change rate from the normal 4.6 changes per hour to 1.3 changes per hour did not significantly change the indoor environment as expressed in terms of temperature, relative humidity, oxygen content level, and CO_2 concentration level. However, computation indicates that, when no mechanical ventilation was provided, the CO_2 concentration level would exceed the 0.5 percent safety limit, indicating that natural air infiltration alone will not provide adequate ventilation for the general health and safety of the students.

BSS98. **Design methods for reducing the risk of progressive collapse in buildings,** E. V. Leyendecker and B. R. Ellingwood, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 98*, 68 pages (Apr. 1977) SN003-003-01765-5.

Key words: abnormal loading; alternate path; building code; design criteria; probability; progressive collapse; reliability; structural engineering; uncertainty.

A progressive collapse is described as a chain reaction of failures following damage to a relatively small portion of a structure. The damage which results characteristically is out of proportion to the damage which initiated the collapse. The basic concepts associated with progressive collapse are described and the background leading to the concepts is summarized. Possible causes of progressive collapse are discussed, with concentration on abnormal events which have a low probability of occurrence but may have catastrophic consequences. A case study of the probability of structural failure as a consequence of one type of abnormal load (a gas explosion) shows that these probabilities exceed levels generally considered acceptable to engineers.

Direct design strategies for reducing progressive collapse are described as (1) the Alternate Path Method and (2) the Specific Local Resistance Method. Equations for load combinations, including appropriate load factors, are presented for each design method. The advantages and disadvantages of each approach are described and it is concluded that the alternate path method affords the designer more flexibility. Although the design strategies are applicable to any type of structure at any time in its life cycle, this report provides detailed recommendations for completed buildings.

BSS100-1. **Building to resist the effect of wind. Volume 1: Overview,** R. D. Marshall, N. J. Raufaste, Jr., and S. A. Kliment, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-1*, 34 pages (May 1977) SN003-003-01717-5.

Key words: codes and standards; disaster mitigation; housing; low-rise buildings; socio-economics; structural connections; technology transfer; wind loads.

This document presents the background, goals, procedures and results of a project to develop improved design criteria that would make low-rise buildings in developing countries better able to withstand the effects of extreme winds. The project stemmed from the belief that additional research on wind was needed to reduce loss of life and property, human suffering, disruption of productive capacity and costs of disaster relief. The 3 1/2 year project began in early 1973 and produced these results: the development of improved design criteria; a methodology for the estimation of extreme wind speeds; the development of wind tunnel modeling techniques; a heightened awareness of the wind problem and the need to guard against it; the emergence of useful working relationships between NBS/AID and public and private decisions makers in developing countries subject to extreme winds, especially the Philippines, Jamaica and Bangladesh; and the documentation of important information in the areas of wind design speeds and pressure coefficients, economic forecasting, socio-economic and architectural concerns, and construction detailing practices. Also during the project, a program began in the training of professionals and technicians in developing countries to carry out wind measurements and analyses. In addition, methods to ensure transfer of information to user groups were employed.

BSS100-2. **Building to resist the effect of wind. Volume 2: Estimation of extreme wind speeds and guide to the determination of wind forces,** E. Simiu and R. D. Marshall, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-2*, 29 pages (May 1977) SN003-003-01718-3.

Key words: building codes; buildings; codes and standards; housing; hurricanes; pressure coefficients; probability distribution functions; risk; statistical analysis; storms; structural engineering; tropical storms; wind loads; wind speeds.

The Agency for International Development sponsored with the National Bureau of Standards, a three and a half year research project to develop improved design criteria for low-rise buildings to better resist the effects of extreme winds.

Project results are presented in five volumes. Volume 1 gives a background of the research activities, accomplishments, results, and recommendations. In Volume 3, a guide for improved use of masonry fasteners and timber connectors are discussed. Volume 4 furnishes a methodology to estimate and forecast housing needs at a regional level. Socioeconomic and architectural considerations for the Philippines, Jamaica, and Bangladesh are presented in Volume 5.

Volume 2 consists of two reports. The first reviews the theoretical and practical considerations that are pertinent to the estimation of probabilistically defined wind speeds. Results of the statistical analysis of extreme wind data in the Philippines are presented and interpreted. Recommendations based on these results are made with regard to the possible redefinition of wind zones, and tentative conclusions are drawn regarding the adequacy of design wind speeds currently used in the Philippines. Report two describes some of the more common flow mechanisms which create wind pressures on low-rise buildings and the effects of building geometry on these pressures. It is assumed that the basic wind speeds are known and a procedure is outlined for calculating design wind speeds which incorporates the expected life of the structure, the mean recurrence interval, and the wind speed averaging time. Pressure coefficients are tabulated for various height-to-width ratios and roof slopes. The steps required to calculate pressures and total drag and uplift forces are summarized and an illustrative example is presented.

BSS100-3. **Building to resist the effect of wind. Volume 3: A guide for improved masonry and timber connections in buildings,** S. G. Fattal, G. E. Sherwood, and T. L. Wilkinson, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-3*, 56 pages (May 1977) SN003-003-01719-1.

Key words: codes and standards; connectors; fasteners; low-rise buildings; masonry walls' structural design; technology transfer; timber roofs; timber walls; wind effects.

The Agency for International Development sponsored with the National Bureau of Standards, a 3½ year research project to develop improved design criteria for low-rise buildings to better resist the effects of extreme winds. This report contains information gathered from this project.

This report investigates the use of connectors for masonry and timber elements in low-rise buildings. Connector characteristics and construction details that improve a building's response to extreme wind effects are given primary emphasis. Recommendations include improvements through better utilization of connector technology showing good feasibility of introduction in developing countries. The building systems considered in this study fall within the low to moderate cost category.

Project results are presented as five volumes. Volume 1 gives an overview of the research activities, accomplishments, results, and recommendations. Volume 2 presents a methodology to estimate design wind speeds and a guide to determine wind forces. In Volume 3, a guide for improved use of masonry fasteners and timber connectors are discussed. Volume 4 furnishes a methodology to estimate and forecast housing needs at a regional level. Socio-economic and architectural considerations of the Philippines, Jamaica, and Bangladesh are presented in Volume 5.

BSS100-4. **Building to resist the effect of wind. Volume 4: Forecasting the economics of housing needs: A methodological guide,** J. G. Kowalski, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-4*, 36 pages (May 1977) SN003-003-01720-5.

Key words: development; forecasts; growth; housing needs; projections.

The Agency for International Development sponsored with the NBS, a 3½ year research project to develop improved design criteria for low-rise buildings to better resist the effects of extreme winds. Housing is probably the single most important consumer good in most economies. Measuring the size of a region's unmet housing need is a first step to planning and implementing improvements in housing conditions. This report analyzes the concept of housing needs in an economic framework. A methodology for estimating and projecting housing needs at the regional level is developed. The methodology attempts to make explicit the income redistribution intent which is the core meaning behind the concept of housing needs.

Project results are presented in five volumes. Volume 1 gives an overview of the research activities, accomplishments, results and recommendations. Volume 2 presents a methodology to estimate design wind speeds and a guide to determine wind forces. Volume 3 discusses a guide for improved use of masonry fasteners and timber connectors. Volume 4 furnishes a methodology to estimate and forecast housing needs at a regional level. Socio-economic and architectural considerations of the Philippines, Jamaica and Bangladesh are presented in Volume 5.

BSS100-5. **Building to resist the effect of wind. Volume 5: Housing in extreme winds: Socio-economic and architectural considerations,** S. A. Kliment, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 100-5*, 37 pages (May 1977) SN003-003-01721-3.

Key words: architectural; design; housing; low income; low-rise buildings; sites and services; socio-economic; structural design; wind-resistant.

Typical socio-economic conditions in the Philippines, Jamaica, and Bangladesh are identified. These conditions include strong respect for traditional materials and methods of house construction, and suspicion of innovative forms and approaches; a rising proportion of urban poor who live in squatter settlements; and a rising ratio of inhabitants whose incomes are at a level where they cannot afford housing of any kind. The importance of land from a social standpoint is stressed. The report reviews the sites and services concept whereby low income persons are provided a site equipped with basic utilities but must erect and maintain a house upon it. Recommendations include: placement of buildings to exploit terrain; adherence to good practices in the configurations of the main elements of a house (these are shown by means of simple drawings); use of cheap, strong and locally available materials.

This report is one of a five volume series describing the results of a three and a half year research study to develop improved design criteria for low-rise buildings to better resist the effects of extreme winds. The project was sponsored by the Agency for International Development, Dept. of State. Vol. 1 gives a background of the research activities, accomplishments, results and recommendations. Vol. 2 presents a methodology to estimate design wind speeds and a guide to determine wind forces. In Vol. 3, a guide for improved use of masonry fasteners and timber connectors are discussed. Vol. 4 furnishes a methodology to estimate and forecast housing needs at a regional level.

BSS103. **Exploratory study of glowing electrical connections,** W. J. Meese and R. W. Beausoliel, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 103*, 29 pages (Oct. 1977) SN003-003-01859-7.

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

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

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

BSS104. **Window design strategies to conserve energy,** S. R. Hastings and R. W. Crenshaw, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 104*, 209 pages (June 1977) SN003-003-01794-9.

Key words: air-tightness; daylighting; energy-conservation; insulation; shading; solar-heating; ventilation; windows.

A multitude of design strategies are available to achieve energy-efficient windows. Opportunities for improving window performance fall into six groups: site, exterior appendages, frame, glazing, interior accessories, and building interior. Design strategies within these groups can improve one or more of the six energy functions of windows: solar heating, daylighting, shading, insulation, air tightness, and ventilation. Included in this report are 33 strategies; an explanation of the physical phenomena responsible for each strategie's energy performance, summarized energy and non-energy advantages and disadvantages; aesthetic considerations; cost approximations; example installations, laboratory studies, or calculations by the authors; and references. Intended readers include professional designers, lessors and owners of commercial space, home buyers and owners, window component manufacturers, and researchers. The report's purpose is to draw attention to the wide range of options currently available to conserve energy with windows.

BSS106. **Earthquake resistant masonry construction: National workshop.** Proceedings of a National Workshop held at the National Bureau of Standards, Boulder, CO, Sept. 13-16, 1976, R. A. Crist and L. E. Cattaneo, Eds., *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 106*, 372 pages (Sept. 1977) SN003-003-00000-0.

Key words: building codes and standards; design criteria; earthquake resistance; masonry construction; seismic design; structural design; structural engineering; structural research.

The National Workshop on Earthquake Resistant Masonry Construction provided an exchange of information between researchers and practicing engineers for the purpose of orienting pertinent research toward national needs concerning current problems related to design criteria. These proceedings contain the reports presented by researchers and by users of design criteria, as well as transcripts of the discussions which followed the individual presentations. In addition, the proceedings include recommendations which emanated from working sessions held by five working groups of participants. Technical areas covered by the groups were (1) code requirements, (2) design criteria, (3) mathematical models, (4) test standardization and material properties, and (5) retrofit and repair. The recommendations were derived to identify research which would lead to improved output in each of the technical areas in order to benefit national needs. *These proceedings include the following papers (indented):*

A perspective view: Brick masonry construction in the U.S.A., A. H. Yorkdale, *BSS106*, pp. 9-16 (Sept. 1977).

A perspective view: Concrete masonry construction in the U.S.A., T. B. Redmond, *BSS106*, pp. 17-39 (Sept. 1977).

Earthquake resistant masonry construction: A perspective view of needed research, R. A. Crist, *BSS106*, pp. 40-59 (Sept. 1977).

Key words: building codes and standards; design criteria; earthquake resistance; limit states design; masonry construction; materials testing standardization; mathematical models; rehabilitation; retrofit; seismic design; structural design; structural research.

An overview of the areas of research needed for improved engineering design of earthquake resistant masonry construction is given and followed by a presentation of the information in the form of a 3-dimensional matrix model. The elements of the matrix representing areas of research and their coordinate intersections (combinations) are used to develop the structuring of a workshop in which 5 major areas of consideration are shown to emerge. These 5 categories of: design criteria; standardized tests for material properties; mathcmatical models; rehabilitation and retrofit; and code requirements; together with respective task statements are each described, in order to organize corresponding workshop groups for accomplishment of the tasks. In conclusion, an order of assigning priorities to needed research is established.

Seismic research on masonry—University of California, Berkeley, 1972-1977, R. L. Mayes, R. W. Clough, and Y. Omote, *BSS106*, pp. 60-90 (Sept. 1977).

Key words: connections; houses; masonry; piers; research; seismic; shear walls; spandrel beams.

This paper describes the scope of the seismic research program that has been ongoing at the Earthquake Engineering Research Center, University of California, Berkeley since September, 1972. The program currently has two major parts. The first is an experimental and analytical study of multistory buildings and the second is an experimental study of housing construction. A summary of results of tests completed to date is included together with a description of tests currently in progress and those planned in the near future.

Expected performance of uniform building code designed masonry buildings, R. L. Mayes, R. W. Clough, Y. Omote, and S. W. Chen, *BSS106*, pp. 91-113 (Sept. 1977).

Key words: codes; design; dynamic analysis; masonry; shear walls.

The paper presents a summary of a study on the evaluation of the seismic design sections of the 1972, 1973, 1974 and 1976 Uniform Building Codes, and the recommended Comprehensive Seismic Design Provisions for Buildings prepared by the Applied Technology Council (ATC-3). In order to evaluate the various codes a three, a nine and a seventeen story building of similar floor plan were studied. The seismic design stresses were calculated in these buildings by the specific code procedures as well as the stress state predicted by a realistic dynamic earthquake response procedure. The adequacy of the codes was then evaluated by comparison of the two types of stress predictions.

The conclusion of the study was that the increasing conservatism of the more recent codes is justified and that greater conservatism is necessary in the most recent codes in buildings of moderate height, such as the nine and seventeen story buildings considered in this study.

An experimental study of concrete masonry under seismic-type loading, G. A. Hegemier, G. Krishnamoorthy, and R. O. Nunn, *BSS106*, pp. 114-153 (Sept. 1977).

Key words: earthquake damage analysis; masonry; rheology, material.

This paper outlines portions of a comprehensive research program on concrete masonry. Objectives, scope, methodology, and sample results obtained to date are presented. Where appropriate practical implications of the latter are delineated. Future experiments are discussed.

An experimental study of connections in reinforced concrete masonry: Masonry structures under seismic loading, J. Isenberg, G. A. Hegemier, and A. Anvar, *BSS106*, pp. 154-165 (Sept. 1977).

Key words: masonry; masonry panels; seismic loading.

This paper describes a University of California, San Diego test program to determine the behavior of typical floor-to-wall connections utilized in reinforced concrete masonry structures. The experiments are part of an extensive research effort on the seismic response of reinforced concrete masonry buildings.

Masonry research and codes in the United Kingdom, W. B. Cranston, *BSS106*, pp. 166-176 (Sept. 1977).

Key words: masonry codes, United Kingdom; masonry research.

A brief description of the various research projects known to the author is given, defining the objectives, conclusions and tentative conclusions where appropriate. Selected references are also given. The second part of the paper gives details of some of the proposed changes and additions to the United Kingdom Masonry Code.

The capacity of unreinforced masonry shear walls under membrane loads, S. G. Fattal, *BSS106*, pp. 177-197 (Sept. 1977).

Key words: brick; clay masonry; concrete block; concrete masonry; failure modes; load capacity; masonry walls; shear walls; splitting strength; ultimate capacity.

Four different types of unreinforced masonry walls and miscellaneous companion prisms were subjected to various configurations of membrane forces to study shear wall limit states in both clay brick and concrete masonry. The specimens that were subjected to diagonal compression, in combination with edge loads applied normal to the bed joint, generally displayed failure modes characterized by diagonal splitting through the masonry units or by separation along the mortar joints. The test results exhibited a dependence between diagonal load capacity and the intensity of normal lodas. Square specimens of dissimilar size but similar in composition developed comparable strength when subjected to diagonal loading alone, providing an experimental basis for evaluating the diagonal compressive strength of masonry by standard tests using small prisms. The directional variation of strength was investigated by means of diametral compression tests of circular walls and diagonal compression tests of rectangular prisms having different aspect ratios.

Canadian code requirements for masonry in earthquake zones, A. H. P. Maurenbrecher, *BSS106*, pp. 198-213 (Sept. 1977).

Key words: bricks; buildings; Canada; concrete blocks; design standards; earthquake resistant structures; masonry.

This paper gives a short review of Canadian seismic requirements for masonry buildings contained in the 1975 National Building Code of Canada and in the proposed revision to the masonry code—CSA draft Standard S304—Masonry Design and Construction for Buildings.

HEW activity in masonry design and construction, R. M. Webb, *BSS106*, pp. 215-217 (Sept. 1977).

NAVFAC interests in earthquake resistant masonry construction, J. V. Tyrrell, *BSS106*, p. 220 (Sept. 1977).

Summary of the Veterans Administration Engineering Program, P. M. Sears, *BSS106*, pp. 221-227 (Sept. 1977).

Seismic requirements of the Phoenix Construction Code, R. C. Hildebrandt, *BSS106*, pp. 228-237 (Sept. 1977).

Concerns of the NYC Housing Authority in the design of multifamily masonry residential structures, E. Nadel, *BSS106*, pp. 238-242 (Sept. 1977).

Requirements of a seismic resistant masonry construction code, C. C. Lederer, *BSS106*, pp. 243-248 (Sept. 1977).

Some research needs of earthquake-resistant masonry, J. E. Amrhein, *BSS106*, pp. 255-258 (Sept. 1977).

Key words: anchor bolts; bond; damping; ductility; earthquake resistance; energy absorption; modulus of elasticity; partial reinforcing; risk; shear modulus; testing; ultimate strength.

This paper outlines in general terms many specific needs of the masonry industry to obtain information, establish performance parameters, improve the final product and develop design criteria. It points up the many areas where information is lacking as related to dynamic seismic performance and reliability.

Suggested researchable items relating to masonry construction, J. F. Meehan, *BSS106*, pp. 259-274 (Sept. 1977).

Key words: allowable bolt loads, end distance, edge distance and spacing; drift; face shells, reinforcing splices; high lift grouting; shotcrete, surface wave instrumentation; veneer anchorage.

The purpose of this paper is to present a brief overview of needs believed necessary to improve the resistance of masonry construction to earthquake forces.

A view on some prerequisites for improved earthquake resistant masonry construction, M. E. Werner, *BSS106*, pp. 275-282 (Sept. 1977).

Arching in masonry walls subjected to out-of-plane forces, B. L. Gabrielsen and K. Kaplan, *BSS106*, pp. 283-313 (Sept. 1977).

Key words: arching; masonry walls.

Nonreinforced masonry walls, confined between rigid supports that restrict in-plane motions and rotation of wall elements about the supports, can display very high resistance to out-of-plane forces by forming three-hinged arches after cracking in flexure. Analysis indicates that two different types of arching can occur depending on whether a wall is tightly fitted between supports (rigid arching), or is separated from one support by a small gap (gapped arching).

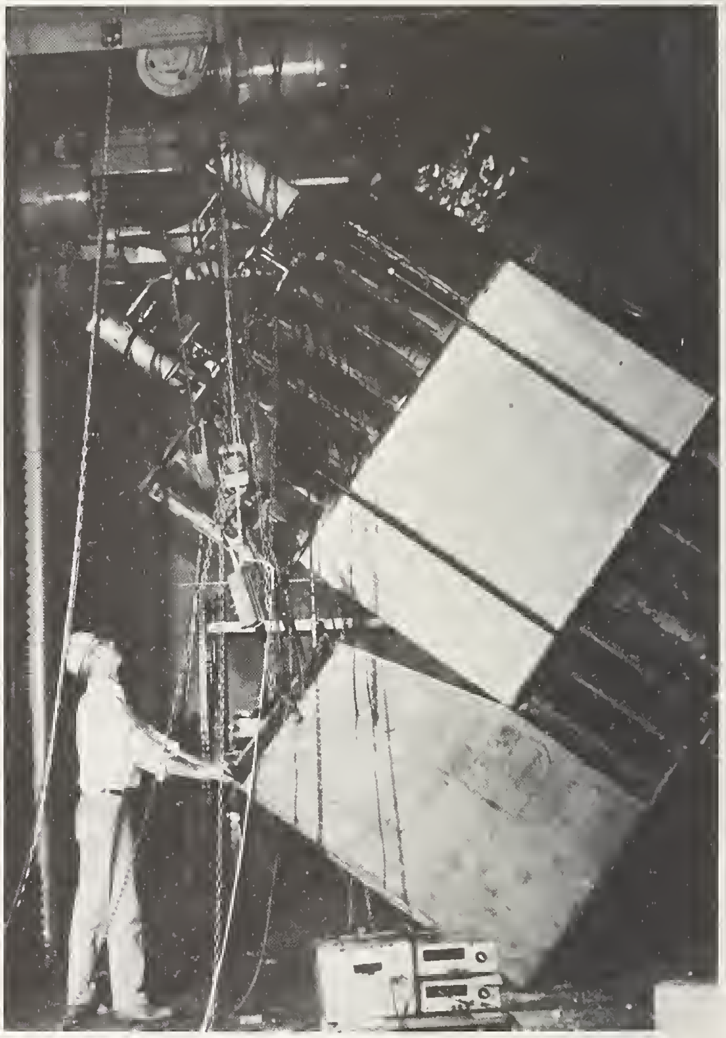
Special static tests were devised to investigate the kinds of loading that occur at the hinges of the arches (line loadings). These tests indicated that rigid arching walls can resist 6 to 8 times the loads that gapped arching walls can, although gapped arching walls are still considerably stronger than either cantilevered walls or walls mounted as simple beams.

An extensive dynamic test program involving full-scale walls, 8 1/2 ft (2.6 m) high and 12 ft (3.7 m) wide, subjected to blast waves in a large shock tunnel, confirmed that brick walls undergoing rigid arching could withstand loadings as high as 19 psi (131 kN/m^2) equivalent to about 34 g. These walls cracked in flexure but did not fail, and then withstood many cycles of reversing loadings with maxima equivalent to accelerations greater than 1 g.

Some thoughts on minimum requirements for the seismic design of load bearing masonry buildings, R. M. Gensert, *BSS106*, pp. 314-326 (Sept. 1977).

Key words: current research; ductility; full scale testing; high-rise masonry; scale factors; shear walls.

A shear wall is analyzed for a 5, 10 and 15-story building for two typical wind zones and four seismic zones. The result shows that one might design a tall unreinforced building in all zones but 3 and 4 for seismic conditions. It is suggested that the need for criteria regarding ductility should come from the testing of actual buildings.



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.

TN933. **An infrared technique for heat-loss measurement,** D. M. Burch, T. Kusuda, and D. G. Blum, *Nat. Bur. Stand. (U.S.), Tech. Note 933*, 52 pages (Apr. 1977) SN003-003-01746-9.

Key words: heat-flow measurements; infrared heat-loss measurement technique; measurement technology; thermography.

This paper describes a newly developed technique for measuring heat-loss rate utilizing an infrared television system. A device called a heat-flow reference pad was developed that makes it possible to measure quantitatively the heat-loss rate through the surface of a building without the need for a conventional heat-flow meter to be mounted on the surface. Technical considerations for the design of a heat-flow reference pad are presented. The infrared measurement technique predicted heat-loss rates in the laboratory and field within approximately 12 percent.

TN934. **Preservation of historic adobe structures—A status report,** J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 934*, 35 pages (Feb. 1977) SN003-003-01740-0.

Key words: adobe building materials; adobe soil; mechanical properties; moisture determination; preservation technology.

The physicochemical and mechanical properties of adobe soils and building materials, and the technology of preserving historic adobe structures have been critically reviewed. In most cases, the deterioration of adobe structures can be directly or indirectly correlated with the presence of excess moisture. Therefore, the successful preservation of most historic adobe structures depends largely on effectively protecting these structures from water. This review indicates that the technology of preserving adobe structures needs further development to ensure the longevity of the structures.

Areas in which research is needed have been identified and include: (1) the development of standard methods to characterize the composition and physical properties of adobe soils, and the mechanical properties of adobe brick; (2) nondestructive methods to measure the water contents of and water movement in adobe structures; and (3) the evaluation of the effectiveness of different types of preservation materials and methods.

TN938. **Recommended practice for the use of metric (SI) units in building design and construction,** H. J. Milton, *Nat. Bur. Stand. (U.S.), Tech. Note 938*, 47 pages (Apr. 1977) SN003-003-01761-2.

Key words: International System of Units (SI); metric design and construction; recommended SI practice.

This Technical Note contains a comprehensive set of recommendations for the use of metric (SI) units in building design and construction.

It includes descriptive material dealing with the structure of the International System of Units (SI); rules and recommendations for the presentation of SI units and symbols, and of numerical values associated with SI; a set of tables showing working units and typical applications for SI units in building design and construction; and a section dealing with special considerations in the selection and use of SI units in design and construction. Appendixes show conversion factors for the most common units; superseded metric units not recommended for use with SI; an SI units and relationships chart; and appropriate references.

This document was prepared to provide the technical basis for an ASTM reference standard on recommended practice for the use of metric (SI) units in building design and construction.

TN940. **The representation and use of design specifications,** S. J. Fenves and R. N. Wright, *Nat. Bur. Stand. (U.S.), Tech. Note 940*, 51 pages (June 1977) SN003-003-01790-6.

Key words: building codes; computer programming; decision tables; graph theory; performance specifications; standards.

Design specifications are presented as the primary communication and control tool for the design and construction industry. Requisite properties of completeness, uniqueness and correctness are identified, and the role of performance and limit state concepts in specifying intent of the specifications are emphasized. Formal representation methods are presented at three levels: decision tables for specification provisions, an information network for related provisions, and argument trees for organizing and outlining. An idealized process for specification development is presented, and the use of the representational tools for checking specifications and providing strategies for textual expression is described and illustrated. Development of computer aids for specification processing in design and conformance checking is described.

TN941. **Stone preservatives: Methods of laboratory testing and preliminary performance criteria,** G. A. Sleater, *Nat. Bur. Stand. (U.S.), Tech. Note 941*, 79 pages (May 1977) SN003-003-01727-2.

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

Although numerous materials have been proposed as preservatives for stone in historic buildings and monuments, their efficacy is difficult to establish. In the work described here, a laboratory research program of accelerated simulated stone decay was used to obtain data on stone preservatives and to suggest criteria for their selection. Over 50 materials usable as stone preservatives were tested.

Tests to simulate stone decay were of two types: 1. exposure to combined weathering factors using a special test chamber for accelerated decay (CAD), in which chemical attack, salt and water action, and thermal effects were simulated in one operation; 2. exposure to single causes of stone decay using sulfurous acid fog, sodium chloride fog, water condensation/evaporation cycling, sodium sulfate penetration and crystallization, and ultraviolet radiation.

Methods for measuring the effects of the exposures are given together with the test data; these have been used to set limits of acceptable performance in preliminary performance criteria for the selection of stone preservatives. The behavior of each stone preservative tested in meeting these criteria is given. No one stone preservative met all criteria.

TN946. **Urea-formaldehyde based foam insulations: An assessment of their properties and performance,** W. J. Rossiter, Jr., R. G. Mathey, D. M. Burch, and E. T. Pierce, *Nat. Bur. Stand. (U.S.), Tech. Note 946*, 92 pages (July 1977) SN003-003-01801-5.

Key words: cellular plastics; foam insulation; insulation; materials properties; performance; urea-formaldehyde.

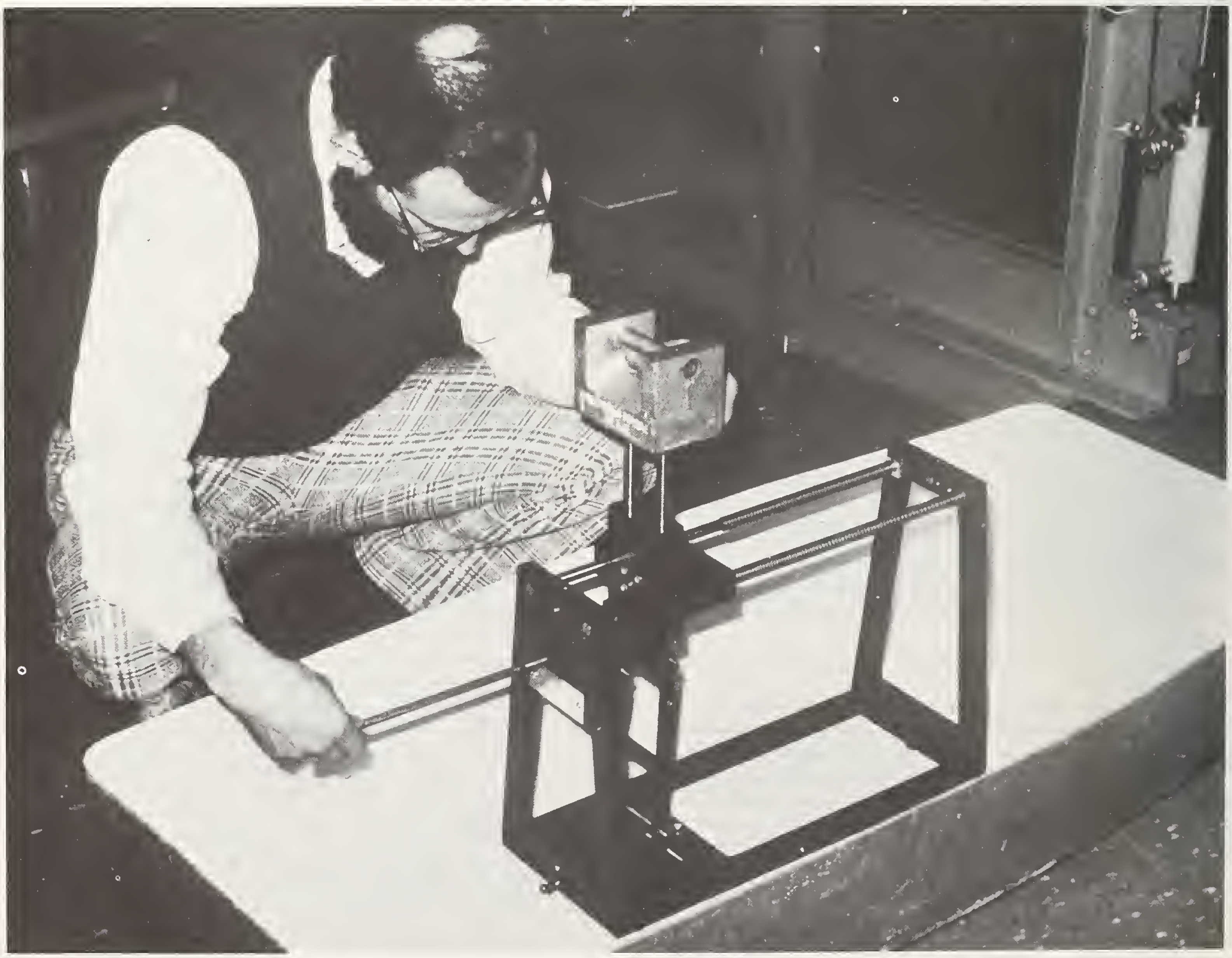
The properties and performance of urea-formaldehyde based foams pertinent to their use as insulation in buildings were assessed based essentially on existing information. Pertinent materials properties were identified and guidelines prepared for the suggested values of these properties along with corresponding methods of test. For certain materials properties information was not found to enable suggested values of these properties. The factors affecting performance of urea-formaldehyde based foam insulations were also identified and discussed. Some performance factors could not be adequately evaluated because of insufficient or contradictory data in the literature. Methods of foam application were studied and suggested general application guidelines were prepared.

The advantages and disadvantages of using urea-formaldehyde based foam insulations were discussed and problem areas identified. Recommendations were made pertaining to the use and assessment of urea-formaldehyde based foam insulations for residential construction.

TN953. **A new portable tester for the evaluation of the slip-resistance of walkway surfaces,** R. J. Brungraber, *Nat. Bur. Stand. (U.S.), Tech. Note 953*, 51 pages (July 1977) SN003-003-01796-5.

Key words: flooring; floor treatments; shoe sole and heel materials; slip-resistance tester; walkway surfaces; waxes and polishes.

The paper describes the available devices for testing the slip-resistance developed between walkway surfaces and shoe sole or heel materials. The limitations of available testers are detailed, and the need for a more reliable tester that can be used on actual floors under true field conditions, such as in the presence of water, is shown. The design and development of the new NBS-Brungraber Slip-Resistance Tester is described, including a discussion of the test programs that were employed to evaluate it.



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.

SP440. **COLOR—Universal language and dictionary of names,** K. L. Kelly and D. B. Judd, *Nat. Bur. Stand. (U.S.), Spec. Publ. 440*, 184 pages (Dec. 1976) SN003-003-01705-1.

Key words: centroid colors; color; color designations; calorimetry; color names; color-order systems; Munsell Color System; Universal Color Language; variable accuracy of color designations.

The Universal Color Language (UCL) has been revised and will be published together with the 7th printing of the Color Names Dictionary. It serves as the means of updating the Dictionary. The UCL brings together all the well-known color-order systems and methods of designating color. It interrelates them in six correlated levels of fineness of color designation, each higher level indicating a finer division of the color solid. It follows closely the original requirements for the ISCC-NBS Method of Designating Colors stated in the Color Names Dictionary. They were: a) accurate enough to satisfy a scientist, b) usable enough to satisfy a manufacturer and c) simple enough to be understood by the average person on the street. The first requirement is satisfied by levels 6 and 5, the second by levels 5, 4 and 3, and the third by levels 3, 2 and 1. The UCL is being increasingly used by science, art and industry. Instructions are included for the application of the UCL at each level.

SP446-1. **Building technology project summaries 1976,** M. Olmert, and CBT Management Group, *Nat. Bur. Stand. (U.S.), Spec. Publ. 446-1*, 83 pages (Sept. 1977) SN-003-003-01846-5.

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

The Center for Building Technology provides the technical and scientific bases for criteria and standards that improve the usefulness, safety, and economy of buildings while conserving building materials and energy. The Center's activities support the building technology program of the Federal, State and local government; assist design professions, building officials and the research community by developing design criteria that improve buildings; and assist manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarized the Center's projects for calendar year 1976. It enables individuals to get a clear impression of CBT research activities.

SP457-1. **Building technology publications 1976—Supplement 1,** J. R. Debelius, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457-1*, 78 pages (June 1977) SN003-003-01802-3.

Key words: bibliography; building technology publications; Center for Building Technology; key word-author indexes; publication abstracts.

The complete citations for publications of the NBS Center for Building Technology (CBT) are given for the period January-December 1976. This supplement to NBS Special Publication 457, "Building Technology Publications 1965-1975," includes the titles and abstracts for CBT papers published during 1976 in both NBS and non-NBS media; key-word and author indexes are also included, along with general information and the availability of CBT publications.

Publications constitute the major end product of CBT programs and provide the primary means of communicating the results of NBS programs to its varied technical audiences, as well as to the general public.

SP458. **Metrication and dimensional coordination—A selected bibliography,** R. E. Clark and C. L. Roat, *Nat. Bur. Stand. (U.S.), Spec. Publ. 458*, 32 pages (Apr. 1977) SN003-003-01684-5.

Key words: building codes and standards; construction industry; dimensional coordination; metrication; metric system; modular coordination; SI.

The United States changeover to the use of the SI (International metric) measurement language presents our construction industry with the need to review and adapt many product standards and practices for the use of metric measurement units. These adaptations and changes can bring substantial benefits to the industry in the form of permanently recurring cost savings. A practice of potentially great benefit would be the incorporation of dimensional coordination in the new metric standards for sizes of building products. For such benefits to be realized, however, the involved issues must be effectively addressed and the requisite decisions made and implemented. Considerable literature pertinent to the issues and decisions has been published in the United States and in the other (primarily English-speaking) countries that have been implementing metrication and dimensional coordination in the past decade. This report aids construction industry consideration and resolution of metrication decisions by providing a guide to the best available sources relevant to the issues.

SP470. **Wind and seismic effects.** Proceedings of the Seventh Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, May 20-23, 1975, Tokyo, Japan, H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 470*, 513 pages (Apr. 1977) SN003-003-01762-1.

Key words: accelerograph; bridges; buildings; codes; disaster; dynamic analysis; earthquakes; ground failures; hydraulic structures; seismicity; soils; standards; structural response; vessels and wind.

The Seventh Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Tokyo, Japan on May 20-23, 1975. The proceedings of the Joint Meeting include the program, the formal resolutions, and the technical papers. The subject matter covered in the papers includes characteristics of strong wind; response of full-scale structures to wind action; geological distribution of seismic activity; maintenance of strong motion accelerographs and data processing; strong earthquake motions and ground failures; response of hydraulic and building structures to seismic forces; aseismic considerations for vessels; recent revisions of design standards on wind and seismic effects; joint research program utilizing large scale testing facilities; and technological assistance to developing countries. *These proceedings include the following papers (indented):*

Present status of wind characteristics in Japan, K. Takeuchi, *SP470*, pp. 1-1—1-17 (Apr. 1977).

Key words: field measurements; model; towers; wind; wind observation; wind tunnel.

The present status of a study on the wind characteristics in Japan is given herein. Observational studies constructed from a tower and an array of towers are described in addition to results obtained from tethered balloons.

The observations obtained from towers in Tokushima Pref. and analysis of the data, which were made by Shiotani (1972 and 1974), are detailed and unique. Also other observations from towers located at Tarama Island, Okinawa Pref. are being conducted by Mitsuta (1974). Detailed analysis of these observations are also presented.

Finally some model experiments on the local wind, using a tunnel, are also presented.

A reexamination of hurricane Camille, A. R. Hull, *SP470*, pp. I-18—I-27 (Apr. 1977).

Key words: hurricane; storm surge; tropical storms; wind; wind data; wind speed.

Newly available oceanographic and meteorological data on major storms and hurricanes striking the Gulf of Mexico during a 31-month period provided by eight petroleum firms present an opportunity to reexamine and reevaluate Hurricane Camille, one of the most severe and destructive storms ever to strike the Gulf. (Maximum wave heights of 72 feet were recorded as the eye of the hurricane passed within 15 miles of one measurement station.) The new data on Camille comprise one of the most comprehensive sets of oceanographic and meteorological information available for such an extreme weather event and should prove invaluable in basic research and offshore engineering applications. With increasing availability of this type of information likely as the Nation develops its offshore energy resources, questions arise as to what procedures should be followed to access, disseminate, and use these data most effectively and what contributions this important new data source may make to current knowledge of extreme storm events and their effects on engineering structures. The data available for Camille are examined to provide tentative answers to these questions.

Fire tornado and its maximum wind-speed, S. Soma and K. Suda, *SP470*, pp. I-28—I-41 (Apr. 1977).

Key words: fires; fire tornados; tornado model; tornados; wind speed.

Very few studies have been conducted on fire tornados, owing to its rare occurrence. However, in Japan, much public attention has been directed to this phenomenon in view of the fact that catastrophic damage has been caused by two fire tornados. One such tornado developed during the Great Kanto Earthquake in 1923 and another at Wakayama City in 1945. The cause of such catastrophic damage, due to these fire tornados is two-fold. One is the formation of a tornado, in burning of the urban area, and the other is the peculiar feature that the tornado is accompanied by strong winds.

In the present report, the characteristics of the fire tornados, which have been experienced in Japan are reported and the estimated maximum wind speed in the tornados are given.

A research project on the wind flow around tall buildings, T. Murota and K. Nakano, *SP470*, pp. I-42—I-49 (Apr. 1977).

Key words: building; wind; wind effects; wind loads; wind observation; wind speed.

The problem of wind effects, produced by the construction of tall buildings, is analyzed. A research project designed to obtain information about this problem and to study the counterpart for the prevention of high winds around tall buildings, has been initiated. Some preliminary observations are described herein.

Wind engineering research program supported by the National Science Foundation, M. P. Gaus, *SP470*, pp. II-1—II-10 (Apr. 1977).

Key words: education; research; research programs; wind engineering; wind studies.

The National Science Foundation is an Agency of the Federal Government established in 1950 to advance scientific and technical progress in the United States. The Foundation fulfills this responsibility primarily by sponsoring scientific research, encouraging and supporting improvements in science education, and fostering scientific information exchange. NSF does not itself conduct research or carry out education projects.

Operating under this charter the Foundation supports a substantial amount of research in Wind and Seismic effects. The Division of Engineering has for the past years had an organized area activity in Wind Engineering Research. The primary emphasis of this research has been toward developing a better understanding of the structure and flow of the earth's boundary layer to develop new knowledge and techniques for predicting and coping with the interaction between the boundary layer wind and manmade or natural objects and to develop methods to assess or predict environmental effects related to wind flow. Almost all of the current research programs being supported are at academic institutions. A summary of these current research projects is given herein.

Study of the wind pressure and the response of roof corners, T. Murota and M. Nakahara, *SP470*, pp. II-1—II-19 (Apr. 1977).

Key words: buildings; dynamic effects; high winds; roofs; typhoon; wind pressure.

In 1972, a number of prefabricated dwellings in the Nagoya district, Japan, suffered damage from high winds caused by Typhoon No. 7220. Much of the damage to the dwellings caused by this typhoon was the removal of the flat roofs of the buildings. It is known that the corners of flat roofs, when subjected to high winds have high suctions with periodic fluctuating force components. The cause of this type of damage has created a need for studying the dynamic effect of wind pressure on roof corners. Such a study has been conducted since 1973 by the Building Research Institute. The results of the 1974 field observations, by the BRI, will be given herein.

On the wind response of the Kanmon Bridge, T. Okubo, N. Narita, and K. Yokoyama, *SP470*, pp. II-20—II-46 (Apr. 1977).

Key words: bridges; displacements; field tests; wind measurements; winds; wind speed.

The resistance against wind of long-span suspension bridges is one of the important design problems because this type of bridge is flexible and sensitive to wind action. The Kanmon Bridge, opened to the public in November 1973, is a typical long-span suspension bridge in Japan. The design of this bridge against wind initiated during the early design phases and its stability against wind was confirmed through wind tunnel experiments on section models. However, confirmation between theory and model tests can only be confirmed by considering field studies and the resulting data. Such studies can reconfirm the bridge safety when the bridge behavior is examined under strong wind conditions. Considering these thoughts, a long-term observation plan system was established on the Kanmon Bridge, with actual observations initiated in April 1974.

In this paper, the research plan for the long-term observation system is reviewed. Then, the characteristics of the approaching wind and the response of the suspended structure are presented. A comparison is then made between observed and theoretical wind gust responses. The results show that the observed response is less than the theoretical response and thus shows the need for accumulation of data which can improve analytical techniques.

Luling, Louisiana cable-stayed bridge wind tunnel section model tests, R. H. Gade, W. Podolny, Jr., and H. R. Bosch, *SP470*, pp. II-47—II-67 (Apr. 1977).

Key words: bridge; cabled stayed; displacements; flutter; models; wind angles; wind tunnel.

Results of wind tunnel section model tests of five orthotropic superstructure configurations for the Luling, Louisiana, cable-stayed bridge are presented.

The 1,235-foot (376.4 meters) long main span crossing of the Mississippi River is designed for 150 miles per hour (67 meters per second) hurricane wind velocity.

The section models, 1/60 scale, are tested at six wind angles: —4°, —2°, 0°, 2°, 4°, and 6°. Flutter coefficients are plotted for all tests.

The tests show freedom from flutter at the design wind speed. Vortex excitation, vertical and torsional, is exhibited.

Testing is performed in smooth flow conditions at the Fairbank Highway Research Station of the Federal Highway Administration, utilizing the George S. Vincent Wind Tunnel.

The regional distribution of the earthquake danger in Japan, S. Hattori, Y. Kitagawa, and T. Santo, *SP470*, pp. III-1—III-17 (Apr. 1977).

Key words: earthquake distribution; earthquakes; field data; frequency maps; ground displacement; Japan.

The values of m and log k in Ishimoro-Iida's statistical Formula are derived for each component of the maximum displacement amplitude observed at many stations of the network maintained by the Japan Meteorological Agency (JMA).

A distribution map of expected maximum displacement amplitudes for the earthquake recurrence period of 100 years is made based on the derived values of m and log k. The map indicates quantitatively the regional distribution of earthquake danger in and around Japan. It is seen from this map that the general level of the earthquake danger varies throughout Japan. This variation is also found to reflect the pattern of seismic activity throughout the area. The earthquake danger increases along the Pacific side of Hokkaido, Tohoku and Kanto districts and decreases in the southwestern and inland areas of Japan. Small variations are also recognized, which might suggest that the earthquake danger is affected by local geological and subsoil effects.

Quantification of seismicity, T. Terashima and T. Santo, *SP470*, pp. III-18—III-28 (Apr. 1977).

Key words: earthquake distributions; epicenters; maps; seismicity index.

A new seismicity index is proposed in this paper. This index is defined by the following equation:

$$S_T = (M_{26}/T)\ \Delta \leq 100 \text{ km } M \geq 6$$

where, N(M) represents the number of shallow earthquakes with $M \geq 6$ which have occurred within a epicentral distance Δ of 100 km during the period T(year). Using this criterion, seismicity index maps in or near Japan for two different periods have been made.

Application of this index indicates that a remarkable change of S_T was found in southern part of Boso Peninsula before and after Great Kanto Earthquake of 1923. Therefore, in the field of earthquake engineering, these seismicity index maps can be used as a zoning map of earthquake risk.

Maintenance of the strong-motion accelerograph and the data processing of the records, E. Kuribayashi, H. Tsuchida, and M. Watabe, *SP470*, pp. IV-1—IV-34 (Apr. 1977).

Key words: accelerographs; earthquake data; earthquake records; field observations; strong-motion accelerographs.

The observation of strong-motion earthquakes, located at harbour, public works and buildings throughout Japan by the national research institute has been made. These observations will be discussed, herein, in addition to such items as the maintenance and checks of the strong-motion accelerographs, main records, processing and analyses of records, and the availability of the data to the public.

The United States strong-motion network: Field operations, R. P. Maley, *SP470*, pp. IV-35—IV-52 (Apr. 1977).

Key words: accelerographs; earthquake data; earthquake records; field stations; strong-motion network.

The national strong-motion instrumentation network operated by the Seismic Engineering Branch of the U.S. Geological Survey is the system established to record the strong motions of damaging earthquakes in the United States. From the original 50 C&GS Standard instruments installed in the 1930's, the network has expanded to more than 1300 accelerographs, with 9 different models, located in 35 states and 9 Central and South American countries.

The network operations section of SEB conducts three interrelated field programs: instrument installation, routine maintenance, and earthquake record recovery. At the present time the large majority of instruments being installed are self-contained three-component accelerographs that record on 70-mm film. Some remote-sensor accelerographs are also being located on structures. Routine maintenance intervals have been lengthened from 2 months a few years ago to 4 months, with the exception of a trial area in Los Angeles where a 6 month interval is now in effect. The higher reliability of modern instrumentation has made this extended maintenance schedule possible. As the network expands, it may be necessary to develop a Remote Interrogation System to provide a method of determining the criterion of the instruments' vital functions by telemetry. After significant earthquakes, SEB personnel promptly collect and develop earthquake records and attach permanent labels providing sufficient data for most analyses. The records are then transmitted to the data management section for further processing.

Strong-motion data management, C. Rojahn, *SP470*, pp. IV-53—IV-66 (Apr. 1977).

Key words: accelerographs; data processing; earthquake records; strong-motion data.

The Seismic Engineering Branch (SEB), of the Office of Earthquake Studies, U.S. Geological Survey, is funded by the National Science Foundation and is responsible for the development and maintenance of a national network of strong-motion instruments and for the processing, management, and dissemination of data obtained from those instruments. Data management is central to the entire strong-motion program; it serves as a focal point for the functions of archiving the records, processing the data, and disseminating both the data and information about the program to the user community. In the archival phase, all records are stored by station and cataloged both by event and by station. In data processing, all significant ground and basement level records are digitized after which the raw digitized data is used to generate the following: uncorrected acceleration time-histories; velocity and displacement time-histories; and various forms of frequency domain spectra. Both SEB and the Environmental Data Service of the National Oceanic and Atmospheric Administration are involved in the data and information dissemination operation. Each organization distributes data, whereas SEB is solely responsible for the dissemination of information about the strong-motion program. Various U.S. Geological Survey professional papers and circulars are the primary media through which the latter function is accomplished.

Brief review on liquefaction during earthquakes in Japan, E. Kuribayashi and F. Tatsuoka, *SP470*, pp. V-1—V-15 (Apr. 1977).

Key words: alluvial deposits; earthquakes; epicentral distance; liquefaction; settlement; soils.

To correlate the actual liquefaction phenomena and site conditions, a literature survey about the liquefaction phenomena caused by earthquakes during the last century in Japan was performed. A liquefaction distribution map of Japan and the regional maps of Kanto, Nobi and Hokuriku are presented and the factors related to liquefaction are discussed. During the last century liquefaction in sub-soils have been observed at some hundred sites during 44 earthquakes where the sites were limited to alluvial deposits and reclaimed lands. Furthermore, it was found that liquefaction occurred repeatedly in different earthquake zones. The estimated JMA intensity scale factor, at the liquefied sites was more than five which means a maximum acceleration of 80 to 250 gals. The extent of the liquefied zones are limited, depending on the magnitude of the earthquake.

Vibration test on settlement of submerged sand layer, K. Sawada and Y. Koga, *SP470*, pp. V-16—V-35 (Apr. 1977).

Key words: earthquakes; liquefaction; sand layer; shake table; vibration tests; void ratios.

A series of vibration tests on submerged sand layer model, using a large shaker table, was performed in order to establish a method which can predict the liquefaction and settlement phenomenon of sandy ground during earthquakes. As a result of these tests, information concerning the vibration behaviour during the liquefaction phenomenon and subsequent settlement behaviour was obtained. Examining these test results and assuming that the vibration and settlement behaviour of a sand layer in the sand container is one-dimensional, it has been found that the test and analysis results agree quite favorably. Therefore, if the shear stress in the ground can be reasonably estimated, the amount of settlement of the sand due to earthquakes can be estimated by this analysis method proposed herein.

Study on earthquake response of structures by considering non-deterministic variables, Y. Yamazaki and Y. Koizumi, *SP470*, pp. VI-1—VI-21 (Apr. 1977).

Key words: deterministic; dynamics; earthquake; probability; random vibrations; safety; structures.

The seismic design coefficient has been widely used because of its simplicity. This design technique provides a safeguard against earthquakes but contains many problems when replacing the dynamic forces with static forces. In addition, the earthquake resistant properties of high-rises or buildings can be investigated by a simulation analysis, using many past earthquake records as input excitation. This type of dynamic analysis of a structure has been made possible by use of electronic computers. In this analysis, an actual structure is transformed into a vibration model, then the structure is subjected to earthquake ground motions, which are simulated by an electronic computer. As an alternate scheme, from a stochastic point of view, vibrational properties of structures subjected to earthquake ground motions have been investigated by utilizing the concept of random vibrations. The theory of random vibration, for dynamic response of structures, considers that earthquake ground motions can be essentially predicted as deterministic phenomena and that the vibrational behaviour of structures during these earthquakes can be predicted stochastically. Studies on developing a more reasonable design method have been conducted using the experiences obtained from earthquake disasters and the analyses of earthquake phenomena. The nondeterministic phenomena of earthquake ground motions will be treated essentially by the application of the theory of random vibration to the earthquake engineering. However, it is also true that a structure cannot be handled as a deterministic system, because the dynamic property variables of an actual structure, such as the masses, spring constants and damping constants, cannot be evaluated deterministically when the structure is designed. Hence, a structure must be designed by considering the nondeterministic properties of the structure as well as those of earthquake ground motions. In this thesis, a theoretical treatment of the earthquake response problems of a structure with nondeterministic variables have been discussed and a reasonable design technique of a structure with appropriate safety has been suggested.

Least weight structures for threshold frequencies, R. D. McConnell, *SP470*, pp. VI-22—VI-32 (Apr. 1977).

Key words: frequency response; least weight; optimization; structures.

This paper demonstrates a method for designing least-weight, or optimized, structures when a threshold frequency (within appropriate force factors) is known. The process is highly amenable to a job-by-job application due to its simplicity. Small mathematical models of a structure can be analyzed by a hand-calculator while standard static-load finite element programs can be used for large structures.

Ductile shear walls in earthquake-resistant multistory buildings, M. Fintel, *SP470*, pp. VI-33—VI-46 (Apr. 1977).

Key words: buildings; damage; dynamic response; earthquakes; safety; shear wall; stiffness.

Slender shear walls in multistory buildings are discussed in this paper and answers are given to such questions as "Why do we need them?" and "What do we know about their design?". Also discussed are the historical development of the use of shear walls, their performance in earthquakes of the past 10 years (both good and bad), and finally, the available design information and our future needs in the area of design of shear walls for strength, stiffness and ductility, as well as needs in the area of analysis for the dynamic response of shear wall structures.

Surveillance of corps of engineers structures in earthquake-prone areas, K. O. O'Donnell, *SP470*, pp. VI-47—VI-63 (Apr. 1977).

Key words: earthquakes; hydraulic structures; inspection; instrumentation; strong-motion accelerographs.

This paper explains the program which the corps of Engineers has adopted to assess the effects of earthquake activity concerning the structural behavior of Civil Works hydraulic structures. The program encompasses reporting earthquake effects and an instrumentation system on dams and appurtenant structures for monitoring. Post-earthquake inspections will be conducted to detect significant structural distress and provide information for the necessary remedial measures for damaged structures. The strong motion instrumentation will provide a record of ground and structure motion during earthquakes. Data provided from this program should be an aid in selecting design earthquakes and may provide preliminary guidance in design procedures for use in predicting, from small earthquakes, the behavior of structures subjected to larger design earthquakes. The accumulated information from the entire program should help in improving the design criteria for future designs.

School and hospital construction in California, J. F. Meehan, *SP470*, pp. VI-64—VI-73 (Apr. 1977).

Key words: building codes; building regulations; design criteria; earthquakes; hospitals; schools.

The California State Legislature has adopted statutes concerning the regulation of the design and construction of public school buildings and hospitals. These statutes were brought about because of the rather poor performance of these types of buildings in California earthquakes. Events leading up to these statutes and the methods of their enforcement will be discussed.

Improved earthquake resistive design and construction of single-family residential dwellings, G. R. Fuller, *SP470*, pp. VI-74—VI-88 (Apr. 1977).

Key words: building codes; buildings; construction; dwellings; earthquakes; seismic design criteria.

This paper presents results of the research program being carried out by the Applied Technology Council (ATC) of the Structural Engineers Association of California (SEAOC) under the sponsorship of the U.S. Department of Housing and Urban Development. The objective of this project was to review and evaluate available manuals, literature and standards concerning design and construction of residential dwellings and response of such structures to earthquake motions; and to then develop a manual of recommended practice for earthquake resistive design and construction. This manual would be primarily directed toward builders, building officials, field inspectors, and house designers and would contain recommended construction details, architectural layouts, design recommendations and types of construction recommended or to be avoided. The manual is now in draft form and copies are available for review. A synopsis of research results developed to date will be presented in this paper. Code comparisons, problem areas, tentative recommendations will be discussed.

The research contract with ATC is not due for completion until June 30, 1975, therefore this paper is an interim report. The final report with the completed manual will be distributed to members of the U.S.-Japan Panel on Wind and Seismic Effects, when available.

Dynamic tests of structures for oil tanks and nuclear power plants, S. Inaba, *SP470*, pp. VII-1—VII-6 (Apr. 1977).

Key words: aseismic design; dynamic tests; nuclear reactors; oil tanks; power plants; shake table.

In Japan, it is necessary to build an increasing number of nuclear power plants in order to overcome the energy problem. Also, an increasing number of large oil tanks have been built in order to increase the amount of standard crude oil. It has, therefore, become important in engineering to design aseismic structures for nuclear power plants, oil plants, gas tanks, and other industrial plants for the purpose of preventing disasters due to the earthquake. Under these circumstances, several dynamic tests of plant structures have been conducted by using a large-scale shake table of the National Research Center for Disaster Prevention (VRCDP) in Tsukuba New Town. This report will present in general the results of dynamic tests on a graphite shielding structure, oil tanks, fuel assemblies of nuclear reactor, and a container vessel of thin shell.

Sheet pile foundation and its structural characteristics against horizontal loads, K. Kawakami, T. Okubo, K. Komada, and M. Okahara, *SP470*, pp. VII-7—VII-60 (Apr. 1977).

Key words: foundation; lateral loads; sheet piles; structural analysis; tests.

The general response of sheet pile foundations, relative to analytical and experimental studies, are discussed. Test results are given, in addition to the development of general design equations.

On specifications for earthquake-resistant design of highway bridges (January, 1971), K. Kawakami, E. Kuribayashi, T. Iwasaki, and Y. Iida, *SP470*, pp. VIII-1—VIII-30 (Apr. 1977).

Key words: earthquakes; highway bridges; seismic provisions; specifications; structural engineering.

This paper presents the details of new specifications for Design of Highway Bridges to Resist Earthquakes, completed in January 1971 by the Highway Bridge Committee of the Japan Road Association.

On specifications for earthquake-resistant design of the Honshu-Shikoku Bridges (JSCE 1974), I. Kawasaki and E. Kuribayashi, *SP470*, pp. VIII-31—VIII-41 (Apr. 1977).

Key words: bridges; earthquake design; earthquake forces; seismic provisions; specifications.

The following describes the general specifications for earthquake-resistant design of the Honshu-Shikoku Bridges, as developed by JSCE in 1974, after significant study.

Recent revision of design standards on seismic effects for port and harbour structures, S. Hayashi, H. Tsuchida, and S. Noda, *SP470*, pp. VIII-42—VIII-55 (Apr. 1977).

Key words: design; earthquakes; harbours; ports; specifications; structures.

The design standards for port structures have been compiled four times in Japan. In these design standards, provisions on earthquake resistant design of wharves are included.

In 1950 the first design standard was published, and in 1959 and 1967 new design standards as an expansion of preceding one were compiled. Those design standards were recognized as the most advanced design procedure in the times and used very widely for design of port structures. However, the standards were not related to any law.

In 1973 Port and Harbour Law was revised and to secure the safety in ports it was assigned to establish engineering requirement of facilities in ports. The requirement has been effective since 1974 and the earthquake resistant design of the facilities are specified in it.

JSCE specifications for earthquake resistant design of submerged tunnels (1975), E. Kuribayashi and H. Tsuchida, *SP470*, pp. VIII-56—VIII-68 (Apr. 1977).

Key words: aseismic design criteria; design provisions; earthquakes; specifications; structural engineering; tunnels.

In response to the request from Ministry of Construction and Ministry of Transport, the Japan Society of Civil Engineers has concluded in March 1975 the final draft of the Specifications for Earthquake Resistant Design of Submerged Tunnels. The writers of this paper have worked on the drafting of these Specifications in cooperation with colleagues of the Public Works Research Institute and Port and Harbor Research Institute during the last four years.

The draft of the Specifications was adopted as Specifications for Earthquake Resistant Design of the Proposed Tunnel across Tolyo Bay. This paper presents the principal provisions and articles of the draft of the Specifications, and contains the following five chapters; General, Investigation, Earthquake Resistant Design, Dynamic Analyses, and Preservation and Countermeasure in Earthquakes.

Joint research program utilizing the large scale testing facilities (free discussion), M. Watabe, M. Hirosawa, and S. Nakata, *SP470*, pp. IX-1—IX-5 (Apr. 1977).

Key words: dynamic testing; lateral load simulation; models; shake tables; testing.

Recently the United States and Japan have made progress in aseismic design of R. C. Structures based on the testing of R. C. members, in which these tests have shown the importance of ductility in columns. However there are a few seismic studies based on the loading tests of full size structures. Fortunately, in Japan there are the greatest loading test facilities in the world, with new larger facilities now under construction. By using these facilities full size aseismic tests can be conducted. This proposal provides a plan for the testing of reinforced concrete structures with shear walls, which should be the first step toward developing an international aseismic code.

Earthquake disaster mitigation: A joint research approach, C. C. Thiel and J. B. Scalzi, *SP470*, pp. IX-6—IX-16 (Apr. 1977).

Key words: buildings; earthquakes; research; structural engineering; structures.

This paper discusses the current earthquake research being undertaken in the USA under sponsorship of the NSF. In addition, possible cooperative research studies between the USA and Japan are described.

High wind study in the Philippines, N. J. Raufaste, *SP470*, pp. X-1—X-11 (Apr. 1977).

Key words: field studies; high winds; instrumentation; Philippines; wind tunnel test.

A review of the National Bureau of Standards three-year high wind study in the Philippines is presented. Accomplishments during the first two years of the study are discussed. Principal accomplishments include: 1) formation of a Philippine Advisory Committee to coordinate local wind research, 2) selection of three field test sites, 3) construction and instrumentation of six test buildings with wind recording equipment at the test sites, 4) instrumentation of the University of Philippines wind tunnel, and 5) participation in two international workshops on high winds in Manila.

Survey on seismology and earthquake engineering in India, Iran and Turkey, M. Watabe and H. Tokuhiro, *SP470*, pp. X-12—X-16 (Apr. 1977).

Key words: earthquake engineering; earthquakes; education; India; Iran; training; Turkey.

A series of earthquake engineering courses have been held in Japan in cooperation with Iran, India and Turkey. This paper presents the details of these courses and the aid such courses have provided to the supporting countries.

SP473. **Research and innovation in the building regulatory process.** Proceedings of the First NBS/NCSBCS Joint Conference held in Providence, RI, on Sept. 21-22, 1976, in conjunction with the Ninth Annual Meeting of the National Conference of States on Building Codes and Standards (NCSBCS), Inc., P. W. Cooke, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 473*, 504 pages (June 1977) SN003-003-01775-2.

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

The First NBS/NCSBCS Joint Conference on Research and Innovation in the Building Regulatory Process was held in Providence, Rhode Island on September 21-22, 1976. The proceedings of the Joint Conference include the opening remarks, the Keynote Address, the technical papers presented at each session, and a summary of a panel discussion on the future of building regulatory research. The subject matter covered in the papers includes: New Alternatives, Environmental Research and the Building Regulatory Process; Energy Conservation, Solar Energy and Building Standards; Coping with Building Innovations and Environmental Considerations; Issues in Building Regulation and Administration; Organization and Structure of Building Regulations; Information Processing and the Building Regulatory Process; Impact, Economics and Metrication of Building Regulation; Preservation, Rehabilitation and the Building Regulatory Process. *These proceedings include the following papers (indented):*

Incentives and constraints in building and the regulatory process, U. P. Gauchat and D. L. Schodek, *SP473*, pp. 17-33 (June 1977).

Key words: alternatives; building codes; building process; constraints; costs; incentives; regulation.

This paper discusses three specific ways to improve the balance between incentives and constraints in the building regulatory process:

1. Reorganizing and controlling the building process with the aim of making the interests of individual participants more congruent.
2. Offering tax incentives at the federal level that would distinguish between those parts of a building which reflect a common objective such as health and safety and those which respond to the wishes of a particular client.
3. Developing federal legislation that prohibits, on the basis of restrictive trade practice, the establishment of arbitrary local code restrictions, particularly those measures which inhibit the national marketing of highly factored building components or sub-assemblies.

How environmental research may affect the technical provisions and enforcement of regulations, S. T. Margulis, *SP473*, pp. 35-53 (June 1977).

Key words: codes and standards; environmental studies; fire safety; health dangers; research needs.

Two case studies illustrate the consequences of knowledge voids on the technical provisions and enforcement of regulations. The first case deals with legal decisions about the reasonableness (and, by implication, the scientific justification for) certain health provisions of a model housing code adopted by a local government. The second case focuses on a situation in which enforcement of the Life Safety Code could have resulted in the forced relocation of institutionalized elderly. In this situation, code enforcement (leading to forced relocation) could have contributed to more deaths than nonenforcement of this fire safety code. The application of environmental research to solve the problem posed by this situation is described. Problems of obtaining and applying environmental research, with regard to policy decisions such as building regulations, are noted.

Interior architecture by consent decree and court order, W. Kleeman, Jr. and R. Reeves, *SP473*, pp. 55-67 (June 1977).

Key words: court orders; human behavior; institutional occupancies; interior design; physical environment; regulation; research; standards.

Mental hospital patients, mental retardates, handicapped people and prisoners in jails are suing various governmental authorities saying, among many other things, that the physical interior environments of these institutions do not meet their needs. Consent decrees and court orders in 16 leading cases are examined. The question is raised as to the origin of the very specific standards in several of the cases. The long-range suitability of these standards is questioned and contrasted with more humane, less specific approaches to the same concerns in Sweden and Canada. The need for further research to establish more useful determinations of the effects of the immediate physical environment on human well-being and behavior is pointed out. The problems of the designer in meeting the special needs of these four types of plaintiffs are also examined.

Residential energy consumption: Socio-physical determinants of energy use in single family dwellings, B. M. Morrison, *SP473*, pp. 69-83 (June 1977).

Key words: energy consumption; input/output models; lifestyle factors; physical environment; residential housing; socio-physical determinants; systems theory.

The paper reports research designed to establish the factors that determine energy consumption, especially in single family detached dwelling units. The research asks the question is it the physical structural components of the housing or the life patterns carried on by the residents or both that make the difference in energy consumption? Using a human/environment ecosystem model, this question comes under scrutiny.

Avoid tunnel vision in implementation of energy conservation building standards, W. J. van der Meer, *SP473*, pp. 85-101 (June 1977).

Key words: alternatives; ASHRAE 90-75; building standards; buildings; energy conservation; minimum property standards; multiple glazing; "U" values.

Aside from recommendations to improve mechanical systems and components or to reduce lighting, most of the present thinking on energy conservation in buildings has the tunnel vision of looking almost exclusively toward lower "U" values. The FHA fell into the "U" value trap in revising their Minimum Property Standards. Even the more permissive and performance oriented ASHRAE Standard 90-75 has succumbed in part to the lower "U" value syndrome because, even though they permit alternative methods in achieving energy conservation, the criterion for allowable energy use by the alternative methods is based upon the estimated energy use of a similar hypothetical building using the appropriate ASHRAE average "U" values (U_o).

Lower "U" values are not the only way to achieve thermal energy efficiency, nor need they necessarily form the criterion for energy conservative building standards. There are many alternatives in energy conservation which are relatively independent of "U" values, several of which will be discussed in this paper.

Standards for solar heating and cooling applications, R. D. Dikkers, *SP473*, pp. 103-112 (June 1977).

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

The "Solar Heating and Cooling Demonstration Act of 1974," along with the "National Program for Solar Heating and Cooling (Residential and Commercial Applications)," call for the development and implementation of performance criteria, consensus standards, certification procedures and design guidelines relating to solar heating and cooling systems and components. This paper describes activities being carried out by the National Bureau of Standards (NBS) in support of the previously cited Federal legislation and program plan.

In cooperation with ERDA and HUD, NBS is developing: (1) performance criteria for solar heating and cooling systems to be used in residential and commercial buildings; (2) standards for solar heating and domestic hot water systems that can be used in conjunction with HUD's Minimum Property Standards; (3) draft standards for materials to be used in solar systems; (4) plans for establishing a solar collector testing laboratory accreditation program; and (5) plans for identifying and developing other needed standards in cooperation with various organizations.

Regulatory barriers to the diffusion of innovation: Some evidence from building codes, S. Oster and J. M. Quigley, *SP473*, pp. 113-135 (June 1977).

Key words: building official; building regulation; education; housing demand; innovation; regulatory barriers; residential construction; unionization.

Previous studies, including most prominently the reports of the Douglas and the Kaiser Commissions, have suggested that outmoded local regulation of residential construction has impeded technical progress in the industry. In this paper, we try to identify the determinants of differences across communities in building regulation. In particular, we use as our dependent variable the permissibility of four particular innovations in a cross section of political jurisdictions in 1970 and try to explain this permissibility using variables measuring attributes of building officials, local firms, labor unions, and housing demand. The data was taken from a special survey of local building departments conducted by Fields and Ventre in 1970. Our results indicate that the education of the chief building official and the level of unionization in the area are the two major factors explaining the probability that a jurisdiction will adopt a construction innovation in its code.

Effectiveness of U.S. municipal design review programs—Preliminary findings, S. Cohn, *SP473*, pp. 137-187 (June 1977).

Key words: architectural controls; buildings; design review; land use; municipalities; regulation; site design.

Design review and architectural controls as regulatory devices for improving building and site design began in the United States in 1930. By 1949, there were some 30 municipalities in the United States using such controls. The desire for more flexible regulatory instruments which could deal with unique contextual situations and designs as well as provide the means for designers to exercise their ingenuity in solving complex problems has resulted in this quasi-judicial regulatory technique becoming increasingly popular throughout the United States. In spite of this growing popularity there has been neither a systematic inventory or evaluation of this particular technique. This study has attempted a comprehensive analysis of design review and architectural control boards in municipalities in the United States with a population of greater than 25,000. In general, it tries to identify the goals, functions, structures, and techniques used by such boards and attempts to relate these to the effectiveness of such boards in achieving these goals.

Natural environmental carrying capacity and building regulation, P. G. Rowe, J. L. Gevirtz, and J. B. Blackburn, Jr., *SP473*, pp. 189-202 (June 1977).

Key words: building codes; carrying capacity; environment; land use; natural system; performance standards; regulatory process.

This paper is an attempt to examine the concept of "natural environmental carrying capacity" in relationship to building regulation. Principally it is an examination of the representational problem involved in achieving conformance between building regulatory mechanisms and understanding of the fundamental characteristics and processes of the natural system.

The first part of the paper presents the concept of "natural environmental carrying capacity" and the problem of translating this into performance standards. Within this framework some of the difficulties of incorporating these concepts in present building regulation formats are described. An attempt is also made to distinguish those environmental issues that seem to be most appropriately regulated at the building code level.

The second part of the paper briefly describes a systematic approach whereby building performance standards can be developed that reflect the ability of different geographic areas within a region to absorb building developments without upsetting the balance of the natural system. This approach takes into consideration the interaction between various building and land-use types with a broad range of natural environmental characteristics.

Decision-aiding communications in the regulatory agency: The partisan uses of technical information, F. T. Ventre, *SP473*, pp. 203-223 (June 1977).

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

This paper, based on a nationally representative survey of 1,200 municipal building departments, describes the partisan uses of information in a regulatory setting. Each of the 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 regulation. 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, equaling sometimes surpassing the positive influence of the model code groups.

Oregon's experience in statewide code uniformity—Third year, W. M. Friday, *SP473*, pp. 225-240 (June 1977).

Key words: building regulation; code administration; enforcement; funding; local government; model codes; state-local relations; statewide codes; uniformity.

This paper has its genesis in an article written in mid-1974 and appearing in the *Building Standards* magazine of November-December, 1975. The information has been updated with the latest Oregon experiences. Prior to 1971, Oregon had four independent agencies enforcing building regulations, with all of the related problems of code conflicts, duplication and nonuniformity of interpretation. In 1971, all of these functions were transferred to the Department of Commerce. New responsibilities were added in 1973, including a law setting statewide code uniformity, state-local government relations, personnel training and certification, adoption of model codes, appeals, statistical reporting, and energy conservation. Model codes have been adopted for all specialty codes. Some of the model codes are almost "pure"; others have significant amendments. A struggle is now under way between advocates of pure model codes and those who have amended it, over the number and quality of amendments.

Regulation and communication in the implementation of a building code for accessibility to the physically handicapped, T. J. R. Raper, *SP473*, pp. 241-251 (June 1977).

Key words: accessibility standards; building code; code administration; communication; enabling legislation; physically handicapped; regulation.

The State of North Carolina pioneered enabling legislation and development of building code requirements for accessibility to the physically handicapped. The "Handicapped Section" of the *North Carolina State Building Code* encompasses almost every occupancy classification in publicly- and privately-owned buildings. Requirements extend from small equipment items, such as water fountains, to spatial arrangements including site development, seating and laboratory space. Consequences of implementing these laws, effective in 1973, were profound for code administrators, the building community and the public.

The approach to implementation is an "extension" approach to code administration, which is exemplary of regulatory reform for the public benefit. Access to public buildings is mandated by law (Public Law 90-480); annually more states and model codes are adopting standards for accessibiblity. As a possible model for others, this paper seeks to explain how the "Handicapped Section" of the *Code* was developed and enacted, how it is being publicized and enforced and how it is being maintained.

Catalogue of building safety instruments, R. S. Ferguson and C. C. Gordon, *SP473*, pp. 259-278 (June 1977).

Key words: building codes; building safety; control; instruments; knowledge; legislation; life safety; regulation; standards.

A building regulation is an instrument to achieve a goal—building safety. At any time and place the building ordinance, bylaw, or act is seen as "the" instrument and little thought is given to other instruments (existing or possible), attention is usually focused inwardly on the bylaw or code. The focus of this paper encompasses many instruments all of which have been or are being used. These instruments ranging from custom to research include law, authority, training, education, standards, guidelines, and administrative techniques. The characteristics of each instrument are discussed. This is an aid to their selective use. Building safety can be likened to a garden which flourishes with the use of many tools, or instruments, from hoes, picks, and rakes to watering cans and fertilizers but only when the right tool is chosen for a specific task at the right time and place. The paper is written in definitive form as a contribution for discussion and subsequenct inclusion in a proposed manual of building safety knowledge.

Performance vs producer-controlled codes, O. Richards, *SP473*, pp. 279-284 (June 1977).

Key words: building codes; concrete testing; evaluation; innovations; in-place testing; performance approach; regulatory domination; standards development.

This is intended to speed evaluation and implementation of innovations in standards and codes, which too often await change initiated by large producer corporations. Such producers tend to take such action only when no damage is done to a status quo that favors them and, further, when they stand to benefit from a change.

The writer, a would-be innovator in in-place field evaluation of concrete insulation and strength for twenty years, would leaven producer domination of codes with more vigorous participation of users. Products and methods should be evaluated not under artificial conditions, but under conditions of intended use. Examples include performance vs potential in thermal insulation and nondestructive in-place strength testing by the pullout method.

Logical analysis of building code provisions, J. R. Harris, *SP473*, pp. 285-316 (June 1977).

Key words: building codes; computer model; decision table; decision theory; networks; specifications; standards; system engineering.

The paper describes a systematic analysis of a set of related building code provisions. The analysis is a part of an overall methodology being developed for the systematic formulation and expression of clear, correct, and complete building regulatory documents. Provisions for the allowable size of buildings are represented with decision tables and networks. The analysis shows the complete hierarchy of decision making necessary to arrive at the final answer. Alternate schemes of arranging the information are developed, and the relation of the information content to the overall organization of the document is shown. The applicability of the analysis for various factions of the building regulatory system is evaluated.

The evolution of the performance approach in plumbing, R. S. Wyly, L. S. Galowin, and M. J. Orloski, *SP473*, pp. 317-348 (June 1977).

Key words: performance approach; performance characteristics; performance criteria; performance evaluation; performance testing; plumbing research; plumbing research needs; reduced-size venting.

The performance approach is reviewed as it relates to plumbing. The approach described provides for the systematic development of performance criteria, reproducible evaluation or test methods, and inspection guidelines, with significant benefits derived for innovators, contractors, code administrators, and the consumer through the utilization of new methods and materials for water supply and drainage in buildings. Performance specifications are seen as complementary or supplementary to the traditional prescriptive-type language of standards and code documents. They have the primary purpose of simplifying, systematizing, and hastening the process of acceptance of innovation. Traditionally, acceptance has occurred through a lengthy trial period during which satisfactory service history is accumulated with great difficulty and considerable expense to the proponents. The gradual movement to performance concepts in the requirements for sanitary drain-waste-vent systems is discussed. An example is described in which planned laboratory and subsequent field research with a performance orientation have provided a technological basis for acceptance of reduced-size venting. This economically attractive new method has only recently been considered by the prescriptive codes and is not yet fully accepted by them.

A theoretical basis and implementation for computer assisted architectural design evaluation, D. A. Bryant and R. B. Dains, *SP473*, pp. 349-368 (June 1977).

Key words: architectural criteria; automated system; building codes; buildings; computer applications; criteria maintenance design evaluation; design guides.

SEARCH: *S*ystematic *E*valuation *A*nd *R*eview of *C*riteria for *H*abitability (SEARCH) is an automated architectural criteria maintenance and design evaluation system. A prototype system is now in the Office of the Chief of Engineers (OCE). SEARCH is used in two phases of Corps of Engineers design work. First, performance type architectural design criteria and selected building code requirements are checked for consistency, documented as to information location, and stored for later use. Second, design layouts produced by Architect/Engineers (A/E) are put into SEARCH. The result is full, unbiased evaluation based on the previously checked and stored criteria. SEARCH is intended to be used by OCE personnel for both criteria maintenance and design evaluation type of work. An example of criteria maintenance would be in checking and storing criteria of the Design Guides now being developed. Design evaluation use will involve evaluating selected architectural designs submitted by Corps Districts as well as design layouts and relationship diagrams in the Design Guides.

The development of computer based systems for building codes, C. Masterson, *SP473*, pp. 369-375 (June 1977).

Key words: building regulation; computer-based systems; computer technology; information processing; performance evaluation; plan review; research and development.

The Purpose is to explain, in a brief fashion, the most important aspects of four years of research into computer-based systems for building regulation. The topics of automated plan review and performance evaluations through computer technology are covered. And, the basic strategies of a master plan for applications oriented development are outlined. The basic thrust of the argument is that computer-based systems can provide major assistance in moving the regulatory process towards a performance-oriented basis.

The use of computers and microfilm in the code enforcement program of the Chicago department of buildings, W. J. Burke and R. P. Moran, *SP473*, pp. 377-382 (June 1977).

Key words: building code; building permits; computers; enforcement; information retrieval; inspection; management control; microfilm.

The Chicago Department of Buildings uses three principal types of computer-supported systems. 1) Several systems use automated devices to issue documents to the public. Notices of violation are prepared on minicomputers using stored violation texts. "Certificates of Inspection" for buildings and elevators are prepared by computer. 2) Computers are used extensively for information retrieval. An on-line system allows access to selected information on specific buildings via CRT display and hard copy. Monthly reports summarizing building permit activity are generated from computer files. 3) Management control reporting is an important computer-based application. Permits, complaints, and follow-up inspection requests are aged by computer; and items open beyond a control age are listed on exception reports. A system to report on inspectional performance is currently in development. About eight years ago the Department was literally forced by the volume of its paper to convert its files to microfilm. We now have approximately 10 million documents on film and are expanding at a rate of approximately 1.5 million documents per year.

Improved communications between code officials and building design and construction groups through education, C. L. Charriere, *SP473*, pp. 383-389 (June 1977).

Key words: building construction groups; certification; code enforcement officials; communications; criteria; education programs; professional competence.

This paper stresses the necessity of developing educational programs in order to provide more effective communication between code enforcement officials and the various branches of the building construction field—architects, engineers and building contractors. The major premise is that code enforcement officials must be elevated to a professional status to communicate more effectively with the building construction groups. To accomplish this, educational background criteria and professional requirements must be established through educational and certification programs. These programs can be offered through two channels: continuing education courses and formal degree programs. The Pennsylvania State University's continuing education program is presented as a model of how educational programs can be offered effectively to upgrade the status of building code officials. Included is a review of Penn State's certificate programs wherein code officials, through evening courses and seminars, are provided the technical background needed to increase their professional competence. Also covered are examples of the development of special programs utilizing the information obtained through the above educational programs, specifically, the Energy Conservation Seminar which provides terminology and principles of heat gain and loss. The program includes a workshop session on the ASHRAE 90-75 requirements. This enables code enforcement officials to interpret and apply ASHRAE 90-75.

Regulation and the housing industry, A. Trellis, *SP473*, pp. 391-396 (June 1977).

Key words: builder-developer; construction; consumers; cost analysis; cost benefits; housing; regulation.

The National Association of Home Builders (NAHB) has become increasingly aware of the disproportionate increase in the cost of owning a new home, in relationship to the general increase in consumer prices. These increases are rapidly raising the cost of housing out of the reach of an ever increasing percentage of the population. What are the reasons for this inordinate increase in housing costs? NAHB has embarked on a major national study effort to answer this question. The study is intended to pinpoint the causes of this cost escalation, and in particular, determine the impact of increasing state, local, and Federal regulations on spiralling housing costs. It is a growing feeling among consumers and homebuilders alike, that a significant portion of the increased regulations associated with housing construction, do not provide benefits in relation to the overall costs incurred by the builder, which of course are ultimately passed on to the home buyer.

Economic impacts of building codes, J. S. McConnaughey, Jr., *SP473*, pp. 397-419 (June 1977).

Key words: accidents; benefit-cost analysis; building codes; building economics; building regulations; economic impact; electric shock; ground fault circuit interrupters; national electric code; safety regulations; standards.

This paper presents an impact evaluation approach for building officials faced with making building code decisions. Types of building code impacts are defined and categorized. A standardized method to measure and evaluate the potential benefit and cost impacts of a specific building code provision is described. The approach is intended to be a relatively simple, easy to apply system which uses available, or easily obtainable information. Benefit and cost impacts of code provisions intended to reduce the risk of death from a building hazard are examined. The paper concludes with case study of the 1975 National Electric Code requirement for the use of Ground Fault Circuit Interrupters (GFCI) in residences to illustrate the approach.

Building codes: Preservation and rehabilitation, R. J. Kapsch, *SP473*, pp. 437-452 (June 1977).

Key words: adaptive reuse; architecture; building codes; building regulations; building safety; construction; performance; preservation; rehabilitation; renovation.

There has been a large rise in interest in the last ten years in building reuse, rehabilitation and preservation projects. This trend is expected to continue in the foreseeable future. Such projects pose difficulties for the building regulatory system since many of these buildings were originally constructed prior to the existence of building codes. Most of these buildings do not meet modern levels of building regulation and application of building regulations to them poses difficulties as these regulations are essentially designed for new construction. The potential impact of these regulations includes the increase of project costs and damage to the fabric of the building intended to be preserved. Yet safety and health must be achieved in existing buildings as well as new. This paper summarizes studies and other activities that are presently being conducted by a number of organizations on this subject. One such study conducted by NBS has indicated that numerous State and local jurisdictions and model code organizations are adopting historic building waiver clauses and similar regulations as a partial answer to this problem. The National Trust for Historic Preservation sponsored the first national conference, in 1974, on this question and is currently cooperating with NBS in a study of the effectiveness of selected historic building waiver clauses. The National Endowment for the Arts has sponsored a grant that would identify tradeoffs that could be used in building regulations. NBS has also sponsored a study, reported in a separate paper in these Proceedings, on how a standard designed for existing buildings might be structured and formatted. NBS is also studying, for the Department of Housing and Urban Development, technological aspects of neighborhood conservation, including the role of building regulations. As of this writing, no final or definitive answer has been developed for the problem of achieving contemporary levels of safety and health in existing buildings.

Information structure of building codes and standards for the needs of existing buildings, B. Smith, *SP473*, pp. 453-489 (June 1977).

Key words: building codes and standards; building code structure; existing buildings; historic preservation; performance attributes; performance evaluation.

With the increased occurrence of rehabilitation and preservation projects, the problem of code compliance for these buildings is growing in magnitude. We are no longer dealing with isolated historic buildings, but with both entire historic districts and an ever increasing number of recycled, adaptively used buildings. The problem of code compliance for these projects frequently causes the destruction of the historic integrity of the building, the replacement of serviceable materials and, at the same time, increases project costs. The compliance problems may stem from the organization and format of the model codes which are based on new construction materials and techniques. This study examines the present organization and format of the three model codes, and develops a decision flow chart which analyzes how these model codes are used. The regulatory problems facing rehabilitation and preservation projects are then reviewed. From this investigation, a proposed decision process, based on the needs of rehabilitation and preservation projects is developed. Such a decision process could be used if and when building regulations are developed for the unique needs of these type projects.

Contractor understanding relative to rehab costs, R. S. Harrington, *SP473*, pp. 491-497 (June 1977).

Key words: building codes; community development; construction costs; contractors; housing; rehabilitation; standards.

The nature of rehabilitation, with its nonvisible elements and its potential for self-help, makes it extremely difficult to accurately estimate the costs involved. The uncertainty is passed on by the Contractor in the fees he charges. Uncertainty exists, as well, in the standards for accomplishing the work at hand. Specifications are normally cumbersome, Work Write-Ups lacking in detail. Therefore understanding is diminished, and costs rise, while quality falls below standards.

With the pending increase in neighborhood code rehabilitation projects, there is the need to increase the supply of competent contractors interested and experienced in rehab. This requires both a method for offering standardization of specifications and work-write-ups with more detail, and the ability to assure a steady flow of work into bidding channels.

SP476. **Opening the doors to better buildings,** S. A. Kliment, *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 476*, 32 pages (July 1977) SN003-003-01804.

Key words: building performance; building process; building systems; construction management; design/build; life-cycle costing; project procurement.

Several problem areas were identified in three workshops and one national symposium which was held to pinpoint choices open to the building community for improved building procurement practices. Some of the problem areas identified are: inconsistency in building codes and standards; inadequate bridges between design and construction; and the dissemination of post-construction information. Other problems which were addressed were: long-term economy; technical innovation; performance data; interdisciplinary training and education; and traditional attitudes in building practices.

SP477. **Wind and seismic effects.** Proceedings of the Eighth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, May 18-21, 1976, National Bureau of Standards, Gaithersburg, Md., H. S. Lew, Ed., *Nat. Bur. Stand.* (*U.S.*), *Spec. Publ. 477*, 626 pages (May 1977) SN003-003-01772-8.

Key words: accelerograph; bridges; buildings; codes; disaster; dynamic analysis; earthquakes; ground failures; nuclear facilities; seismicity; soils; standards; structural response; winds.

The Eighth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Gaithersburg, Maryland on May 18-21, 1976. The proceedings of the Joint Meeting include the program, the formal resolutions, and the technical papers. The subject matter covered in the papers includes wind effects on structures and design criteria; extreme winds for structural design; earthquake ground motions and instrumentation; seismicity and earthquake risk; seismic effects on structures and design criteria; lessons learned from recent natural disasters; design of nuclear reactor facilities. *These proceedings include the following papers (indented):*

Aspects of hurricane winds as recorded at an instrumented suspension bridge, R. H. Gade and R. H. Scanlan, *SP477*, pp. I-1—I-11 (May 1977).

Key words: wind; wind velocity spectra.

Velocity spectra of the winds of tropical storm Doria in its passage over the Newport, Rhode Island, Suspension Bridge is presented for four mean wind speeds. Data was acquired with five 3-component Gill propeller anemometers, spaced at approximately 350 feet (108 m) intervals along the semispan of the bridge. This paper presents final information on the wind mean angle of attack, turbulence levels, vertical and horizontal spectra of wind of various velocity levels, derived surface drag coefficients, and a comparison of results with standard spectra and other applicable data from the Japanese, United States, and Canadian wind literature.

Study on the wind effect on eaves, T. Murota, *SP477*, pp. I-12—I-20 (May 1977).

Key words: dynamics; failure; roofs; wind.

Recently in Japan damage to flat roofs of light weight roofing is increasing. The damage is often very severe to the extent that complete removal of the roofs occurs. The dynamic behavior of the eaves is related to the damage. A current research project is also described.

Measurements of wind loads and tie-down forces on mobile homes, R. D. Marshall and R. A. Crist, *SP477*, pp. I-21—I-33 (May 1977).

Key words: aerodynamics; buildings; full-scale testing; mobile homes; wind loads.

This paper describes instrumentation, experimental techniques and progress to date on a program of research into the effects of wind on mobile homes. Direct measurements of lift and drag forces on a nominal 12 × 60 ft. (3.66 × 18.3 m) mobile home provide more reliable information on load fluctuations than is possible with the usual approach of measuring surface pressure alone. Results of spectral analysis conducted on time histories of overturning forces suggest that a simple quasi-static approach, when used with appropriate gust factors, can be employed to calculate loads for the design of mobile home anchoring systems.

On the wind resistant design specifications for the proposed Honshu-Shikoku bridges (1975), T. Okubo and N. Narita, *SP477*, pp. I-34—I-48 (May 1977).

Key words: bridges; specifications; wind.

The newly revised specifications for the wind resistant design of the proposed Honshu-Shikoku Bridges are introduced in this paper. The previous specifications (the first edition was issued in 1964, and the second edition in 1972) have been revised by taking into account recent research activities, resulting in final edition as established in the fall of 1975.

The main subjects discussed in this paper are: 1. Scope of application; 2. Basic wind and design wind speed; 3. Drag coefficients; 4. Gust response; 5. Wind resistibility of structures under construction.

Equivalent static wind loads for tall building design, E. Simiu, *SP477*, pp. I-49—I-65 (May 1977).

Key words: design; equivalent loads; tall buildings; wind loads.

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

A wood house will resist wind forces, B. Bohannan, *SP477*, pp. I-66—I-69 (May 1977).

Key words: concentrated loads; design criteria; mode of failure; racking resistance; structural performance; uniform loads.

Experience tells us that wood-frame houses built by conventional construction practices will be long-lived structures. Why then should we be doing research on light-frame wood construction.

The answer seems simple. There are reasons to believe that the conventional wood frame systems are overbuilt in many respects. Initial evaluations have indicated that significant material savings are possible without sacrificing any of the structural integrity of wood-frame systems.

The actual structural performance of the conventional wood-frame house is not well understood. Little or no structural engineering goes into its design. While a lot of research effort has gone into defining pieces and parts of houses, much of this research has been aimed at very narrow objectives. Little attention was given to the house as a complete structural system. The interaction of components has not been evaluated.

It is assumed that the resistance to wind-caused racking or shear would be provided solely by the end-walls of a conventional wood-frame house. There are no known formulae for calculating the racking resistance of these walls. In fact, there is even some question as to how much of the total wind force actually reaches the end-walls.

Wind loads on low-rise buildings, N. J. Raufaste, Jr., *SP477*, pp. I-70—I-78 (May 1977).

Key words: codes and standards; disaster mitigation; housing; low-rise buildings; socio-economics; structural connections; wind loads.

The National Bureau of Standards is continuing its project to develop improved design criteria for low-rise buildings in developing countries to better withstand the effects of extreme winds. This paper is an overview of the results of the project, some of which have occurred since the Seventh meeting of the U.S.-Japan Panel on Wind and Seismic Effects, that is to say, the third year of this 3 ½ year project. To date, most data analyses have been completed and presented in several NBS published progress reports. The final report is expected to be published in the Fall of 1976.

Characteristics of the high wind at Hachijojima Island on the occasion of typhoon No. 7513, S. Soma, *SP477*, pp. II-1—II-14 (May 1977).

Key words: damage; effects; houses; typhoon; wind speeds.

A typhoon that attacked Hachijojima Island on October 5, 1975 brought to this island very strong winds which were beyond expectations. The value of the peak gust observed at the weather station, located at the central part of the Island, was 67.8 m/s. Moreover, in the premises of the lighthouse situated on the southeastern part of the Island, an incredible wind of 82.4 m/s was recorded. This wind was extraordinarily strong and was the third strongest recorded wind in our country. Due to this high wind, a great deal of damage was caused in various parts of the Island. Houses and buildings suffered the most from the high wind. The damage rate to houses which varied in different areas, had a high of 7.3 percent, which were completely destroyed, and 21 percent in which half of the houses were completely destroyed. Whether this strong wind was innate in the typhoon, or whether it was brought about due to the peculiar topographic features of the Island was the subject of this study. However, it was not possible to clarify these points quantitatively. Although, in certain areas, it was realized that topographic influences were apparent.

While making this survey on the typhoon's effect, it was noted that severe damage occurred to the windowpanes in tall buildings. An administrator of the building told us that these panes were broken by fragments of houses that were scattered in the high wind. This, therefore, indicates that a problem exists when tall buildings are surrounded by houses which have low wind-resistance in their vicinity. Therefore, the damage indicates that in town planning, not only a wind resistant design of individual buildings is required but also wind resistant planning of the entire environment is essential.

High winds in the United States, 1975, A. R. Hull, T. D. Potter, and N. B. Guttman, *SP477*, pp. II-15—II-29 (May 1977).

Key words: extra-tropical storms; hurricanes; thunderstroms; tornadoes; wind; wind damage.

During 1975, high winds in the United States were associated with tornado and thunderstorm activity, major extra-tropical storms and Hurricane Eloise.

Hurricane Eloise reached the coast of Florida with an observed minimum pressure of 95.5 kPa and sustained surface winds estimated at 202 km/h (56 m/s). Associated gale winds were reported from Cedar Key, Florida, to southeastern Louisiana and northward over most of Alabama, western Georgia, and extreme southeastern Tennessee. A unique set of hourly meteorological data and some oceanographic data was collected by two buoys during the approach and passage of the eye of Hurricane Eloise. These data, along with simultaneous ship, aircraft, and satellite data are being assembled and packaged for hurricane research studies.

During 1975, 918 tornadoes and numerous storms with high winds caused damage estimated in excess of 2 billion dollars.

A devastating January blizzard dumped up to 58 cm (.58 m) of snow in some areas of the North Central States and was accompanied by winds of up to 130 km/h (36 m/s). In contrast, a severe sandstorm struck southern California on June 17-18, bringing near zero visibility and windspeeds of 144 km/h (40 m/s). Damage to power lines, poles, and other facilities exceeded $100,000.

Mean speed profiles of hurricane winds, E. Simiu, V. C. Patel, and J. F. Nash, *SP477*, pp. II-30—II-40 (May 1977).

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

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

Planning and design of strong-motion instrument networks, R. B. Matthiesen, *SP477*, pp. III-1—III-15 (May 1977).

Key words: cost effectiveness; ground motion; network design; strong-motion record.

The types of research studies that utilize strong-motion data may be classified as: source mechanism studies, ground motion studies, soil failure studies, studies of the response of typical structures (including soil-structure interaction effects), and studies of the response of equipment.

In planning networks and arrays to make these studies, criteria must be established based on the tectonic setting, the seismicity or recurrence of strong ground motions, the reliability of operations in different regions, and a cost/benefit analysis of the data that may be obtained. A review of the strong-motion records that have been obtained during the past 40 years indicates significant variations in the recurrence of strong ground motions in the seismically active regions of the western United States. When combined with instrument costs, maintenance costs, and the reliability of operations, these recurrence relations can be interpreted in terms of the cost per record for different levels of motion. The benefits to be derived from each type of study in each region need to be established.

Current plans call for additional arrays to be installed in California, the Mississippi embayment, the Yellowstone Park region, and Alaska to study the spectral characteristics of strong ground motions in these regions. Special studies of local site effects and structural response are being planned in the more seismically active regions of California. Similar criteria and planning should be applied in the establishment of arrays of strong-motion instruments on a worldwide basis.

Observation of earthquake response of ground with horizontal and vertical seismometer arrays, S. Hayashi, H. Tsuchida, and E. Kurata, *SP477*, pp. III-16—III-25 (May 1977).

Key words: arrays; earthquakes; ground motion; records; results; seismometers.

A horizontal seismometer array, having six observation points along a straight line of 2500 meters in length, have been established at the Tokyo International Airport. Each observation point is equipped with two horizontal seismometers. Downhole seismometer arrays have also been established at two points, one at the end of the observation line and the other at a point 500 meters inside from the other end of the line. The observation started in April 1974 and since then 28 earthquakes have been recorded as of June 1975. Correlations among the ground motions at the points on the ground surface and the two points in the ground where the downhole seismometers have been installed, have been studied. The relative displacements between the points have also been studied.

It was assumed that there had been a straight pipeline made of steel along the observation line and the pipe motions had been equal to the observed ground motions. Then, the stresses in the pipe were estimated, and it was found that the stresses due to axial deformations were remarkably larger than those due to the bending deformations.

Building strong-motion earthquake instrumentation, C. Rojahn, *SP477*, pp. III-26—III-40 (May 1977).

Key words: buildings; instruments; strong motion.

Based on the recommendations of a special ad-hoc committee, twenty-one geographic areas will be instrumented under the building instrumentation phase of the California Strong-Motion Instrumentation Program, a statewide program established by law in 1971 and funded through an assessment of estimated construction costs collected statewide from building permits. The areas were selected on the

basis of population density, locations of buildings already instrumented, and the probability for potentially damaging earthquakes. Buildings to be instrumented will be of typical construction, simple in framing and design, and of various heights with the instrumentation of low-rise buildings emphasized. Remote recording instrumentation, consisting of single or multiaxial accelerometers connected via data cable to a central recorder, will be installed in each building. The accelerometers will be placed on the lowest level, at the roof level, and, in many cases, at one or more intermediate levels. The instrumentation will be situated so as to separately record both translational and torsional response.

On the basis of current projected revenues, and instrument procurement, installation and maintenance expenses, it is estimated that as many as 400 buildings may be instrumented under the State program.

Characteristics of underground seismic motions at four sites around Tokyo Bay, T. Iwasaki, S. Wakabayashi, and F. Tatsuoka, *SP477*, pp. III-41—III-56 (May 1977).

Key words: acceleration records; dynamic behavior; earthquakes; response spectra; soils.

This paper discusses the dynamic behavior of subsurface soil and rock layers on the basis of acceleration records triggered during actual small to moderate earthquakes. Borehole accelerometers are installed at four sites around the Bay of Tokyo. These were installed in 1970-74, in connection with the Tokyo Bay Loop Highway Project proposed by the Ministry of Construction.

Important acceleration records were obtained during sixteen moderate earthquakes (Magnitude-4.8-7.2) which occurred near the area in September 1970 through February 1975. From distributions of maximum accelerations at the four stations, it seems that the surface magnification factors (ratios of the surface acceleration to the base acceleration) are large (2.5 to 3.5) at the soft clayey soil site, small (about 1.5) at the rocky site, and medium (1.5 to 3) at sandy soil sites.

Response spectrum curves from typical acceleration records are shown. Comparison of the spectral curves from records obtained at three (or four) levels of one station during an earthquake suggests that frequency characteristics at the several depths are comparatively similar. Also it seems that frequency characteristics of earthquake ground motions are influenced by seismic conditions (such as magnitudes, epicentral distance, etc.) as well as soil conditions at the sites.

Relationship between earthquake damage of existing wooden houses and seismic intensities, E. Kuribayashi, T. Tazaku, and T. Hadate, *SP477*, pp. IV-1—IV-17 (May 1977).

Key words: classification; damage; intensity; seismic; wooden house.

This report discusses a quantitative relationship between a ratio of earthquake damage of existing wooden houses and seismic intensities.

The ratio of earthquake damage of the houses is useful not only for understanding house and building design criteria but for presuming the damage ratio of other structures such as bridges, roads, public utilities, etc.

Using statistics of disaster documents on short distant earthquakes; Fukui Earthquake (M = 7.3, 1948), Isuhanto-Oki Earthquake (M = 6.8, 1974) and Ebino Earthquake (M = 6.1, 1968) the relationship between the ratio of razed houses and epicentral distances or magnitudes of earthquakes was analyzed. The equivalent ratio of razed houses in earthquakes (D1) and the orignal ratio of razed houses (D2) are defined as; D_1 = (Number of Razed Houses + 0.5 × Number of Half Razed Houses/Total Number of Existing Houses) × 100 (%); D_2 = (Number of Razed Houses/Total Number of Existing Houses) × 100 (%).

Conclusively D_1 in the area of diluvium or tertiary (given as D_{1I}) and in the area of alluvium (given as D_{1II}) can be tentatively expressed as follows:

$$D_{1I} = K_I \times 10^{k}I$$

$$D_{1II} = K_{II} \times 10^{k}II$$

where K_I and K_{II} are respective constant values, K_I and K_{II} are functions of epicentral distances and earthquake magnitudes.

Moreover D_1 and D_2 correlate with each other and D_{2II} (in the area of alluvium) is greater than D_{21} (in the area of diluvium or tertiary).

A method for calculating nonlinear seismic response in two dimensions, W. B. Joyner, *SP477*, pp. IV-18—IV-46 (May 1977).

Key words: bedrock; modeling; rheological; seismic response; two-dimensions.

A method is presented for calculating the seismic response of two-dimensional configurations of soil testing on bedrock. The method, which is based on a rheological model suggested by Iwan, takes account of the nonlinear, hysteretic behavior of soil and offers considerable flexibility for incorporating laboratory data on soil behavior. An approximate treatment of the boundary conditions is employed which permits energy to be radiated into the underlying medium. Examples are shown to illustrate the method.

A new scale representing the "quake-sensitivity" at a certain region, T. Terashima and T. Santo, *SP477*, pp. IV-47—IV-54 (May 1977).

Key words: earthquake; index; quake-sensitivity; seismic index; seismicity.

The nature of ground motions due to earthquakes, depends on the property of the superficial materials of the ground, which vary in different areas. In this paper, the different characteristics of the ground motions is normalized by a new scale designated as "Quake-Sensitivity." This scale is defined as a ratio of N(I)/S, where N(I) is the annual mean frequency of seismic intensity of more than III (in J.M.A. scale) and S is seismicity index which has been defined previously by the authors.

A seismic zoning map was then made for Japan Islands relative to the "Quake-Sensitivity." The area having a large value of N(I)/S means that the area is sensitive to earthquake motions or the neighboring area has moderate earthquakes.

Damage to the civil engineering structures in Hachijojima Island by typhoon 7513, T. Okubo, N. Narita, and K. Yokoyama, *SP477*, pp. V-1—V-20 (May 1977).

Key words: damage; structures; typhoon; wind; wind effects.

Typhoon 7513 passed across Hachijojima Island on 16:40, October 5, 1975 and caused damage to property, houses and public service. The Public Works Research Institute performed a field investigation in Hachijojima Island. In this paper the record of strong wind and the state of damage are introduced. Typhoon 7513 is classified as a small but strong typhoon, and the maximum wind speed, averaged over ten minute intervals was 35.5 m/s, and the maximum instantaneous wind speed was 67.8 m/s.

The number of the wounded was 85, but fortunately no one was killed. A great deal of damage was done to houses, trees, poles and fences. The damage, with regard to public service was the destruction of a school and hospital building, and the interruption of electric power, telephone, and roads. The damage to large scale structures consisted of the destruction of a guyed tower 80 meters high, a panzer-mast, a bridge and four arc lamp standards.

Cyclone Tracy, R. D. Marshall, *SP477*, pp. V-21—V-53 (May 1977).

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

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

On the damage to buildings in Hachijojima caused by typhoon No. 7513, T. Murota, *SP477*, pp. V-54—V-59 (May 1977).

Key words: damage; typhoon; wind; wind effects.

On October 5, 1975 Typhoon No. 7513 hit Hachijojima Island, Tokyo and the maximum peak gust of 67.8 m/s was observed. The damage to this island was severe and widespread, damage to buildings, services, crops, trees, electric power lines and telephone lines occurred. The wind records and the rate of damage to buildings was one of the largest in Japan.

The Building Research Institute investigated the damage to the buildings in Hachijojima Island from 9 to 16, October. This paper describes results of the investigation.

Description of the typhoon and meteorological environment in the Island during the passage of the typhoon are referred in detail by Soma (1) and therefore are not referred to herein.

Seismic response of reinforced concrete highway bridges, J. Penzien, W. G. Godden, M. C. Chen, D. Williams, and K. Kawashima, *SP477*, pp. VI-1—VI-9 (May 1977).

Key words: bridges; design; experiments; nonlinear response; reinforced concrete.

Presented is a brief progress report of an investigation entitled "An Investigation of the Effectiveness of Existing Bridge Design Methodology in Providing Adequate Structural Resistance to Seismic Disturbances" which was initiated in 1971 within the Earthquake Engineering Research Center, University of California, Berkeley, under the sponsorship of the U.S. Department of Transportation, Federal Highway Administration.

An evaluation method for the earthquake resistant capacity of reinforced concrete and steel reinforced concrete columns, M. Ozaki and Y. Ishiyama, *SP477*, pp. VI-10—VI-27 (May 1977).

Key words: columns; concrete; earthquake; hysteretic envelope; reinforced; strength.

An evaluation method for the earthquake resistant capacity of reinforced concrete and steel reinforced concrete columns by utilizing the force deflection relationship of column specimens subjected to axial force and repeated and reversed lateral loading of considerable intensity is proposed.

An approximate response analysis for a nonlinear structural system was developed based on random vibration theory and was applied to models represented by a single-degree-of-freedom system subjected to a constant white noise acceleration. The mean expected maximum response values of the models with two different natural periods 0.1 and 0.5 sec. were calculated. Each model has a degrading stiffness system and various hysteretic envelope slopes after four different yield point levels. The viscous damping ratio is considered to be 5 percent of the critical damping for the entire processes of the models, and the hysteretic damping ratio after yielding is assumed to increase according to the increase of ductility factor. The ductility factors of the models calculated by the nonlinear response analysis are shown in tables and figures.

The maximum strength of the linear model having the equivalent earthquake resistant capacity of a column specimen can be assumed if the yield point, hysteretic envelope slope tangent, coefficient of hysteretic damping ratio and ductility factor of the specimen are measured by testing.

A facility was designed for testing large models of reinforced concrete and steel reinforced concrete columns under action simulating gravity load and ground motion in order to standardize the testing techniques and to forestall possible errors that may be induced by the use of different types of testing facilities.

An example of evaluation for the earthquake resistant capacity of a reinforced concrete column is presented by utilizing the force deflection relationship of the specimen obtained by the testing facility.

It is confirmed that yield point level, hysteretic envelope slope, hysteretic damping ratio and ductility factor are the most important components of earthquake resistant capacity.

The earthquake engineering program of the National Science Foundation, J. B. Scalzi, *SP477*, pp. VI-28—VI-36 (May 1977).

Key words: earthquake; program; research; seismic.

The general research program, supported by the National Science Foundation, is given in general terms. The required interaction between the social, economic and technology is described.

Large-scale testing programs related to wind and seismic effects currently underway in Japan, S. Inaba, *SP477*, pp. VI-37—VI-43 (May 1977).

Key words: earthquake; research programs; seismic; testing; wind.

This list has been prepared in order to discuss cooperative research problems in the area of large-scale testing of structures at the 8th Joint Meeting of U.S.-Japan Panel on Wind and Seismic Effects. The Japan Panel selected the following four members to work on the task committee on the large-scale testing program: Seiichi Inaba, National Research Center for Disaster Prevention; Makoto Watabe, Building Research Institute; Kenkichi Sawada, Public Works Research Institute; Nobuyuki Narita, Public Works Research Institute.

In accordance with the exchange of letters between Dr. C. Culver of the National Bureau of Standards of the U.S. Panel and Mr. S. Inaba of the Japan Panel, this list has been drafted to inform the U.S.-Japan Panel of work being conducted in this area. The list includes the large-scale testing programs currently underway in Japan, the organization, the name of individuals in charge, and a brief description of the objectives, status and time schedule.

Earthquake damages to earth structures, K. Sawada, *SP477*, pp. VI-44—VI-49 (May 1977).

Key words: construction; dams; earthquake; earth structures; roads; survey.

This paper will present the problems associated with the damage to earth structures during earthquakes, and how some of the problems have been solved. In addition this paper will present the principle of the design of earth structures, that to date have not been discussed.

Initially, data has been collected on the amount of damage to earth structures during earthquakes, how they have failed and relationships to such failures. These data are then used in formulating the mechanics of the failure.

Finally, the details of the repair work required, as listed by field engineers engaged in this repair work was examined.

Dynamic test of a circuit breaker for transformer substation, S. Inaba and S. Kinoshita, *SP477*, pp. VI-50—VI-60 (May 1977).

Key words: circuit breaker; data; experiment; shake table; testing; transformer.

During earthquakes, dependability of electric power supply systems, is required. However, earthquake damage to the electric power industry has resulted from the structural failure of porcelain insulators, which are commonly used for electric transmission equipment.

Dynamic tests of a circuit breaker of capacity 72/84 kilovolts used for a transformer substation were conducted using the large-scale shaking table of the National Research Center for Disaster Prevention in 1975. The test was performed under the sponsorship of Meidensha, a Japanese Manufacturer of electric power equipment. The purpose of the test was to determine the dynamic characteristics of the prototype structure shielded with the porcelain insulator. Sinusoidal waves of resonant frequency and earthquake simulated waves were applied to the test structure. It was found that the failure of the porcelain insulator governs the seismic resistibility of the circuit breaker and the maximum allowable acceleration at the top of the structure is 8.0 g.

Comprehensive seismic design provisions for buildings—A status report, C. G. Culver, *SP477*, pp. VI-61—VI-68 (May 1977).

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

A review of the first draft of recently developed U.S. seismic design provisions for building is presented. The draft includes regulatory provisions suitable for inclusion as part of a building code and technical criteria for earthquake resistant design. The provisions are intended for implementation by standards organizations, model code groups, Federal agencies and other regulatory groups. Technical criteria for structural design, architectural and mechanical-electrical design, and existing buildings are discussed.

Retrofitting of vulnerability in earthquake disaster mitigation problems, K. Ichihara, E. Kuribayashi, and T. Tazaki, *SP477*, pp. VI-69—VI-84 (May 1977).

Key words: costs; existing structures; optimization; retrofitting; seismic.

This paper discusses a criterion for retrofitting of existing structures vulnerable to disastrous earthquakes.

It would be ideal if all structural damage could be avoided during earthquakes, however, to completely strengthen structures is not practical because of the limitation of resources and land-space. On the basis of execution, it is necessary to classify the structures by functional importance and structural vulnerability. The first category of classification deals with the structure load. In the category dealing with the location, the densely inhabited and effectively utilized structure, should have preferential earthquake resistance, and this consideration is the basic philosophy of urban design including the countermeasure to earthquakes. The second category is classified according to the purpose of the structure. Life lines, such as traffic, transportation, water and energy transmission, and communication are indispensable during evacuation and rescue, so that these structures would be required to retain safety. This is especially true for roads, which are used not only for a path of evacuation but also for rescue space, fire fighting etc. immediately after earthquakes. However, it seems impossible that all existing roads can be modified to such a high standard of earthquake resistance because of the extreme cost involved. It is therefore more practical and rational to select the important routes which should be modified to meet specific earthquakes.

In this situation the following principles have been chosen in the retrofitting and the vulnerability for such a decision-making process.

If given certain model routes, retrofitting costs can be obtained for several methods, for example, perfect, medium and rough, for which the retrofitting cost should not be more than the cost of reconstruction. Next, suitable load-retrofitting relations and suitable load-safety relations are examined. Using these quantitative results a final decision can be made.

Dynamic response characteristics of a model arch dam, C. D. Norman, R. D. Crowson, and J. P. Balsara, *SP477*, pp. VI-85—VI-117 (May 1977).

Key words: arch dam; deflections; dynamic tests; model; structural analysis; velocities; vibrations.

The dynamic response characteristics of a model arch dam are given in detail. These characteristics were determined by subjecting the model to a vibratory loading. Resulting deformations and velocities are given.

The measurement of the dynamic k-value in site and its application to design, T. Kunihiro, K. Yahagi, and M. Okahara, *SP477*, pp. VI-118—VI-140 (May 1977).

Key words: bore hole; k property; property; soil; stiffness; testing.

The determination of the dynamic soil k property is determined by a series of bore hole tests. Results from these tests are discussed and the significance of these data are presented.

Laboratory investigation of undisturbed sampling and standard penetration tests on fine sands, M. F. Marcuson, S. S. Cooper, and M. A. Bieganousky, *SP477*, pp. VI-141—VI-157 (May 1977).

Key words: density; liquefaction; sand; soils; tests; undisturbed sampling.

Determination of density of sand is presented. Densities determined from using undisturbed samples and from the standard penetration tests are compared. It is shown that the standard penetration test is not sufficiently accurate to be recommended for final evaluation of the density at a site unless site specific correlations are developed.

Dynamic soil properties with emphasis on comparison of laboratory tests and field measurements, T. Iwasaki and F. Tatsuoka, *SP477*, pp. VI-158—VI-178 (May 1977).

Key words: dynamics; field tests; laboratory tests; relationships; soil properties.

In order to evaluate analytically the motion of the ground during earthquakes, it becomes necessary to obtain the dynamic deformation properties of the soil deposits, especially the strain amplitude-dependent shear moduli and the damping coefficients. At two sites, Iruma, Minami-Isucho and Ohgi-shima, Kawasaki-shi, insitu seismic surveys were performed. At the former site, a sand embankment was damaged during the Off-Izu-peninsula earthquake on

May 9, 1974 and at the latter is located reclaimed land where borehole accelerometers are installed. Furthermore, sand sampled from these sites was tested with the resonant-column apparatus of the Drnevich type in order to obtain the shear moduli and damping capacities at small strains. Laboratory test results showed that the two natural sands, which are well-graded and include fine particles, have smaller shear moduli than does uniform clean sands such as Toyoura-sand and Ottawa-sand.

A comparison of the shear moduli from shear wave velocities and those from resonant column tests was performed, giving excellent correlation for sands from both sites.

Design earthquakes, E. L. Krinitzsky and F. K. Chang, *SP477*, pp. VI-179—VI-191 (May 1977).

Key words: data; displacements; intensity; seismic records; velocity.

Relationships between earthquake intensity and epicentral distance are presented. Peak motion results, from 187 field records, are also given for examination. Also presented is data on displacements, velocities and intensities.

Relation between seismic coefficient and ground acceleration for gravity quaywall, S. Hayashi, S. Noda, and T. Uwabe, *SP477*, pp. VI-192—VI-198 (May 1977).

Key words: acceleration; accelerogram; gravity quaywall; rock motion; seismic coefficient.

The present design standard for port and harbor structures, utilizes seismic coefficients which were obtained from records of 129 gravity quaywalls in 49 ports damaged by 12 earthquakes. The maximum ground accelerations in the ports were estimated by calculating the ground response during the earthquake with reference to the attenuation curves of the base rock acceleration based on the accelerograms in port area.

The seismic coefficients in past earthquakes had upper values of 0.25, and this upper limit can be related between the coefficient and the maximum ground acceleration by the following equation:

$$e_A = 1/3(\alpha/g)^{1/3}$$

Where e_A: seismic coefficient; α: maximum ground acceleration (gal); g: acceleration of gravity (gal).

Investigation of earthquake resistance of structural (shear) wall buildings carried out at Portland Cement Association, M. Finkel, *SP477*, pp. VI-199—VI-219 (May 1977).

Key words: design procedures; earthquake excitation of structures; earthquake resistant structures; reinforcing details; structural walls.

In July of 1974, PCA started (with NSF-RANN sponsorship) a comprehensive analytical and experimental study to investigate the response to earthquake excitation of reinforced concrete structures containing structural (shear) walls. The aim of the study is to develop design procedures and reinforcing details for earthquake resistant multistory reinforced concrete structures containing structural walls.

A philosophy for structural integrity of large panel buildings, M. Fintel and D. M. Schultz, *SP477*, pp. VI-220—VI-251 (May 1977).

Key words: buildings; collapse; concrete; panels; structural integrity.

The paper reviews the various methods to reduce risk from abnormal loads. To limit the occurrence of progressive collapse in large panel residential structures, a philosophy for establishing General Structural Integrity is developed to assure bridging of local damage while maintaining overall stability, thus eliminating the need to design for any particular abnormal load. In this approach, tensile continuity and ductility of the elements, and their connections as well as of the overall structure, is stressed. The rationale for a minimum tie system consisting of transversal, longitudinal, vertical and peripheral ties to establish this General Structural Integrity is developed.

The objective of this approach is not to afford absolute safety in regard to any exceptional event in any part of every building; rather, the intention is to limit and substantially reduce the general risk of collapse, as compared to that existing if no such measures were taken.

Wind and seismic design of United States nuclear power plants, L. C. Shao, R. J. Stuart, and C. H. Hofmayer, *SP477*, pp. VII-1—VII-28 (May 1977).

Key words: nuclear power plant; seismic effects; tornado; wind.

All U.S. Nuclear Power Plants are currently designed to resist the effects of severe and extreme environmental loads in combination with operating and accident loads (tornado and accident loads are not combined). This affords two levels of resistance to wind and seismic loads i.e., the plant can remain operational during and following the operating basis earthquake or the design wind, and shall be able to safely shut down following the design basis tornado or safe shutdown earthquake. The design wind parameters are normally selected based upon a one hundred year recurrence interval. These parameters (wind velocity, velocity vertical profiles, and applicable gust factors) are transformed into applied pressures on exposed surfaces of safety related structures considering the effects of ground exposure, shape coefficients and pressure profiles at discontinuities. The design basis tornado is selected as the most severe tornado that can reasonably be predicted at a site based on the geographical distribution of the frequency of tornado occurence. The continental United States is divided into three tornado regions and for each region the following tornado characteristics are specified: the rotational wind speed, the translational wind speed, the pressure drop across the tornado, the rate of pressure drop and the radius of maximum rotational wind speed. The conversion of these parameters to design pressures must consider the orientation of the tornado relative to the structure as well as the other factors considered for the design wind. Various design tornado missiles and corresponding velocities are specified for each plant. Safety related structures are designed to resist both local damage (penetration and spalling) and overall structural response due to these missiles. The SSE (Safe Shotdown Earthquake) is chosen as the maximum earthquake expected to occur at the site and normally has a probability of occurrence of less than 10^{-5}. The OBE is chosen as the earthquake which could reasonably be expected to affect the plant during its operating life; however, its magnitude cannot be less than one half that of the SSE. Vertical and horizontal ground acceleration values and broad band ground response spectra are specified for each plant site. A detailed dynamic analysis is required for each plant, including the consideration of the effects of damping, soil-structure interaction, three components of earthquake motion, combination of modal responses, etc. These considerations are detailed in recently published U.S. Nuclear Regulatory Commission's Standard Review Plans 3.7.1 Seismic Input, 3.7.2 Seismic System Analysis, 3.7.3 Seismic Subsystem Analysis and 3.7.4 Seismic Instrumentation.

Outline of basic philosophy and practices of aseismatic design for nuclear facilities in Japan, M. Watabe and Y. Ohsaki, *SP477*, pp. VII-29—VII-35 (May 1977).

Key words: design guides; nuclear facilities.

In Japan, consistent standard specifications or guide lines for the aseismatic design of nuclear facilities has not officially been established. Only recently, in March 1975, has the Regulatory Guide of Design Earthquake Ground Motions for Nuclear Power Facilities been proposed. The proposed Regulatory Guide has already had an effect in a practical sense in spite of its interim nature. It is the purpose of this paper to briefly summarize the design philosophies and procedures of this aseismatic design currently being used in practice in Japan.

Tornado-borne missiles, J. F. Costello, *SP477*, pp. VII-36—VII-41 (May 1977).

Key words: dynamics; missiles; power plants; structural engineering; tornadoes; trajectories.

Nuclear power plants are designed to withstand the effects of severe environmental events, including tornadoes, without endangering public health and safety. Along with high wind velocities and drops in pressure, an effect which must be considered is the fact that objects of varying sizes are displaced by tornadoes. Predictions of what objects are likely to fly and at what velocities are difficult. Knowledge of the actual windfields present in a tornado is sketchy as is information about the aerodynamics of bluff bodies. This paper outlines methods which have been developed in order to make conservative estimates of the effects of tornado-generated missiles.

Structural damage to bridges resulting from the Guatemala earthquake, J. D. Cooper, *SP477*, pp. VIII-1—VIII-27 (May 1977).

Key words: bridges; earthquake damage; Guatemala earthquake.

The Guatemala earthquakes of February 4 and 6, 1976, caused severe economic hardships because of highway bridge failures and damage. The damage to three major bridges, Agua Caliente, LaAsuncion, and Incienso is described. A general discussion of damage to bridges and the roadway along a major highway, the Atlantic Highway, (Route CA9), is also presented.

SP489. **Abstracted reports and articles of the HUD Modular Integrated Utility Systems (MIUS) Program,** J. D. Ryan and B. Reznek, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 489*, 153 pages (Aug. 1977) SN003-003-01830-9.

Key words: abstracted reports and articles; HUD Modular Integrated Utility Systems (MIUS) Program; total energy; utility systems.

This document provides a complete listing of reports and articles relating to the HUD-MIUS Program. Reports from 1970 through August 1976 are included. The entry for each report contains an abstract and other pertinent information, including procurement sources and procedures. Reports are presented by 4 general subject categories; Program and Concept Description, Systems Analysis, Technology Evaluation, and Hardware Evaluation and Demonstration. The reports are further classified into 3 publication/availability categories: government publications (Published Reports), nongovernment publications and articles (Outside Publications) and unpublished reports and data (Open-File Reports).

SP490. **Observations on the behavior of buildings in the Romania earthquake of March 4, 1977,** G. Fattal, E. Simiu, and C. Culver, *Nat. Bur. Stand. (U.S.), Spec. Publ. 490*, 168 pages (Sept. 1977) SN003-003-01841-4.

Key words: buildings; building codes; earthquakes; natural disasters; structural engineering.

Observations are presented of the damage to buildings resulting from the earthquake of March 4, 1977 in Romania. The report was prepared by engineers from the National Bureau of Standards who participated as members of the U.S. government team dispatched to Romania under the auspices of the Office of Foreign Disaster Assistance, Agency for International Development. A summary of the team's activities is included. Background data on the seismic history of Romania, the characteristics of the earthquake and descriptions of damage to specific buildings are also included. The types of building construction and the history of the development of seismic design requirements for buildings in Romania are discussed. Recommendations are presented for needed building research based on the observations.

HANDBOOKS

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

H121. **Waste heat management guidebook,** K. G. Kreider and M. B. McNeil, Eds., *Nat. Bur. Stand. (U.S.), Handb. 121*, 174 pages (Feb. 1977) SN003-003-01669-1.

Key words: boilers; economics; energy conservation; instrumentation; recuperators; waste.

Sources of waste (i.e., discarded) heat in industrial processes are reviewed, and an overview of off-the-shelf technology available for its use is given. Discussions of waste heat measurement technology and economics are included, as are fourteen case studies of successful industrial waste-heat recovery installations.

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 76-1005. **A comparison of two testers in evaluating the slip-resistance of bathtub and shower base surfaces,** R. J. Brungraber and T. J. R. Raper, 59 pages (Oct. 1977). Order from NTIS as PB273120.

Key words: Kollsman tester; NBS-Brungraber tester; safety of bathrooms; slip-resistance of bathtub and shower base surfaces; slip-resistance testers.

The report describes a program of tests planned by ASTM Committee F15.03 on Safety Standards for Bathtub and Shower Structures, and conducted at the National Bureau of Standards for the purpose of comparing the NBS-Brungraber and the Kollsman tester with respect to their effectiveness in evaluating the slip-resistance of bathtub and shower base surfaces. This program represents a contribution by the National Bureau of Standards to the efforts of the American Society for Testing and Materials and the Consumer Product Safety Commission in developing safety standards for bathrooms and bathroom fixtures. Both testers employ the same material (drumheads of "slunk") to simulate human skin, and the report concludes that both testers will satisfactorily discriminate between different bathroom surfaces on the basis of slip-resistance. The conclusion may be made that the NBS-Brungraber tester is considerably more convenient to use.

NBSIR 76-1088. **Estimating the energy conservation potential of ventilation control through weather data analysis,** T. Kusuda and J. W. Bean, 51 pages (Aug. 1977). Order from NTIS as PB273949.

Key words: air conditioning requirements; energy conservation; intermittent ventilation; ventilation control; weather data analysis.

Hourly weather data for six selected cities in the United States covering eleven consecutive years were analyzed to aid in estimating the possible energy saving that could be achieved by closing the outdoor dampers during unoccupied hours. The analysis shows that, depending upon the local weather condition, and with some simplifying assumptions, from 74 to 83 percent of the energy used for heating the make-up air could potentially be saved by closing the outdoor dampers when the building is not occupied. Based upon a premise that the energy required for cooling the outdoor ventilation air is proportional to the average enthalpy difference between the outdoor air and the air leaving the cooling coil, from 53 to 63 percent of the energy for cooling of ventilation air could be saved by closing the outdoor dampers during unoccupied hours.

Hourly temperature and enthalpy values are presented in histogram form for occupied and unoccupied periods (office use), with the suggestion that similar data processing be carried out for other cities as well.

NBSIR 76-1103. **Some institutional factors affecting MIUS—A case study and annotated bibliography,** J. Elder, 65 pages (June 1977). Order from NTIS as PB268425.

Key words: institutional factors; Modular Integrated Utility System; total energy; utility system.

This report considers some of the institutional factors which might affect the development and implementation of an innovative utility project and in particular of a Modular Integrated Utility System (MIUS). A case study of the planning and implementation stages of a major utility project was undertaken along with several studies of less complex utility projects. An annotated bibliography exploring the literature on institutional response to existing or proposed utility projects and to innovation in general is included. The case studies and literature survey indicated a number of institutional factors along with a wide range of issues associated with these factors. Specifically, the institutional factors which are considered fall into the following areas: utility company response, local citizen group response, environmental group response, labor interest, builder/developer role, local planning agency and local, state and Federal agency involvement. Economic and legal/regulatory factors are not considered in any detail. In addition to the case studies and the annotated bibliography, the report contains a list of researchers currently working on related programs and a list of journals and other major references which are likely to include relevant material.

NBSIR 76-1177. **Comparison of computer-predicted and observed energy uses in a multi-family high-rise apartment building,** J. P. Barnett and S. T. Liu, 37 pages (June 1977). Order from NTIS as PB267829.

Key words: building energy analysis; computerized energy analysis; energy consumption; heating and cooling loads.

A comparison has been made of the results of two computer programs, the National Bureau of Standards Load Determination Program (NBSLD) and the American Gas Associations E-CUBE program, in predicting the energy consumption of a multi-family high-rise apartment building located in Omaha, Nebraska. Results are given on a monthly basis for the computed energy values and compared with average monthly values of metered data obtained over a five-year period. Close agreement was found between the energy consumption predicted by the two different computer programs, as well as between the predicted values and the metered data (less than 7% difference on an annual basis).

NBSIR 76-1178. **Air leakage and thermal performance of a MARK III relocatable Lewis building,** C. W. Phillips, B. A. Peavy, and M. E. Kuklewicz, 42 pages (Dec. 1976). Order from NTIS as PB264211.

Key words: air leakage of buildings; building heat transfer; honeycomb panel construction; relocatable buildings; windload racking.

This report presents the findings of air leakage and heat transfer tests of a Mark III relocatable building at the National Bureau of Standards, Building Environment Division, for the U.S. Department of the Navy. Quantitative and qualitative (smoke trace) air leakage tests with the building pressurized, and the heat transfer test, were performed with the building erected in an environmental laboratory. The quantitative air leakage tests were performed in two phases. One was with the building racked to simulate a wind load and the other was without racking. The building was of prefabricated honeycomb panel construction using aluminum skins. Included are photographs of the building and test equipment and tables and charts showing the magnitude of air leaks at the windows and doors. Racking had negligible effect on the air leakage rate.

NBSIR 76-1182. **The thermal performance of a two-bedroom mobile home,** G. J. Teitsma and B. A. Peavy, 104 pages (Jan. 1977). Order from NTIS as PB263883.

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

Tests were conducted on a mobile home located in an Environmental Climatic 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 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.

NBSIR 76-1184. **Performance of branch circuit electrical terminations of copper and aluminum non-metallic sheathed cable,** L. W. Masters, E. J. Clark, and E. J. Embree, 35 pages (Nov. 1976). Order from NTIS as PB267221.

Key words: aluminum wiring; branch circuits; copper wiring; military buildings.

A study was performed to provide the Tri-Services Committee on Building Materials with guidelines regarding the use of aluminum branch circuit wiring in military buildings. The first part of the study consisted of identifying military bases which contain buildings with aluminum wired branch circuits. Personnel at a number of the bases were contacted in order to estimate the extent of observed problems. Laboratory tests were performed on CO/ALR and non-CO/ALR duplex receptacles wired with both aluminum and copper nonmetallic sheathed cable. Overheating of aluminum wired termination points was observed with some receptacles in a current cycling test using non-CO/ALR receptacles at screw torque levels of 0.023 and 0.069 kg-m (2 and 6 lb-in). Aluminum wired non-CO/ALR receptacles tested at 0.138 kg-m (12 lb-in) screw torque showed no signs of overheating and copper wired non-CO/ALR receptacles showed no signs of overheating regardless of screw torque.

This report presents the findings of the study and includes guidelines regarding the use of aluminum branch circuit wiring in military buildings.

NBSIR 76-1193. **Earthquake related activities of the Center for Building Technology,** C. G. Culver, 24 pages (Mar. 1977). Order from NTIS as PB265103.

Key words: buildings; design; disaster mitigation; earthquakes; engineering.

This report describes activities related to earthquake engineering being carried out by the Center for Building Technology as part of the Center's overall Disaster Mitigation Program. Laboratory and field research, post disaster investigations and efforts to develop comprehensive earthquake resistant design provisions are included. The professional disciplines within the Center and the laboratory facilities are discussed. Recent accomplishments and mechanisms employed for facilitating implementation of the Center's research results are also discussed.

NBSIR 77-1196. **Wind tunnel studies of RP-US Bayanihan permanent school building,** R. D. Marshall, 28 pages (Dec. 1977). Order from NTIS as PB274647.

Key words: aerodynamics; boundary layers; buildings; turbulence; wind loads; wind tunnels.

Wind pressures measured on a 1:80 scale model of the RP-US Bayanihan Permanent School Building are compared with wind pressures used in the original design calculations. The wind tunnel studies were conducted in a tunnel fitted with spires and roughness elements to generate a thick, turbulent boundary layer. This boundary layer is believed to be a reasonable simulation of the lowest portion of the atmospheric surface layer developed over rolling countryside with scattered trees or over suburban areas. While the wind tunnel test results are in fair agreement with the overall design wind pressures, edges of the roof along the end walls can be subjected to pressures which substantially exceed the design values. It is recommended that the load capacity of certain roof elements be reexamined and that ridge ventilators be used in future construction to reduce the uplift loads on the roof structure.

NBSIR 77-1197. **How houses can better resist high wind,** S. Kliment, N. J. Raufaste, and R. D. Marshall, Coordinators, 12 pages (Feb. 1977). Order from NTIS as PB268081.

Key words: architecture; buildings; connectors; design criteria; fasteners; wind.

This guide presents to designers, builders, government and private building authorities, and building owners and occupants a series of effective methods for improving the resistance of new and existing buildings against high winds. The methods described may be applied to improving the construction of new buildings as well as to increase the wind resistance of existing buildings. This material offers guidelines for selecting the location and orientation of buildings and the building shapes, for suggesting methods of construction, for recommended building details, and for local production of connectors and fasteners. It covers two common types of construction—masonry and timber—as well as selected details based on local materials such as bamboo and adobe.

NBSIR 77-1207. **Performance of the engine-generators used in the Jersey City total energy plant,** J. B. Coble, M. E. Kuklewicz, and J. H. Hebrank, 22 pages (Mar. 1977). Order from NTIS as PB264427.

Key words: diesel engine performance; engine-generator efficiency; engine-generator performance; heat recovery; total energy systems.

Each of five 600-kilowatt (kW), diesel engine-generators which were to be installed in a total energy plant was performance tested under NBS direction at the engine-generator vendor's plant. These tests provided a basis for acceptance of the engine-generators and for comparison with installed performance.

This testing was performed as a part of a comprehensive study to assess engineering, economic, and environmental aspects of a total energy plant which supplies all electrical power, hot water, and chilled water to an apartment complex in Jersey City, New Jersey. Under sponsorship of the Department of Housing and Urban Development (HUD), the National Bureau of Standards (NBS) has instrumented the total energy site for engineering data and is collecting economic and environmental data.

The engines were tested at seven power levels ranging from 0 to 110 percent rated electrical load. In the tests, fuel consumption, electrical output, and jacket-water heat recovery were measured, as well as many other parameters. Results are reported for fuel consumption, electrical efficiency, and electrical-plus-thermal efficiency, and comparisons are made with measured data from the total energy plant.

NBSIR 77-1210. **Equipment maintenance for energy conservation,** J. Levy, 56 pages (Feb. 1977). Order from NTIS as PB264297.

Key words: dynamic programming; economic analysis; energy conservation; equipment maintenance; Markow 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 Markovian decision process. The report supplies a listing for a program in BASIC of the policy improvement algorithm for finding a best policy. The model will help maintenance engineers, building managers and/or others responsible for making decisions concerning maintenance policies in selecting economically efficient levels of maintenance for elements of building service equipment. The report also contains an illustrative example applying the model to the maintenance of an air handling unit.

NBSIR 77-1233. **U.S. team visit to France on health care facilities,** S. Kramer and R. Kapsch, 56 pages (Apr. 1977). Order from NTIS as PB265436.

Key words: architecture; building technology; construction; health facilities; hospitals; medical facilities; medical planning.

The U.S. Center for Building Technology (CBT), Institute for Applied Technology, National Bureau of Standards, and the French Centre Scientifique et Technique du Batiment (CSTB) regularly exchange special study teams for selected areas of building technology. This report is on the visit of the U S. team to France on health care facilities, held in April 1972. The U.S. team consisted of representatives from the Center for Building Technology; the Department of Defense; the Veterans Administration; and the Department of Health, Education and Welfare. The team visited health facilities in Paris, Meaux, Dijon, Beaune and Lyon. Innovative methods for the planning, design and construction of French health facilities were reviewed by the team participants. This report contains the findings and observations of the team. These findings and observations were originally recorded in a letter report which was exchanged with members of the U.S. team and the respective cooperating groups in France. However, it is felt that the documentation of the observations in the open literature is important for record purposes and will provide a source document for future discussions on the planning and design of medical and health care facilities.

NBSIR 77-1237. **Transpiration heat transfer in thermal energy storage devices,** B. A. Peavy and W. E. Dressler, 31 pages (May 1977). Order from NTIS as PB267281.

Key words: porous media; thermal energy storage; transpiration heat transfer.

The storage of thermal energy at a suitable temperature level from sources such as solar energy or waste heat processes can make that energy available for space heating at a later time period. This report is concerned with sensible heat transfer that takes place in a thermal storage device composed of a porous material with a fluid (water) transpiring through it. Experiments were performed on a prototype thermal storage device and the results were compared to numerical values computed from an analytical model. The comparison can be considered very good. Further experimentation is considered necessary to define test parameters such as steady initial condition, steady input water temperatures, piston and mixing-type flows, effects of heat losses, and conduction heat flow in the heat storage container.

NBSIR 77-1243. **Performance analysis of the Jersey City total energy site: Interim report,** J. Hebrank, C. W. Hurley, J. D. Ryan, W. Obright, and W. Rippey, 175 pages (July 1977). Order from NTIS as PB269517.

Key words: absorption chillers; boiler performance; central utility plant; diesel engine; engine-generator efficiency; heat recovery; performance; total energy systems.

Under the sponsorship of the Department of Housing and Urban Development (HUD), the National Bureau of Standards (NBS) has gathered engineering and economic data from an operating diesel total energy plant which supplies all electrical power, hot water, and chilled water to a 485-unit apartment/commercial building complex in Jersey City, New Jersey.

Engineering data has been continuously collected since April 1975 by a data acquisition system (DAS) which monitors approximately 200 sensors located in the plant and site buildings. In this report, data for a one-year period from November 1975 through October 1976 is presented. Electrical and thermal demands by the site and plant equipment efficiencies have been determined from this data and are reported. Reliability data is also reported.

Relative fuel savings by the total energy plant have been determined from the engineering data. Adjustments were performed to compensate for the malfunctioning absorption chillers. Calculations indicate that an alternative conventional central plant using purchased electrical power, oil-fired boilers, and absorption chillers would have required 17.3 percent more fuel than required by the JCTE plant as adjusted. These savings correspond to 160,000 gallons (606 m^3) of fuel oil annually. Minor design modifications are suggested in this report which would improve the JCTE plant performance an additional 5.7 percent. If the JCTE plant chillers were properly adjusted and the suggested minor modifications were performed, the above alternative conventional plant would have consumed 24.5 percent more fuel oil annually. Economic data describing the capital, operating, owning, and maintenance costs during the one-year period are also presented. Unit cost of electrical, heating and cooling energy commodities are determined and compared to conventionally-supplied energy unit costs.

NBSIR 77-1244. **Survey of uses of waste materials in construction in the United States,** J. R. Clifton, P. W. Brown, and G. Frohnsdorff, 63 pages (July 1977). Order from NTIS as PB270854.

Key words: coal by-products; construction materials; industrial wastes; mining wastes; municipal waste; slags; waste materials.

A survey has been made of the sources, amounts and methods of disposal of major mining, industrial and municipal wastes available in the 48 counterminous states of the United States. This includes the present and potential uses of these wastes as construction materials.

While over 3×10^9 tons of waste materials are generated annually in the United States, only small amounts are being used by the construction industry. The low level of use does not yet reflect the advances being made in converting wastes into viable construction materials. In several cases, construction materials produced from wastes have been at least the technological equivalent of materials produced from virgin resources. Factors which are impeding the increased utilization of wastes are discussed and emerging incentives which could facilitate their increased use are covered.

NBSIR 77-1246. **Evaluation of the egress provisions of the HUD mobile home construction and safety standard,** S. Adler, 78 pages (May 1977). Order from NTIS as PB268389.

Key words: emergency egress; HUD; mobile home; racking; research; safety; standard; window.

Evaluative tests were carried out to assess the adequacy and sufficiency of the HUD Mobile Home Construction and Safety Standards. Project activities included library research, laboratory testing and construction of a Mobile Home Emergency Egress Demonstration Unit. The study recommended: (1) establishment of performance goals to relate the desired objective (safe egress) to the specific requirements of the standard: (2) expansion of the scope of the requirements to assure that egress devices do not adversely affect the safety or security of the mobile home under normal living conditions; and (3) support of applied research to interrelate egress requirements, device characteristics, and human capabilities.

NBSIR 77-1250. **Analysis of housing data collected in a lead-based paint survey in Pittsburgh, Pennsylvania—Part I,** D. R. Shier and W. G. Hall, 100 pages (May 1977). Order from NTIS as PB268150.

Key words: children; data analysis; housing; lead paint; lead poisoning; surveys; x-ray fluorescence.

This report is a companion document to a previous report (NBSIR 76-1024) on blood lead levels of children tested during a lead-based paint survey in Pittsburgh, Pennsylvania. The emphasis in this report is on the methodology used and types of housing-related information collected by the survey. Through the use of portable x-ray fluorescence lead detectors, measurements were taken from a variety of surfaces within rooms of the dwelling unit as well as at locations exterior to the unit. Analyses of these x-ray fluorescence measurements established that older housing units exhibit considerably greater lead levels than newer housing units. In addition, wet rooms (kitchen and bathrooms) have higher levels than other (dry) rooms, rooms with a poor surface/substrate condition have higher levels than rooms with a good surface/substrate condition, and trim surfaces (e.g., doors, windows, baseboards) have higher levels than walls. Also, exterior surfaces show higher readings than functionally similar interior surfaces. While the present report concentrates on the housing aspect of the survey, subsequent processing of the Pittsburgh data is under way to determine possible relationships among blood lead levels, socioeconomic variables and housing-related characteristics.

NBSIR 77-1254. **Transportation, handling and field service loads for air mobility shelter systems,** C. W. C. Yancey, 74 pages (July 1977). Order from NTIS as PB269354.

Key words: acceleration; airplanes; cargo; dynamic loads; equivalent static force; gravity load; handling devices; handling loads; military field shelters; probability distributions; shocks, snow load; static load; trains; transportation; trucks; vibrations; wind load.

To fulfill one of the prerequisites for establishing design criteria for military field shelters, transportation, handling and field service load data are presented. An extensive literature search was conducted to determine the magnitude and frequencies of shock and vibration responses produced by railroad, road and air cargo vehicles and by devices commonly used in handling field shelters. Summary data, extracted from field study reports, are presented in the form of acceleration versus frequency diagrams. The acceleration values can be used to compute an Equivalent Static Force input for the design and analysis of shelter models. The probabilities of occurrence of the acceleration amplitudes generated by the three transportation modes are indicated in cases where data reduction included statistical analyses. Sources of the dynamic load data included flatbed trucks, propeller and jet airplanes, helicopters, railroad flatcars and forklift trucks. Where possible, the shock and vibration data used in presenting the summary diagrams were restricted to that obtained from tests involving military vehicles commonly used to transport shelters. Recommendations are presented for the selection of static design loads to account for gravity, snow, ice and wind effects.

NBSIR 77-1256. **Properties of 21 year old coal-tar pitch roofing membranes: A comparison with the NBS preliminary performance criteria,** R. G. Mathey and W. J. Rossiter, Jr., 26 pages (June 1977). Order from NTIS as PB267845.

Key words: bituminous roof membranes; built-up roof membranes; coal-tar pitch; performance criteria; physical and engineering properties; test methods.

The properties of coal-tar pitch roof membranes approximately 21 years old were compared to the properties reported for such membranes in NBS Building Science Series 55, "Preliminary Performance Criteria for Bituminous Membrane Roofing." Samples of the old membranes were taken from eight buildings having roof areas that range from 0.5 to 1.5 million square feet (4.6 to 15 km^2). The buildings were located at three sites in or near the state of Kentucky. The roof membranes on these buildings had been subjected to different maintenance procedures.

Laboratory tests conducted on 47 membrane samples included tensile strength, modulus of elongation and coefficient of expansion. The thermal shock factor was calculated for each sample. Laboratory observations were made of the membrane samples to determine between-ply bitumen thickness, weight per unit area, ply adhesion, pliability and condition of the membrane.

The tensile strengths of the membranes determined at 0 °F (−18 °C) in their longitudinal and transverse directions were comparable to values reported in NBS Building Science Series 55. Values of the coefficient of expansion measured over the temperature range of 0 to −30 °F (−18 to −34 °C) were also comparable to those reported in NBS Building Science Series 55. The modulus of elongation was considerably higher
old membrane samplds which rdsulted in lower values of thermal shock factor. The lower values of extensibility of the old membranes were attributed to their brittleness caused by aging. The type and frequency of roof maintenance procedures was considered to have had a definite effect on the properties of these old roof membranes.

NBSIR 77-1259. **Building energy conservation programs—A preliminary examination of regulatory activities at the State level,** P. W. Cooke and R. M. Eisenhard, 125 pages (June 1977). Order from NTIS as PB268873.

Key words: buildings; energy conservation; enforcement; legislation; regulations; solar energy; standards; state-of-the-art study.

Background information on the current regulatory status and degree of implementation of building energy conservation programs at the State level are described, including those programs dealing with solar energy. The objective of the study is to provide the Federal Energy Administration (FEA) with a data base of standards implementation experience. This data base can be drawn upon to promote utilization of building thermal efficiency standards on a uniform basis throughout the country. From information collected in a survey of twenty-one selected States, the survey report presents the current state-of-the-art on common problems experienced at the State level in the promulgation and implementation of building energy conservation regulations. Based on these findings, several types of assistance that could facilitate the orderly adoption and implementation of uniform standards are identified.

NBSIR 77-1261. **Laboratory tests of thermoplastic piping assemblies subjected to water hammer and intermittent hot water flow,** D. E. Rorrer, J. R. Shaver, and R. S. Wyly, 51 pages (Aug. 1977). Order from NTIS as PB270867.

Key words: intermittent hot water exposure tests of thermoplastic pipe; pressure shock in thermoplastic pipe; water hammer in thermoplastic pipe.

Evaluation procedures are described that were used at the National Bureau of Standards (NBS) for simulating the long-term effects of water hammer (shock pressure) and cyclic hot water flow (thermal cycling) on chlorinated polyvinyl (CPVC) thermoplastic pressure piping assemblies. Also included are the procedures used to study the effects of thermal cycling of two (2) polyvinyl chloride (PVC) thermoplastic drainage stack assemblies. The results obtained using these test procedures are presented and, in addition, related work of other investigators is briefly reviewed.

The shock pressure results show that a fatigue life curve can be established for CPVC as a function of temperature and pressure. As the temperature is decreased the number of shock pressure applications necessary to produce failure increases. An estimated use-life of at least 50 years was indicated at the maximum test temperature of 180 °F (82 °C) with pressures of 150 psi (1034 kPa).

With intermittent hot water flow all test assemblies were performing satisfactorily when the test was terminated after more than 1500 cycles had been completed.

NBSIR 77-1263. **Radiant heating in seamless flooring—A feasibility study,** P. G. Campbell, M. A. Post, M. Godette, and W. E. Roberts, 30 pages (July 1977). Order from NTIS as PB273946.

Key words: electrical heating elements; materials performance; radiant panel-seamless flooring system; seamless flooring; temperature characteristics.

The purpose of this study was to determine the feasibility of using radiant heating in seamless flooring as a supplemental heating source in housing units. The resistance of twenty seamless flooring systems to abrasion, flow, impact, flame, stain, moisture and elevated temperature were evaluated using laboratory tests. Power requirements and the magnitude and uniformity of surface temperatures of nine electrical heating elements, functioning as radiant heating panels, were experimentally determined and evaluated. The radiant heating panels were coated with selected seamless flooring systems and the performance characteristics of the radiant panel-seamless flooring system were evaluated. The report contains a summary of test results demonstrating the feasibility of the radiant panel-seamless flooring system and the identification of areas for future research.

NBSIR 77-1272. **Intermediate standards for solar domestic hot water systems/HUD initiative,** J. K. Holton, et al., 153 pages (July 1977). Order from NTIS as PB271758.

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

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

NBSIR 77-1274. **Retrofitting an existing wood frame residence for energy conservation—An experimental study,** D. M. Burch and C. M. Hunt, 159 pages (July 1977). Order from NTIS as PB269847.

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 these 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.

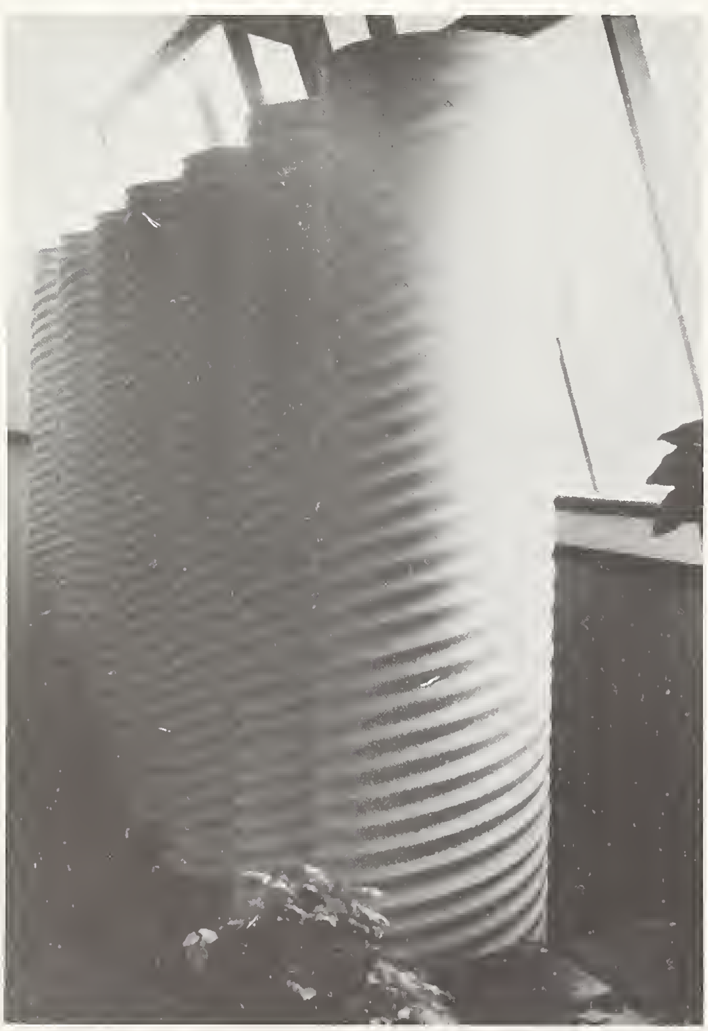
NBSIR 77-1297. **State solar energy legislation of 1976: A review of statutes relating to buildings,** R. M. Eisenhard, 255 pages (Sept. 1977). Order from NTIS as PB273899.

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

This report reviews State legislation on solar energy use in buildings enacted in 1976. Acts involve tax incentives for the installation of solar devices, support for the proposed Solar Energy Research Institute called for in Public Law 93-473, solar standards, State energy offices, studies, building requirements and solar projects. The Acts are identified and abstracted and responsible State officials listed. The Acts, as well as supporting forms and other information, are included in the appendixes.

NBSIR 77-1303. **A simplified procedure for calculating the direct components of contrast rendition factor and equivalent sphere illumination,** J. B. Murdoch, 75 pages (Nov. 1977). Order from NTIS as PB274331

Key words: body shadow; contrast rendition; hand calculator; illuminating engineering; light design; luminaire effectiveness; luminance factor; office lighting; sphere illumination.



A procedure is presented which enables the user to compute the direct components of contrast rendition factor (CRF) and equivalent sphere illumination (ESI) for an interior lighting design with the aid of a card-programmable hand calculator. The underlying theory and equations of CRF and ESI are discussed, including a consideration of body shadow, intensity distribution curve interpolations, bidirectional luminance factor approximating equations and Inverse Square approximations.

The procedure is designed so that the user is a participant in the computations as they progress and thus is able to modify a lighting design in "midstream" to improve CRF or ESI. A set of user instructions is included with the calculator programs.

NBSIR 77-1305. **Provisional flat plate solar collector testing procedures,** Solar Energy Program Team, Center for Building Technology, 56 pages (Sept. 1977). Order from NTIS as PB272500

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

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 ERDA and HUD respectively. These test methods and rating criteria do not, however, represent a consensus of industry and are therefore provisional in nature. 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 77-1307. **A review of computer software applicable to the MIUS Program,** W. L. Carroll and J. R. Schaefgen, Jr., 102 pages (Oct. 1977). Order from NTIS as PB273175.

Key words: computer programs; cooling; energy analysis; financial analysis; heating; load calculation; MIUS; modular integrated utility system; simulation; utility services.

Thirteen computer programs are examined for potential application to the Modular Integrated Utility System (MIUS) program. The software programs considered calculate all or partial combinations of: heating and cooling loads, simulation of physical systems to determine the energy requirements necessary to satisfy those loads, prediction of optimal operation schedules and associated costs, and accomplishment of full life-cycle economic analyses. A set of criteria for evaluation of this software is presented. Information regarding the programs, obtained from user manuals and a series of seminar presentations, is collected and systematically summarized in a standardized format using information available as of June 1974. An evaluation summary of each program as of that date is given. Program comparison activities are discussed and evaluated. Conclusions regarding applicability, validity, and utility of programs are reached. Recommendations are made concerning future software development and utilization.

NBSIR 77-1309. **Three proposed typical house designs for energy conservation research,** S. R. Hastings, 38 pages (Oct. 1977). Order from NTIS as PB274334

Key words: building envelope; energy conservation base; insulation; residential design practices; typical construction characteristics; typical new house materials; windows.

This report provides three house designs typifying the majority of new house construction in the U.S. Included are: scaled drawings detailing the construction of the houses, a breakdown of envelope components by surface area, a schedule of materials with supporting survey statistics from the National Association of Home Builders, a table of heat transfer properties of the specified materials, and recommendations for how these typical house designs can provide a basis for further work in the areas of fire research, durability, security, and environmental behavior in addition to energy conservation.

The background work for this report was completed in support of two other reports: "Geographic Variation in the Heating and Cooling Requirements of a Typical Single-Family House," and "Determination of Optimal Energy Conservation Designs in Single-Family Housing: Preliminary Results." This report is a wrap-up of the support to these two reports and provides a thorough documentation of the three designs to provide a basis for future work.

NBSIR 77-1313. **An assessment of the technical literature on emergency egress from buildings,** F. I. Stahl and J. Archea, 66 pages (Oct. 1977). Order from NTIS as PB273944.

Key words: architectural psychology; architectural research; building codes; building design; building fires; building regulatory standards; emergency egress; exit capacity; fire safety; human performance; occupational safety; regulatory data.

An assessment was made of the literature on research related to current emergency egress regulations promulgated by the Occupational Safety and Health Administration (OSHA). The purposes of this assessment were to ascertain the extent to which these regulations were based upon empirical research, and to determine the adequacy of available research findings from which OSHA emergency egress regulations may be developed. Three areas of research on emergency egress were identified: research on (1) the carrying capacity of exitways, (2) signage, lighting, and visibility through smoke, and (3) occupant responses to, and experiences in building fires. Only research on the carrying capacity of exitways appears to have had direct impact on current OSHA regulations, which are based largely on empirical findings reported in 1935. Much of the available data on egress signage, lighting, visibility through smoke, and occupants' responses in real fire situations have appeared since the adoption of standards by OSHA. Consequently, these areas have had minimal impact on OSHA egress regulations. This study provides specific recommendations concerning the technical adequacy and range of applicability of the available empirical literature on emergency egress from buildings. In addition, it provides specific recommendations concerning directions and methodological requirements for future research.

NBSIR 77-1316. **Performance criteria resource document for innovative construction,** T. K. Faison, 165 pages (Nov. 1977). Order from NTIS as PB274404.

Key words: acoustics; appliances; atmospheric; durability; electrical; environment; housing technology; HVAC; innovative construction; maintainability; materials; minimum property standards; performance criteria; performance evaluation; plumbing; safety; structures; test methods.

Performance criteria for innovative construction are presented in this resource report in order to assist in the broad technical acceptance of new building products and materials. The levels of performance stated are intended to be equivalent to the Minimum Property Standards (MPS) which reflects acceptable performance of conventional building materials and designs for programs sponsored by the Department of Housing and Urban Development. The report is structured so that new performance criteria can be added in the future as additional technical data and evaluation methods become available.

NBSIR 77-1390. **A preliminary examination of building regulations adopted by the states and major cities,** P. W. Cooke and R. M. Eisenhard, 124 pages (Nov. 1977). Order from NTIS as PB274335.

Key words: building construction; building regulations; cities; code uniformity; enforcement; legislation; rules and regulations; statewide codes; summary tables.

Preliminary information describing regulatory codes and standards bearing on building construction and occupancy which have been adopted by the various States and certain major cities in the U.S. are presented in a series of summary tables. The tables and accompanying notes provide information on salient elements of the enabling legislation, the type of codes and standards promulgated, and the respective agencies charged with the administration and enforcement of each regulatory program. Other features of the various regulatory programs (e.g., occupancy classifications covered, preemptive status of codes, etc.) are also enumerated. The regulatory programs and the respective code disciplines which are summarized include: building; mechanical; plumbing; electrical; fire and life safety; elevators; gas fittings; and boiler and pressure vessels.

GOVERNMENT CONTRACT REPORTS

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-77-87. **Government-supported residential rehabilitation,** M. C. McFarland, 55 pages (May 1977). Order from NTIS as PB268132.

Key words: building codes; housing; rehabilitation; remodeling; residential; urban renewal.

The NBS is developing new research to determine how best to remodel and rehabilitate existing buildings as a way of conserving the Nation's resources. As background information, this report discusses the three major programs in residential rehabilitation which HUD has conducted in the past. The programs, whose needs, history, examples, and outcomes are discussed, are (1) urban renewal rehabilitation, (2) concentrated code enforcement, and (3) project rehabilitation. The author, Carter McFarland was an economist at HUD when these programs were conceived and carried out, and was involved with them either directly or indirectly.

NBS-GCR-77-88. **Self-help housing construction: Effects of regulatory codes and standards,** D. B. Ward, 121 pages (May 1977). Order from NTIS as PB268131.

Key words: building codes; building regulation; do-it-yourself; home construction; housing; rehabilitation; remodeling; renewal; renovation; self-help; standards.

The NBS is pursuing new research into how best to construct buildings, including housing. This report discusses one type of housing construction—self-help, wherein the proposed occupant and owner builds his own dwelling either on his own, or collaboratively with a group of prospective homeowners. The self-help idea can also be applied to remodeling, rehabilitation, dwelling additions, or just minor repairs and improvements, for which it is also referred to as "do-it-yourself" labor. This report describes self-help, suggests how self-help projects can be supported, explores the feasibility of using component systems in self-help projects, and provides references and bibliographic materials.

NBS-GCR-77-91. **Guidebook on anthropomorphic test dummy usage,** D. H. Robbins, 84 pages (Mar. 1977). Order from NTIS as PB268904.

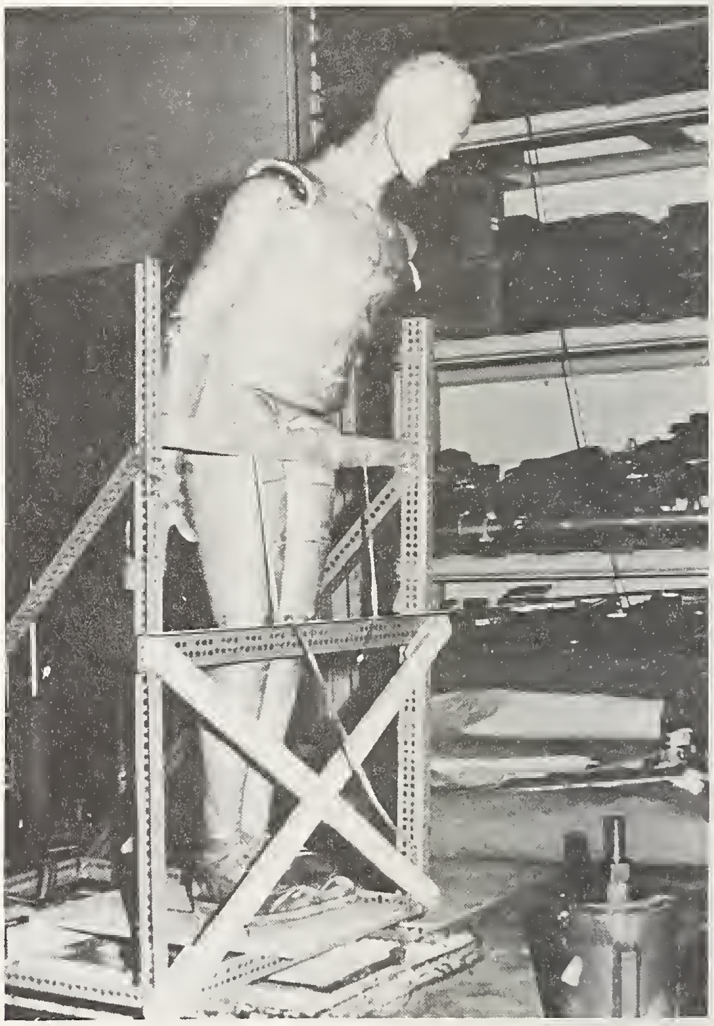
Key words: anthropomorphic dummies; building safety; dummies; guidebook; testing.

This report addresses the role which may be played by impact test dummies in developing countermeasures to cope with the high incidence of safety problems related to building structures. Possible roles are discussed in safety problem identification, countermeasure development, and in the preparation of standardized test procedures. The parameters of a test using a dummy are grouped according to: 1. representation of a human victim; 2. representation of the environment in which an injury may occur; 3. the interaction between the victim (dummy) and his environment; and 4. the injuries (transducer or other measurements in the case of the dummy) which occur. Dummies are classified according to sophistication ranging from anthropometric form to impact body blocks and finally to sophisticated anthropomorphic test devices used in automotive safety. Test procedures and data processing are discussed. A bibliography, coded by subject, is also included.

NBS-GCR-77-92. **Simulating human behavior in high-rise building fires: Modeling occupant movement through a fire-floor from initial alert to safe egress,** F. I. Stahl, 55 pages (Aug. 1977). Order from NTIS as PB273166.

Key words: building fires; fire behavior; high-rise buildings; occupant behavior in fires; simulated behavior.

The objective of the current study is to present an alternative means through which to model the building fire system, predict human responses in building fires, and test safety policies and building design alternatives. Focusing on the case of the high-rise office building, the investigation develops a methodology, and explores its implications for building design, planning and policy evaluation, and theory.



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.

16686. Dikkers, R. D., **Development and implementation of standards for solar heating and cooling applications,** *Proc. Joint Solar Energy Conf. on Sharing the Sun 76 Solar Technology in the Seventies, Winnipeg, Manitoba, Canada, Aug. 15-20, 1976,* **1,** 83-90 (Pergamon Press, Elmsford, NY, 1976).

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

Solar energy program activities being conducted by the National Bureau of Standards (NBS) are primarily centered around projects related to the development and implementation of standards and performance criteria for solar heating and cooling applications. In support of the Energy Research and Development Administration (ERDA) and the Department of Housing and Urban Development's (HUD) solar energy research and demonstration programs, NBS has prepared interim performance criteria for residential solar energy systems, and test procedures for determining the thermal performance of solar collectors and thermal storage devices. Currently, NBS is developing: (1) interim performance criteria for commercial solar energy systems; (2) intermediate standards for solar heating and domestic hot water systems that can be used in conjunction with HUD's Minimum Property Standards; (3) draft standards for materials (i.e., sealants, cover plates, insulation) to be used in solar systems; (4) plans for establishing a solar collector testing laboratory accreditation program; and (5) plans for identifying and developing other needed standards in cooperation with various standards-writing organizations such as ASTM and ASHRAE.

16705. Fenves, S. J., Wright, R. N., **The representation and use of design specifications,** (Proc. Symp. on Structural and Geotechnical Mechanics, Urbana, IL, Oct. 2-3, 1975), Paper in *Structural and Geotechnical Mechanics*, W. J. Hall, Ed., pp. 278-304 (Prentice-Hall, Inc., Englewood Cliffs, NJ, 1977).

Key words: building codes; computer programming; decision tables; graph theory; performance specifications; standards.

Design specifications are presented as the primary communication and control tool for the design and construction industry. Requisite properties of completeness, uniqueness, and correctness are identified, and the role of performance and limit state concepts in specifying intent of the specifications are emphasized. Formal representational methods are presented at three levels: decision tables for specification provisions, an information network for related provisions, and argument trees for organizing and outlining. An idealized process for specification development is presented, and the use of the representation tools for checking specifications and providing strategies for textual expression is described and illustrated. Development of computer aids for specification processing in design and conformance checking is described.

16708. Culver, C. G., **Live-load survey results for office buildings,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST12, 2269-2284 (Dec. 1976).

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

Live load data obtained from a survey of twenty-three office buildings located in various regions throughout the United States are presented. The buildings ranged in height from two stories to forty-nine stories. Data for government and private office buildings are included. Statistical summaries of the data are presented and the effects of various factors such as building height, building age, geographic location, room use and room size are discussed. A mathematical model expressing the relationship between the live load in offices and the significant factors affecting the load magnitude is also presented. The data presented may be used to evaluate current requirements for design loads for buildings and also for research studies of load effects in buildings.

16712. Brown, P. W., Clifton, J. R., **Nondestructive techniques for evaluating metallic artifacts of historical interest,** *Bull. Assoc. Preserv. Technol.* **VIII,** No. 4, 2-21 (1976).

Key words: compositional analysis; instrumental methods; metallic artifacts; microstructural analysis; nondestructive evaluation techniques.

This paper describes a variety of nondestructive evaluation (NDE) techniques which can be used to characterize the compositions and methods of fabrication of metallic artifacts, to form a basis for approximating their ages and determining their sources. This paper was prepared with the objective of showing preservation technologists how NDE methods can be used in the course of their work. This paper was written in response to a request by Mr. L. H. Nelson, editor of the Bulletin of the Association for Preservation Technology. Because the paper is addressed to an audience not versed in this area, it has been reviewed by Mr. Nelson who approves of the format and the level of technical content.

16714. Stroik, J. S., **Physical security of door assemblies and components,** *NILECJ-STD-0306.00*, 33 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, May 1976).

Key words: burglary resistance; door assemblies; door components; doors; frames; hardware; hinges; locks; security standards.

Security standards for doors have been developed at the National Bureau of Standards to evaluate burglar-resistance of door assemblies and components. Criteria were established by analysis of available data on burglary methods, by duplication of the attacks, and finally by measurement of the duplicated attacks applicable to the standards' scope. The scope includes development of standards designed to resist only burglary attacks defined as "common" or "opportunity" attacks on residences and small businesses. Four classes were established, from class I which includes attributes for the lowest level of resistance, up to class IV with attributes for the highest level of resistance. Requirements are specified as performance criteria with test methods described in detail. Two classification methods were established, one for door assemblies, the other for door assembly components. Included in an appendix is a description of the test equipment used at the National Bureau of Standards.

16733. Holton, J. K., **Interfacing building design and solar energy research and standards,** *Proc. 1976 Joint Solar Energy Conf., on Sharing the Sun: Solar Technology in the Seventies, Winnipeg, Manitoba, Canada, Aug. 15-20, 1976*, **9**, 74-82 (Pergamon Press, Elmsford, NY, 1976).

Key words: communication of research and standards; National Bureau of Standards; solar energy standards; standards users.

An extensive program of solar energy research and standards development has been undertaken by the National Bureau of Standards in support of the national effort to expedite the introduction of solar usage. The communication between researchers and the building community, who will utilize the products of this research, is of critical importance for effective conduct of this program. This paper examines a number of the programs being conducted at NBS, identifies the intended user groups, and describes some of the paths of communication that are being used. It is hoped that a clearer understanding of the research/user linkage will lead to more effective communication between those working in the field.

16768. Brown, P. W., Berger, R. L., Clifton, J. R., Frohnsdorff, G., **Limitations to fly ash use in blended cements,** *Proc. 4th Int. Ash Utilization Symp., St. Louis, MO, Mar. 24-25, 1976*, pp. 518-529 (Energy Research & Development Administration, Morgantown, WV, 1976).

Key words: blended cements; fly ash; specifications.

The production and utilization of blended cements containing fly ash is less than one million tons a year in the U.S. This accounts for only about one percent of the cement produced. It has been demonstrated that utilization of fly ash with portland cement to make blended cement results in energy and raw materials savings almost directly proportional to the amount of ash used. In view of the benefits derived from ash utilization in this way the level of production of blended cement may be expected to increase. However, additional property data need to be developed to address uncertainties and misconceptions regarding the performance of blended cements. Facilitation of blended cement use requires the development of data to be used by voluntary consensus standards organizations as a basis for standard test procedures and specifications.

16770. Kusuda, T., **Energy calculations for energy conservation design of buildings,** *APEC J.*, pp. 18-22 (Automated Procedures for Engineering Consultants, Dayton, OH, Winter 1976-1977).

Key words: computerized energy analysis; energy conservation standards; new building design; retrofit design.

Since energy calculation is an essential element of energy conservation standards, an accurate and comprehensive yet "easy-to-use" computer program for such calculation is most desirable. This paper reviews the existing state of energy-analysis procedures and identifies the areas for needed improvement. The paper also points out that the computational procedures suitable for new building design could be simpler than those required to simulate the energy consumption performance of existing buildings.

Standardization of input and output is also considered a key factor for the "easy-to-use" issue for the implementation of computerized energy calculation for building energy conservation standards.

16843. Vaicaitis, R., Simiu, E., **Nonlinear pressure terms and alongwind response,** *J. Struct. Div. ASCE Tech. Notes* **103**, ST4, 903-906 (Apr. 1977).

Key words: aerodynamics; building (codes); pressure; spectra; structural engineering; tall buildings; turbulence; wind.

Current procedures for estimating alongwind response on structures are based upon the assumption that the fluctuations about the mean of the wind pressures are proportional to the fluctuations about the mean of the wind speeds. Preliminary time-domain calculations have been reported in Ref. 5 which suggest that the errors inherent in this assumption may, in certain cases, be significant. The extent to which this is the case is investigated herein for building heights and terrain roughness conditions covering the range of interest in structural design.

16856. Simiu, E., Ellingwood, B., **Code calibration of extreme wind return periods,** *J. Struct. Div. ASCE Tech. Notes* **103**, ST3, 725-729 (Mar. 1977).

Key words: codes; probability; statistics; structural design; wind.

Design wind speeds upon which the Uniform Building Code provisions are based represent the highest fastest mile wind speeds observed in a 39-year period at the recording stations. This study shows that the most likely value of the largest of n maximum yearly wind speeds is nearly equal to the wind speed corresponding to an n-year mean recurrence interval. UBC provisions can thus be directly compared to probabilistic provisions which are based on the return period concept.

16901. Hurley, C. W., Kreider, K. G., **Applications of thermography in industry,** *Proc. Third Biennial Infrared Information Exchange, St. Louis, MO, Aug. 24-26, 1976*, C. Warren, Ed., pp. 53-59 (AGA Corp., 550 County Ave., Secaucus, NJ, 1977).

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

The Bureau of Standards has been conducting a project to develop a method for assessing heat losses in industrial equipment. This project is part of the NBS industrial energy conservation program. The IR surveys have included industrial facilities such as tire, cement, copper, brick, and paper plants as well as foundries and forging plants. The infrared survey was used to detect heat losses which require maintenance and repair or improvement. Several examples are presented. In addition the IR thermographic mapping was used to analyze the total heat losses of industrial furnaces as part of the energy balance on the furnace. This quantitative heat loss study is discussed as an inprogress report.

16902. Grot, R. A., Harrje, D. T., Johnston, L. C., **Application of thermography for evaluating effectiveness of retrofit measures,** *Proc. Third Biennial Infrared Information Exchange, St. Louis, MO, Aug. 24-26, 1976*, C. Warren, Ed., pp. 103-117 (AGA Corp., 550 County Ave., Secaucus, NJ, 1977).

Key words: buildings; energy conservation; evaluation; inspection; retrofit; thermography.

Retrofit measures in single family dwellings are considered an important part of the overall U.S. energy conservation program. Thermography was used to evaluate the effectiveness of a number of different retrofit measures normally available to the resident-owner. In this study, a group of townhouses was selected which, it was suspected, could benefit by commonly available retrofit measures. These houses were thermographically inspected before and after various retrofit measures were performed. Thermography was found to be an effective tool for evaluating these retrofit measures which decreased the energy consumption by about 25 percent.

16922. Chi, J., **DEPAF—A computer model for design and performance analysis of furnaces,** *Proc. Conf. on AIChE-ASME Heat Transfer, Salt Lake City, UT, Aug. 15-17, 1977*, pp. 1-9 (American Society of Mechanical Engineers, New York, NY, 1977).

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

This report covers the development of a computer simulation program DEPAF (DEsign and Performance Analysis of Furnaces) for residential fossil-fuel-fired furnaces. DEPAF is based upon an analytical model which accounts for cyclic (on-and-off) operation of furnace burner and blower. Transmission of heat at on-cycle uses the theory of radiative and convective heat transfer; transmission of heat at off-cycle uses the theories of turbulent and free convective heat transfer. Confidence in DEPAF was established by the use of available experimental data on a gas-fired forced-warm-air furnace. While the theory of transient heat transfer in combustion is complex in nature, theoretical results based upon quasi-steady-state analysis are in excellent agreement with experiments. If the building heat loss is known, DEPAF can be used to calculate the annual performance and operating cost for residential heating systems with furnaces. Examples are given to illustrate applications of DEPAF to examine quantitatively the effect of design and operating variables on annual performance and operating costs of residential forced-warm-air furnaces. It was found that considerable savings in fuel and operating costs can often be achieved by performing certain modifications to existing furnaces.

16923. Benzinger, T. H., Mangum, B. W., Hill, J. E., **The design, construction and operation of a scanning radiometer for measurement of plane radiant temperature in buildings,** (Proc. ASHRAE Semi-annual Meeting, Seattle, WA, June 25-July 1, 1976), *ASHRAE Trans.* **82,** 260-278 (1976).

Key words: comfort; measurement; radiation.

In order to accurately determine the effect of low-temperature radiation on the thermal comfort of building occupants, a new scanning radiometer has been designed and constructed. The instrument has been constructed using commercially available semiconductor thermopiles which have been arranged in a chessboard fashion with alternate thermopiles being coated with either a highly absorptive or highly reflective surface. The instrument has been designed to measure the effective temperature in a hemisphere facing the sensor over the temperature range normally encountered in building occupied spaces. It can be used in a stationary position or to "scan" an occupied space to determine the degree of asymmetry of the radiation.

17006. Parken, W. H., Jr., Beausoliel, R. W., Kelly, G. E., **Factors affecting the performance of a residential air-to-air heat pump,** (Proc. Symp. on Seasonal Operating Performance of Central Forced Air Heating and Cooling Systems, ASHRAE Annual Meeting, Chicago, IL, Feb. 13-17, 1977), *ASHRAE Trans.* **83,** Pt. 1, 839-849 (1977).

Key words: air conditioning; comfort; heat pump; load-calculation; rating; residential; space heating; testing.

An experimental investigation was conducted to determine the performance of a 3-ton (1.055 E+04W) air-to-air heat pump. Coefficients of performance of the heat pump were determined in the laboratory under steady and cyclic conditions in both heating and cooling modes of operation for a range of

simulated outdoor conditions. The results indicate a significant reduction in performance for both heating and cooling modes under cyclic operation. Full-load heating performance results were found to be slightly higher than the manufacturer's published ratings for outdoor temperatures above 42 °F (5.5 °C). The results show a lower heating capacity and coefficient of performance than the manufacturer's published ratings for outdoor temperatures ranging from 42 °F (5.5 °C) to 17 °F (−8.3 °C), tending towards agreement at the lower temperatures. This discrepancy in results for outdoor temperatures below 42 °F (5.5 °C) is due to the effects of frosting and defrosting of the outdoor coil.

17010. Brown, P., Clifton, J. R., **Energy conservation through the use of waste materials in cement and concrete,** *Proc. Seminar on Energy and Resource Conservation in the Cement and Concrete Industry, Ottawa, Ontario, Canada, Nov. 8-9, 1976*, V. M. Malhotra, E. E. Berry, and T. A. Wheat, Eds., Paper 3.2, pp. 3.2.1-3.2.33 (Canada Centre for Mineral and Energy Technology, Ottawa, Canada, 1977).

Key words: cement manufacture; energy conservation; fly ashes; mineral waste utilization; slags.

The utilization of suitable mineral-waste products can reduce the energy requirement in cement manufacture. Wastes and byproducts, when used as the raw materials in cement production, can reduce the energy requirements associated with raw materials processing and pyro-processing. Intergrinding waste materials with cement clinker or blending them with finished cement also reduces the energy consumption in the manufacture of cement, in this instance by replacing a portion of the portland cement clinker. The relative energy savings achieved through waste utilization by these methods are discussed. Factors affecting the selection of waste materials, such as compositional suitability, availability and cost, are considered along with the effects of market-related factors and consensus standards.

17015. Yonemura, G. T., **Considerations and standards for visual inspection techniques,** (Proc. Symp. on Nondestructive Testing Standards, Gaithersburg, MD, May 19-21, 1976), *Am. Soc. Test. Mater. Spec. Tech. Publ. 624, Nondestructive Testing Standards—A Review*, H. Berger, Ed., pp. 220-230 (June 1977).

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

When we look at the capacity of the human visual system we see that man can adjust to a wide variety of operating conditions. But, unless we have detailed information of the conditions for which these processes are to be standardized and quantitative descriptions of the tasks to be performed, the advantages to be obtained by visual science applications cannot be utilized optimally. The modulation transfer function would be an image evaluation technique applicable to nondestructive testing (NDT). Standardized tests to assess day-to-day performance as well as initial capacities should be developed. These tests should be derived from visual capacities correlated with the tasks to be performed.

17036. Glass, R. A., Rubin, A. I., **Emergency communications in high-rise buildings,** Chapter 22 in *Human Response to Tall Buildings*, D. J. Conway, Ed., **CDS/34,** 293-301 (Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA, 1977).

Key words: communications; disaster communication; emergency communications; fire communications; high-rise communications; high-rise emergency; information transfer; occupant needs; sensory stimuli.

The safety of occupants of high rise buildings during fire emergencies is often determined by the adequacy of the communications available to them—indicating how to respond. Visual signals (warning lights and directional signs) and auditory alarms and verbal messages are generally employed to serve this function. The actual signals now used in buildings have been developed over the years in a piecemeal fashion with minimal systematic research input. The adequacy of these signals have come into question in recent years, especially as a result of the potential for a major disaster associated with high-rise building fires. The paper traces the problems associated with communications systems presently in use from the standpoint of the occupant.

17040. Milton, H. J., **Metrication: Take the tide at its flood,** *Concrete Constr.* **22,** No. 8, 429-431, 440-442 (Aug. 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 approach 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.

17060. Rossiter, W. J., Jr., Mathey, R. G., **Effect of insulation on the surface temperature of roof membranes,** *Roofing Spec.*, pp. 28-39 (May 1976).

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

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

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

17061. Rossiter, W. J., Jr., Mathey, R. G., **Effect of insulation on the surface temperature of roof membranes,** *Roofing/Siding/Insulation*, pp. 35-38, 136 (Apr. 1976).

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

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

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

17062. Burch, D., Ed., **Technical guidelines for energy conservation,** *AFCEC-TR-77-12*, 403 pages (Air Force Civil Engineering Center, Tyndall Air Force Base, FL, June 1977).

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 measures for tactical or mission-related equipment such as ground vehicles or fighter aircraft.

17107. Marshall, H. E., Ruegg, R. T., **Energy conservation through life-cycle costing,** *J. Archit. Ed.* **XXX,** No. 3, 42-51 (Feb. 1977).

Key words: building design; cost; energy conservation; energy standards; fenestration; life-cycle costing; retrofitting; solar.

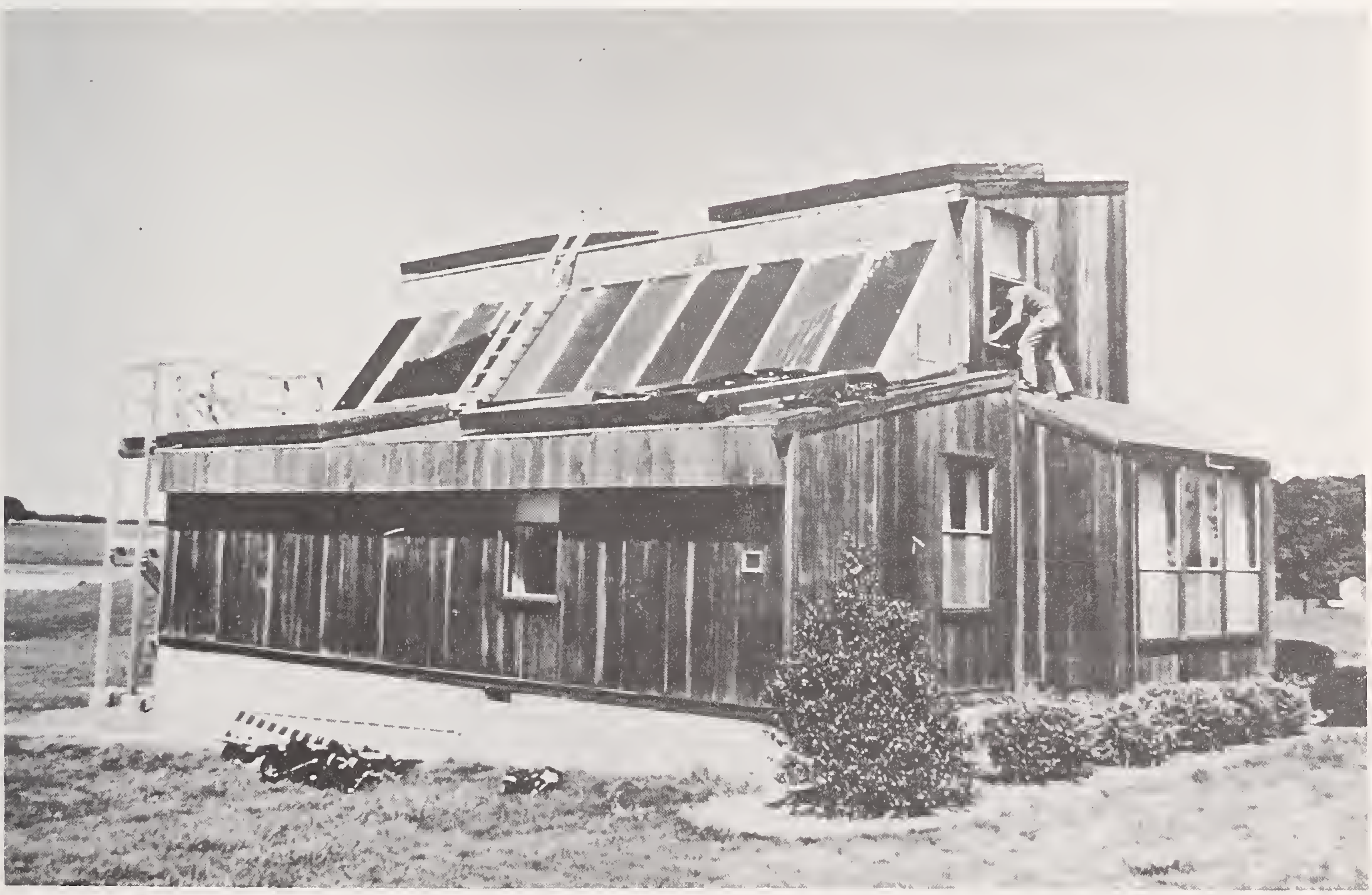
Architects, engineers, building operators and owners, and others who make decisions about the design and use of buildings need cost information about alternative energy conservation designs for old and new buildings. Specifically, they need to know the cost over time from introducing energy conserving techniques as compared to the cost savings over time from reduced energy bills. Life-cycle costing of energy conservation alternatives in buildings can be applied at the working level to reduce the owning and operating costs of buildings, to reduce energy consumption, and to encourage the optimal retrofit of old and design of new buildings with respect to rising fuel costs. This article provides practicing architects, architectural students, and others interested in the design process an overview of state-of-the-art methods for estimating the life-cycle cost (LCC) of alternative energy conservation techniques and a description of selected applications of LCC methods to energy conservation in buildings.

Retrofitting existing residential buildings for energy conservation is examined in LCC terms. The design of envelope features and subsystems for energy conservation in new buildings is explored in the context of LCC analysis. Finally, energy standards for buildings are examined in the LCC context to show why varying climates and fuel prices must be considered in developing economically efficient standards.

17110. Trechsel, H. R., **Research in energy conservation,** *J. Archit. Ed.* **XXX,** No. 3, 31-33 (Feb. 1977).

Key words: building; building environment; energy conservation; engineering; human factor; resource impact factors.

The paper discusses past and current energy conservation research dealing with engineering, human factor, and building use factors. The paper also indicates critical research needs and identifies a number of specific issues related to energy conservation, specifically the need to consider the effect of energy conservation on building environment and on human occupants, the need for multidisciplinary and interdisciplinary research, and the requirement for accounting for the scarcity of individual energy forms or resource impact factors.



17111. Gross, J. G., Pielert, J. H., **Building standards and codes for energy conservation,** *J. Archit. Ed.* **XXX,** No. 3, 54-56 (Feb. 1977).

Key words: buildings; codes; energy conservation; regulatory community; standards.

Over the last few years, public attention has been increasingly attracted to problems related to the shortage of energy. A major area where the conservation of energy would be possible is in the design and construction of new buildings and the retrofitting of existing buildings. Building standards and codes, traditionally written for health and safety, are viewed as a mechanism for accomplishing such conservation. The purpose of this paper is to review activities relative to this objective at the Federal level and within the various segments of the building regulatory community including State and local governments, model building code groups, standards developing organizations and building regulators.

17115. Marshall, R. D., **Full scale testing: Low rise,** *Proc. Workshop on Wind Load Requirements for Buildings, Northwestern Univ., Evanston, IL, June 3-4, 1976*, pp. 159-162 (1976).

Key words: ANSI 58; low-rise buildings; wind study.

This paper gives a brief description of the work being done by the Center for Building Technology in the area of wind forces on single family dwellings and the ANSI 58 code.

17284. Burch, D. M., Siu, C. I., Powell, F. J., **Comparison of the thermal performance of three insulating materials commonly used to retrofit exterior frame walls in existing residences,** (Proc. Annual Meeting of Com. B.1, IIF-IIR on Heat and Mass Transfer in Porous Structures, Washington, DC, Sept. 14-16, 1976), *Bul. Inst. Int. Froid* **2,** 151-162 (1976).

Key words: condensation in walls; insulating properties; thermal conductivity; thermal insulation.

This paper describes experimental measurements conducted at the National Bureau of Standards to compare the thermal performance of three different insulating materials commonly used to retrofit the exterior frame walls of existing residential buildings. The insulation materials selected for study were cellulosic fiber, fibrous glass wool, and urea-formaldehyde foam. The thermal conductivities of the three materials were measured using the guarded-hot-plate apparatus according to Standard Method of Test ASTM C 177-71. Heat-transmission and moisture measurements were performed on a full-scale test wall that was exposed to simulated winter conditions in the laboratory. Similar measurements were also conducted on wall sections of a test house insulated with the various materials. Other performance properties such as shrinkage and settling are also reported.

17286. Powell, F. J., Hahn, M. H., **Measurement of the frost point of air in sealed insulating glass,** (Proc. Annual Meeting of Com. B.1, IIF-IIR on Heat and Mass Transfer in Porous Structures, Washington, DC, Sept. 14-16, 1976), *Bul. Inst. Int. Froid* **2,** 131-138 (1976).

Key words: ASTM Test Standard for insulating glass; frost-point measuring apparatus; moisture condensation; seal durability and longevity; sealed insulating glass.

The background, objective and results of the Research Associate Program recently completed at the National Bureau of Standards (NBS) with the American Society for Testing and Materials (ASTM) is summarized. This program was concerned with the development of test methods and standards for use with factory-produced double-glazed insulating-glass window units. A permanently sealed air space between two or more panes of glass is desired to increase the resistance to the flow of heat through window glass and at the same time provide a unit that would not allow moisture condensation to form on the interior glass surfaces over the lifetime of the unit. In addition to interfering with vision, repeated moisture condensation in the form of liquid water or frost, with subsequent evaporation of the moisture, tends to leave a residue on these surfaces that are not accessible for cleaning. A new device for making non-destructive measurements (repeatable to within 0.5 °C (1 °F) of the dew/frost point of the air-space in these sealed units is described (U.S. Patent 3,896,658) and the ASTM Standards produced in conjunction with the program are described and referenced (ASTM designation E546-75, E576-76, E-6 P1, E-6 P2, and E-6 P3).

17289. Achenbach, P. R., Heldenbrand, J. L., **Development of performance-based energy conservation standards for buildings,** *Proc. Canadian Building Congress on Energy and Buildings, Toronto, Canada, Oct. 25-27, 1976*, pp. 1-31 (1976).

Key words: codes and standards; energy conserving buildings; energy legislation; energy performance criteria; energy performance standards.

The criteria for energy conservation in new buildings, developed by the National Bureau of Standards at the request of the National Conference of States on Building Codes and Standards in February 1974 (NBSIR 74-452), were based on performance requirements for the components of a building and its mechanical and electrical systems, because that approach appeared to be the practical limit in the application of the performance concept at that time. Using the NBS document as a framework, the American Society of Heating, Refrigeration, and Air-Conditioning Engineers has subsequently developed ASHRAE Standard 90-75. However, the design professions have expressed a preference for specification of design annual energy budgets for whole buildings, as a more direct means of achieving freedom for trade-offs and innovations. NBS is now assisting the Department of Housing and Urban Development and the Energy Research and Development Administration in developing such performance standards for energy conservation in buildings, as required by Title III of Public Law 94-385. The performance concept being recommended by NBS is based on overall energy use and life-cycle cost of a building, supplemented by performance requirements related to thermal comfort, visual environment, indoor air quality, durability and health and safety considerations.

17290. Heldenbrand, J. L., **Development and application of design performance standards for energy conservation in buildings,** *Ind. Forum.* **8,** No. 3, 9-20 (Aug. 1977).

Key words: building codes; energy conservation; energy efficiency; energy performance; model codes; standards.

One-third of the energy consumed in the United States is used to heat and cool buildings and to provide illumination, water heating, and other building services. About 40 percent of this energy can be saved through the effective application of existing technology, without reducing building performance. The first comprehensive and nationally applicable design standard for energy conservation in buildings, ASHRAE Standard 90-75, has recently been developed and applied, and it offers the opportunity for substantial energy savings. How this design standard was developed and applied provides an example of productive cooperation among many organizations. This example is of interest since such cooperation is essential if societal needs are to be met through the effective use of science and technology, and if remaining issues are to be resolved. Those involved included Federal and State governments and their agencies concerned with energy and building construction, societies of the major design professions, industrial and energy trade associations, and building researchers.

17293. Yonemura, G. T., Task lighting—Another view, *Lighting Design, Appl.*, pp. 27-30 (Nov. 1977).

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

The current North American lighting level recommendations are based on data derived from experiments in which the observers were required to detect the presence of a luminous disc. Experiments were conducted at real world levels, that is, the targets are seen 100 percent of the time but with differing levels of "goodness of seeing." I see better under condition A rather than B. Under these suprathreshold conditions the behavior of the eye is different from that obtained under threshold conditions. Experiments were conducted with gratings and alphabets as test objects. 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. The implementation of these findings as a reference base for recommending levels of illumination are discussed.

17296. Marshall, H. E., Ruegg, R. T., Wyly, R. S., **Cost savings from reduced-sized venting,** *Plumbing Eng. Part 1*, **5**, No. 4, 35-38, 42 (July-Aug. 1977); Part 2, **5**, No. 5, 45-46, 64, (Sept.-Oct. 1977).

Key words: cost savings; drainage-waste-vent; economics; life cycle; performance standards; pipe; plumbing; reduced-size vents; sanitary drainage system; venting.

Venting is required for all sanitary drain-waste-vent systems in buildings to maintain the traps of plumbing fixtures and thereby help prevent the entry of sewer gases into the building. Past research at NBS has shown that reduced-sized-venting (RSV), an innovative type of venting which utilizes dry vent pipes substantially smaller in size than those permitted by existing plumbing codes, meets the performance requirements imposed on conventional vent systems by the prescriptive requirements of codes for one and two-story houses. Builders, contractors, plumbers, and consumers of housing want to know the potential money savings from using RSV. Based on use of plastic pipe and depending on other assumptions made, estimates of potential savings per single-family household over the next 11 years are from $74 to $129, and for the nation as a whole, from $88 million to $244 million. Realization of these potential savings depends on how fast code authorities accept RSV in the plumbing codes and how fast builders and developers implement RSV technology once it is authorized in the codes.

17298. Hastings, S. R., **Performance evaluation of window strategies,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of the Performance of External Vertical Surfaces of Buildings, Otaniemi, Finland, Aug. 28-Sept. 2, 1977*, **II**, 113-122 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: daylighting; infiltration; insulation; passive-solar-heating; sun-shading; ventilation; windows.

Windows can be an important determinant of the energy comsumption of buildings. Properly designed windows can partially or wholly fulfill environmental requirements otherwise necessitating extensive purchased energy consumption by costly mechanical and illumination systems. The energy value of a window, considering the energy cost of replicating its contributions artificially, may even exceed the energy costs attributed to its limitations. To insure its value as a net asset, numerous design strategies are available to improve the conditions in which it performs. Adverse climatic forces can be mitigated through site design or use of exterior appendages. Interior accessories can compensate for the limitations of glass. Finally, building interior design can increase the utility of a window's contribution.

17299. Ruegg, R. T., **Life-cycle cost evaluation of the personal patrol car program,** *J. Police Sci. Admin.* **5**, No. 3, 290-298 (Sept. 1977).

Key words: breakeven analysis; life-cycle costing; patrol cars; personal car plan; police fleet administration; take-home car program.

This paper provides assistance to the police fleet administrator in selecting an economically efficient vehicle program. It presents a general method for evaluating and comparing the costs and benefits of a personal patrol car program (PCP) and a multi-shift, pool car program (MSP). It identifies and illustrates with realistic data the cash flows associated with each of the two vehicle programs, and compares the life-cycle costs of a PCP with a MSP under alternative assumptions.

17302. Weber, S. F., **Resource impact factors and the optimal energy conservation standard for buildings,** *Energy Bldgs.* **1**, No. 2, 1-13 (Oct. 1977).

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

The effects of using "Resource Impact Factors" (RIFs) in the determination of an optimal energy conservation performance standard for buildings are assessed. RIFs may be generally defined as indices constructed to reflect the full social costs of using various energy types. The major elements which RIF's should take into account are discussed as well as the appropriate method of formulating them. A cost minimization model for determining the optimal standard is used in conjunction with a range of RIF values so that a comparison can be made between a standard that is optimal from the private point of view (without RIFs) and one that is optimal from the social point of view (with RIFs). The comparison is made in terms of the amount of energy saved by each standard in climates of differing severity.

17303. Ellingwood, B., Shaver, J., **Reliability of RC beams subjected to fire,** *J. Structural Div., ASCE* **103**, ST5, 1047-1059 (May 1977).

Key words: fire endurance; fire tests; probability theory; reinforced concrete; reliability; statistical analysis; structural engineering.

Methods for analytically predicting the behavior of reinforced concrete beams subjected to fire are presented. These incorporate the temperature-dependent strength degradation in the steel as well as thermal and creep strains. The parameters most important for predicting beam behavior are identified through a sensitivity study, and the application of reliability analysis in developing fire-resistant design procedures is discussed.

17304. Ellingwood, B., **Statistical analysis of RC beam-column interaction,** *J. Structural Div., ASCE* **103,** ST7, 1377-1388 (July 1977).

Key words: probability; reinforced concrete; reliability; statistical analysis; structural engineering; uncertainty.

Analysis of uncertainties plays a central role in all reliability-based design procedures. Herein, the uncertainty in the resistance of reinforced concrete numbers subjected to combined bending and thrust is studied using Monte-Carlo techniques. The effects of load eccentricity, reinforcement ratio, and the contributions of individual uncertainties in the design parameters are examined. The results should aid in determining resistance factors for reinforced concrete design which are commensurate with the level of uncertainty using reliability-based concepts.

17305. Ellingwood, B., Culver, C., **Analysis of live loads in office buildings,** *J. Structural Div., ASCE* **103,** ST8, 1551-1560 (Aug. 1977).

Key words: buildings (codes); live loads; load surveys; probability theory; structural engineering.

An analysis of live loads in offices is presented, which applies probabilistic live load models to the results of a recent survey of U.S. office buildings conducted by the National Bureau of Standards. The results are compared to a study of live loads in offices in the United Kingdom and to the design loads currently specified by ANSI A58.1-1972. On the basis of this study, a new expression for computing allowable reductions in live loads at large loaded areas is proposed.

17306. Ellingwood, B., Harris, J. R., **Reliability-based performance criteria for structures,** *Proc. Second Annual Engineering Mechanics Division Specialty Conf., Raleigh, NC, May 23-25, 1977*, pp. 124-127 (American Society of Civil Engineers, New York, NY, 1977).

Key words: load factors; performance approach; performance criteria; reliability analysis; reliability-based design; resistance factors; structural engineering.

The performance concept systematizes the development of design criteria by first identifying specific performance attributes and then posing a series of criteria that would indicate an acceptable level of performance. In this study, performance criteria to assure adequate structural safety are presented. Reliability analysis techniques are used to develop load and resistance factors which assure that required levels of safety are attained. The load side of the design equation is developed so as to be applicable for a wide range of materials. This approach affords the designer an increased degree of flexibility, as similar levels of performance should be achieved regardless of which material is selected.

17335. Burch, D. M., Kusuda, T., **An infrared technique for measuring heat loss,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of Performance of External Vertical Surfaces of Buildings, Helsinki, Finland, Aug. 28-Sept. 2, 1977*, pp. 62-72 (Technical Research Centre of Finland, Helsinki, Finland, 1977).

Key words: heat-flow reference pad; heat loss; infrared television system.

This paper describes a newly developed technique for estimating heat-loss rate utilizing an infrared television system. A device called a heat-flow reference pad was developed that makes it possible to estimate quantitatively the heat-loss rate at the surface of a building without the need for a conventional heat-flow meter to be mounted on the surface. The infrared measurement technique predicted heat-loss rates in the laboratory and field within approximately 12 percent.

17340. Kusuda, T., Ellis, W., **Vapor condensation in air-pervious insulation,** (Proc. Annual Meeting of Com. B.1, IIF-IIR on Heat and Mass Transfer in Porous Structures, Washington, DC, Sept. 14-16, 1976), *Bul. Inst. Int. Froid* **2,** 139-150 (1976).

Key words: air, moisture and heat transfer theory; cold storage insulation; fibrous-glass insulation; vapor condensation.

Theoretical and experimental studies were conducted on moisture accumulation problems in air-pervious insulation subjected to a steep temperature gradient. The principal test wall studied was a wooden partition for a cold storage installation consisting of warm-side vapor barrier, six inches of fibrous glass insulation, and a one-inch fibrous-glass interior finish board. Experimental data indicated that moisture accumulation became serious only when the vapor barrier was punctured both at the top and bottom of the test wall, thus causing a convective air in-flow at the top and out-flow at the bottom. The data further showed that with this type of leakage, most of the moisture accumulation occurred only at the top region of the wall.

A small-scale apparatus was used to test the moisture accumulation and drying-out performance of tube-type specimens that represent a portion of an insulated exterior wall subjected to simultaneous flow of air, moisture, and heat. These test results show that a slight air pressure differential across the insulation has much stronger influence on the vapor condensation problem than the much higher water vapor pressure differential.

17341. Kusuda, T., **SATG: A useful concept for window heat gain analysis,** *Proc. RILEM/ASTM/CIB Symp. on Evaluation of Performance of External Vertical Surfaces of Buildings, Helsinki, Finland, Aug. 28-Sept. 2, 1977*, pp. 157-167 (Technical Research Centre of Finland, Helsinki, Finland 1977).

Key words: climatic data; cloud cover modifier; energy conservation; shading coefficient; solar heat gain; window design.

In an effort to evaluate the combined effect of solar heat gain and conduction heat transfer window through glass, a new concept called SATG (Sol-Air Temperature for Glass) is introduced. SATG is a combined index for outdoor temperature and the solar heat gain divided by the overall heat transfer coefficient. It represents a maximum possible temperature that space behind the window can attain, had there been no heat loss. Hourly SATG values for the single- and double-glaze windows of various orientations were determined by using ten years weather record of Washington, D.C. and were represented in the form of a frequency histogram. Also developed from these data are hourly solar-air degree hours as an index to evaluate the net heat transfer through windows.

17347. Hill, J. E., Kelly, G. E., Peavy, B. A., **A method of testing for rating thermal storage devices based on thermal performance,** *Solar Energy* **19,** 721-732 (1977).

Key words: standard test; thermal storage.

This paper describes a proposed test method for determining the "effective capacity" and heat loss characteristics of thermal storage devices. The prescribed series of tests should provide useful data for the rating of thermal storage devices based on thermal performance. The apparatuses and major components used in the tests have been prescribed so a liquid or air can be used as the transfer fluid. The series of tests to be conducted consist of one steady-state test to determine the heat loss characteristics and eight transient tests to determine the "effective capacity" for both heat storage and heat removal. During the transient tests, the entering fluid temperature is changed in a step-wise manner and amount of energy either stored or removed over a specified test time is determined. Sample experimental data are given in the paper to demonstrate the concept of the transient tests.

Author Index

Key word Index

A

Appliances; atmospheric; durability; electrical; environment; housing technology; HVAC; innovative construction; maintainability; materials; minimum property standards; performance criteria; performance evaluation; plumbing; safety; structures; test methods; acoustics; *NBSIR 77-1316*.

Arch dam; deflections; dynamic tests; model; structural analysis; velocities; vibrations; *SP477*, pp. VI-85—VI-117 (May 1977).

Arching; masonry walls; *BSS106*, pp. 283-313 (Sept. 1977).

Architectural; design; housing; low income; low-rise buildings; sites and services; socio-economic; structural design; wind-resistant; *BSS100-5*.

Architectural controls; buildings; design review; land use; municipalities; regulation; site design; *SP473*, pp. 137-187 (June 1977).

Architectural criteria; automated system; building codes; buildings; computer applications; criteria maintenance design evaluation; design guides; *SP473*, pp. 349-368 (June 1977).

Architectural psychology; architectural research; building codes; building design; building fires; building regulatory standards; emergency egress; exit capacity; fire safety; human performance; occupational safety; regulatory data; *NBSIR 77-1313*.

Architectural research; building codes; building design; building fires; building regulatory standards; emergency egress; exit capacity; fire safety; human performance; occupational safety; regulatory data; architectural psychology; *NBSIR 77-1313*.

Architecture; building codes; building regulations; building safety; construction; performance; preservation; rehabilitation; renovation; adaptive reuse; *SP473*, pp. 437-452 (June 1977).

Architecture; building technology; construction; health facilities; hospitals; medical facilities; medical planning; *NBSIR 77-1233*.

Architecture; buildings; connectors; design criteria; fasteners; wind; *NBSIR 77-1197*.

Architecture; buildings; design; energy; legislation; solar; standards; State; *NBSIR 77-1297*.

Arcing/sparking; branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections; *BSS103*.

Arrays; earthquakes; ground motion; records; results; seismometers; *SP477*, pp. III-16—III-25 (May 1977).

Aseismic design; dynamic tests; nuclear reactors; oil tanks; power plants; shake table; *SP470*, pp. VII-1—VII-6 (Apr. 1977).

Aseismic design criteria; design provisions; earthquakes; specifications; structural engineering; tunnels; *SP470*, pp. VIII-56—VIII-68 (Apr. 1977).

ASHRAE 90-75; building standards; buildings; energy conservation; minimum property standards; multiple glazing; "U" values; alternatives; *SP473*, pp. 85-101 (June 1977).

ASTM Test Standard for insulating glass; frost-point measuring apparatus; moisture condensation; seal durability and longevity; sealed insulating glass; *17286*.

Atmospheric; durability; electrical; environment; housing technology; HVAC; innovative construction; maintainability; materials; minimum property standards; performance criteria; performance evaluation; plumbing; safety; structures; test methods; acoustics; appliances; *NBSIR 77-1316*.

Automated system; building codes; buildings; computer applications; criteria maintenance design evaluation; design guides; architectural criteria; *SP473*, pp. 349-368 (June 1977).

B

Bedrock; modeling; rheological; seismic response; two-dimensions; *SP477*, pp. IV-18—IV-46 (May 1977).

Benefit-cost analysis; building codes; building economics; building regulations; economic impact; electric shock; ground fault circuit interrupters; national electric code; safety regulations; standards; accidents; *SP473*, pp. 397-419 (June 1977).

Bibliography; building technology publications; Center for Building Technology; key word-author indexes; publication abstracts; *SP457-1*.

Bituminous roof membranes; built-up roof membranes; coal-tar pitch; performance criteria; physical and engineering properties; test methods; *NBSIR 77-1256*.

Blended cements; fly ash; specifications; *16768*.

Body shadow; contrast rendition; hand calculator; illuminating engineering; light design; luminaire effectiveness; luminance factor; office lighting; sphere illumination; *NBSIR 77-1303*.

Boiler performance; central utility plant; diesel engine; engine-generator efficiency; heat recovery; performance; total energy systems; absorption chillers; *NBSIR 77-1243*.

Boilers; economics; energy conservation; instrumentation; recuperators; waste; *H121*.

Bond; damping; ductility; earthquake resistance; energy absorption; modulus of elasticity; partial reinforcing; risk; shear modulus; testing; ultimate strength; anchor bolts; *BSS106*, pp. 255-258 (Sept. 1977).

Bore hole; k property; property; soil; stiffness; testing; *SP477*, pp. VI-118—VI-140 (May 1977).

Boundary layer; hurricanes; loads (forces); natural analysis; tall buildings; wind profiles; *SP477*, pp. II-30—II-40 (May 1977).

Boundary layers; buildings; turbulence; wind loads; wind tunnels; aerodynamics; *NBSIR 77-1196*.

Branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections; arcing/sparking; *BSS103*.

Branch circuits; copper wiring; military buildings; aluminum wiring; *NBSIR 76-1184*.

Breakeven analysis; life-cycle costing; patrol cars; personal car plan; police fleet administration; take-home car program; *17299*.

Brick; clay masonry; concrete block; concrete masonry; failure modes; load capacity; masonry walls; shear walls; splitting strength; ultimate capacity; *BSS106*, pp. 177-197 (Sept. 1977).

Bricks; buildings; Canada; concrete blocks; design standards; earthquake resistant structures; masonry; *BSS106*, pp. 198-213 (Sept. 1977).

Bridge; cabled stayed; displacements; flutter; models; wind angles; wind tunnel; *SP470*, pp. II-47—II-67 (Apr. 1977).

Bridges; buildings; codes; disaster; dynamic analysis; earthquakes; ground failures; hydraulic structures; seismicity; soils; standards; structural response; vessels and wind; accelerograph; *SP470*.

Bridges; buildings; codes; disaster; dynamic analysis; earthquakes; ground failures; nuclear facilities; seismicity; soils; standards; structural response; winds, accelerograph; *SP477*.

Bridges; design; experiments; nonlinear response; reinforced concrete; *SP477*, pp. VI-1—VI-9 (May 1977).

Bridges; displacements; field tests; wind measurements; winds; wind speed; *SP470*, pp. II-20—II-46 (Apr. 1977).

Bridges; earthquake damage; Guatemala earthquake; *SP477*, pp. VIII-1—VIII-27 (May 1977).

C

Codes; design; dynamic analysis; masonry; shear walls; *BSS106*, pp. 91-113 (Sept. 1977).

Codes; disaster; dynamic analysis; earthquakes; ground failures; hydraulic structures; seismicity; soils; standards; structural response; vessels and wind; accelerograph; bridges; buildings; *SP470*.

Codes; disaster; dynamic analysis; earthquakes; ground failures; nuclear facilities; seismicity; soils; standards; structural response; winds; accelerograph; bridges; buildings; *SP477*.

Codes; energy conservation; regulatory community; standards; buildings; *17111*.

Codes; probability; statistics; structural design; wind; *16856*.

Codes and standards; connectors; fasteners; low-rise buildings; masonry walls' structural design; technology transfer; timber roofs; timber walls; wind effects; *BSS100-3*.

Codes and standards; disaster mitigation; housing; low-rise buildings; socio-economics; structural connections; technology transfer; wind loads; *BSS100-1*.

Codes and standards; disaster mitigation; housing; low-rise buildings; socio-economics; structural connections; wind loads; *SP477*, pp. I-70—I-78 (May 1977).

Codes and standards; energy conserving buildings; energy legislation; energy performance criteria; energy performance standards; *17289*.

Codes and standards; environmental studies; fire safety; health dangers; research needs; *SP473*, pp. 35-53 (June 1977).

Codes and standards; housing; hurricanes; pressure coefficients; probability distribution functions; risk; statistical analysis; storms; structural engineering; tropical storms; wind loads; wind speeds; building codes; buildings; *BSS100-2*.

Cold storage insulation; fibrous-glass insulation; vapor condensation; air, moisture and heat transfer theory; *17340*.

Collapse; concrete; concrete strength; construction; flexure; progressive collapse; shear; strength; apartment building; *BSS94*.

Collapse; concrete; panels; structural integrity; buildings; *SP477*, pp. VI-220—VI-251 (May 1977).

Color; color designations; calorimetry; color names; color-order systems; Munsell Color System; Universal Color Language; variable accuracy of color designations; centroid colors; *SP440*.

Color designations; calorimetry; color names; color-order systems; Munsell Color System; Universal Color Language; variable accuracy of color designations; centroid colors; color; *SP440*.

Color names; color-order systems; Munsell Color System; Universal Color Language; variable accuracy of color designations; centroid colors; color; color designations; calorimetry; *SP440*.

Color-order systems; Munsell Color System; Universal Color Language; variable accuracy of color designations; centroid colors; color; color designations; calorimetry; color names; *SP440*.

Columns; concrete; earthquake; hysteretic envelope; reinforced; strength; *SP477*, pp. VI-10—VI-27 (May 1977).

Comfort; heat pump; load-calculation; rating; residential; space heating; testing; air conditioning; *17006*.

Comfort; measurement; radiation; *16923*.

Communication; enabling legislation; physically handicapped; regulation; accessibility standards; building code; code administration; *SP473*, pp. 241-251 (June 1977).

Communication of research and standards; National Bureau of Standards; solar energy standards; standards users; *16733*.

Communications; criteria; education programs; professional competence; building construction groups; certification; code enforcement officials; *SP473*, pp. 383-389 (June 1977).

Communications; disaster communication; emergency communications; fire communications; high-rise communications; high-rise emergency; information transfer; occupant needs; sensory stimuli; *17036*.

Community development; construction costs; contractors; housing; rehabilitation; standards; building codes; *SP473*, pp. 491-497 (June 1977).

Compositional analysis; instrumental methods; metallic artifacts; microstructural analysis; nondestructive evaluation techniques; *16712*.

Compressive strength; deflection; design; flexural strength; masonry walls; racking strength; seismic loading; shear strength; shear wall; stiffness; analysis; *BSS62*.

Computer; energy; radiation; solar; *BSS96*.

Computer applications; criteria maintenance design evaluation; design guides; architectural criteria; automated system; building codes; buildings; *SP473*, pp. 349-368 (June 1977).

Computer model; decision table; decision theory; networks; specifications; standards; system engineering; building codes; *SP473*, pp. 285-316 (June 1977).

Computer programming; decision tables; graph theory; performance specifications; standards; building codes; *TN940*.

Computer programming; decision tables; graph theory; performance specifications; standards; building codes; *16705*.

Computer programs; cooling; energy analysis; financial analysis; heating; load calculation; MIUS; modular integrated utility system; simulation; utility services; *NBSIR 77-1307*.

Computer simulation; energy conservation; furnace; operating cost; seasonal performance; building heating system; *16922*.

Computer technology; information processing; performance evaluation; plan review; research and development; building regulation; computer-based systems; *SP473*, pp. 369-375 (June 1977).

Computer-based systems; computer technology; information processing; performance evaluation; plan review; research and development; building regulation; *SP473*, pp. 369-375 (June 1977).

Computerized energy analysis; energy consumption; heating and cooling loads; building energy analysis; *NBSIR 76-1177*.

Computerized energy analysis; energy conservation standards; new building design; retrofit design; *16770*.

Computerized thermal simulation; CO_2 concentration; energy conservation in schools; energy consumption; energy utilization in schools; oxygen content; reduced ventilation rate; school operation schedule; ventilation test; *BSS97*.

Computers; enforcement; information retrieval; inspection; management control; microfilm; building code; building permits; *SP473*, pp. 377-382 (June 1977).

Concentrated loads; design criteria; mode of failure; racking resistance; structural performance; uniform loads; *SP477*, pp. I-66—I-69 (May 1977).

Concrete; concrete strength; construction; flexure; progressive collapse; shear; strength; apartment building; collapse; *BSS94*.

Concrete; earthquake; hysteretic envelope; reinforced; strength; columns; *SP477*, pp. VI-10—VI-27 (May 1977).

Concrete; panels; structural integrity; buildings; collapse; *SP477*, pp. VI-220—VI-251 (May 1977).

Concrete block; concrete masonry; failure modes; load capacity; masonry walls; shear walls; splitting strength; ultimate capacity; brick; clay masonry; *BSS106*, pp. 177-197 (Sept. 1977).

Concrete blocks; design standards; earthquake resistant structures; masonry; bricks; buildings; Canada; *BSS106*, pp. 198-213 (Sept. 1977).

Concrete masonry; failure modes; load capacity; masonry walls; shear walls; splitting strength; ultimate capacity; brick; clay masonry; concrete block; *BSS106*, pp. 177-197 (Sept. 1977).

Concrete strength; construction; flexure; progressive collapse; shear; strength; apartment building; collapse; concrete; *BSS94*.

Concrete testing; evaluation; innovations; in-place testing; performance approach; regulatory domination; standards development; building codes; *SP473*, pp. 279-284 (June 1977).

Condensation in buildings; energy conservation; energy measurements; fuel savings; heat-loss reduction; insulation properties; residential heat loss; retrofitting houses; thermal conductivity; thermal insulation; thermography; air infiltration; *NBSIR 77-1274*.

Condensation in walls; insulating properties; thermal conductivity; thermal insulation; *17284*.

Connections; houses; masonry; piers; research; seismic; shear walls; spandrel beams; *BSS106*, pp. 60-90 (Sept. 1977).

Connectors; design criteria; fasteners; wind; architecture; buildings; *NBSIR 77-1197*.

Connectors; fasteners; low-rise buildings; masonry walls' structural design; technology transfer; timber roofs; timber walls; wind effects; codes and standards; *BSS100-3*.

Constraints; costs; incentives; regulation; alternatives; building codes; building process; *SP473*, pp. 17-33 (June 1977).

Construction; consumers; cost analysis; cost benefits; housing; regulation; builder-developer; *SP473*, pp. 391-396 (June 1977).

Construction; dams; earthquake; earth structures; roads; survey; *SP477*, pp. VI-44—VI-49 (May 1977).

Construction; dwellings; earthquakes; seismic design criteria; building codes; buildings; *SP470*, pp. VI-74—VI-88 (Apr. 1977).

Construction; flexure; progressive collapse; shear; strength; apartment building; collapse; concrete; concrete strength; *BSS94*.

Construction; health facilities; hospitals; medical facilities; medical planning; architecture; building technology; *NBSIR 77-1233*.

Construction; performance; preservation; rehabilitation; renovation; adaptive reuse; architecture; building codes; building regulations; building safety; *SP473*, pp. 437-452 (June 1977).

Construction costs; contractors; housing; rehabilitation; standards; building codes; community development; *SP473*, pp. 491-497 (June 1977).

Construction industry; dimensional coordination; metrication; metric system; modular coordination; SI; building codes and standards; *SP458*.

Construction industry metrication; metrication benefits; rationalization; technical issues in metrication; *17040*.

Construction management; design/build; life-cycle costing; project procurement; building performance; building process; building systems; *SP476*.

Construction materials; industrial wastes; mining wastes; municipal waste; slags; waste materials; coal by-products; *NBSIR 77-1244*.

Consumers; cost analysis; cost benefits; housing; regulation; builder-developer; construction; *SP473*, pp. 391-396 (June 1977).

Contact resistance; electrical connections; fire hazard; glowing electrical connections; arcing/sparking; branch circuit; *BSS103*.

Contractors; housing; rehabilitation; standards; building codes; community development; construction costs; *SP473*, pp. 491-497 (June 1977).

Contrast rendition; hand calculator; illuminating engineering; light design; luminaire effectiveness; luminance factor; office lighting; sphere illumination; body shadow; *NBSIR 77-1303*.

Control; instruments; knowledge; legislation; life safety; regulation; standards; building codes; building safety; *SP473*, pp. 259-278 (June 1977).

Cooling; energy analysis; financial analysis; heating; load calculation; MIUS; modular integrated utility system; simulation; utility services; computer programs; *NBSIR 77-1307*.

Cooling; heating; laboratory accreditation; performance criteria; solar energy; standards; buildings; *16686*.

Cooling; heating; performance criteria; solar collectors; solar energy; standards; buildings; *SP473*, pp. 103-112 (June 1977).

Cooling and heating coefficients of performance; effective seasonal heating COP; heat pumps; heat pumps and energy conservation; part-load performance; seasonal performance factor; *BSS93*.

Copper wiring; military buildings; aluminum wiring; branch circuits; *NBSIR 76-1184*.

Cost; energy conservation; energy standards; fenestration; life-cycle costing; retrofitting; solar; building design; *17107*.

Cost analysis; cost benefits; housing; regulation; builder-developer; construction; consumers; *SP473*, pp. 391-396 (June 1977).

Cost benefits; housing; regulation; builder-developer; construction; consumers; cost analysis; *SP473*, pp. 391-396 (June 1977).

Cost effectiveness; ground motion; network design; strong-motion record; *SP477*, pp. III-1—III-15 (May 1977).

Cost savings; drainage-waste-vent; economics; life cycle; performance standards; pipe; plumbing; reduced-size vents; sanitary drainage system; venting; *17296*.

Costs; existing structures; optimization; retrofitting; seismic; *SP477*, pp. VI-69—VI-84 (May 1977).

Costs; incentives; regulation; alternatives; building codes; building process; constraints; *SP473*, pp. 17-33 (June 1977).

Court orders; human behavior; institutional occupancies; interior design; physical environment; regulation; research; standards; *SP473*, pp. 55-67 (June 1977).

CO_2 concentration; energy conservation in schools; energy consumption; energy utilization in schools; oxygen content; reduced ventilation rate; school operation schedule; ventilation test; computerized thermal simulation; *BSS97*.

Criteria; education programs; professional competence; building construction groups; certification; code enforcement officials; communications; *SP473*, pp. 383-389 (June 1977).

Criteria; project summaries; standards; technical bases; building research; building technology; codes; *SP446-1*.

Criteria maintenance design evaluation; design guides; architectural criteria; automated system; building codes; buildings; computer applications; *SP473*, pp. 349-368 (June 1977).

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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 Library (1962).
Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
University:
University of Alabama, School of Law Library (1967).
University of Alabama Library (1860)–REGIONAL

ALASKA

Anchorage:
Anchorage Higher Education Consortium Library (1961).
Supreme Court of Alaska Library (1973).
College: University of Alaska, Elmer E. Rasmuson Library (1922).
Juneau: Alaska State Library (1964).
Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).
Flagstaff: Northern Arizona University Library (1937).
Phoenix:
Department of Library and Archives (unknown)–REGIONAL.
Phoenix Public Library (1917).
Prescott: Yavapai College Library (1976).
Tempe: Arizona State University, Matthews Library (1944).
Thatcher: Eastern Arizona Junior College Library (1963).
Tucson:
Tucson Public Library (1970).
University of Arizona Library (1907)–REGIONAL.
Yuma: Yuma City-County Library (1963).

ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).
Batesville: Arkansas College Library (1963).
Clarksville: College of the Ozarks Library (1925).
Conway: Hendrix College, O. C. Bailey Library (1903).
Fayetteville: University of Arkansas Library (1907).
Little Rock:
Arkansas Supreme Court Library (1962).
Little Rock Public Library (1953).
University of Arkansas at Little Rock Library (1973).
Magnolia: Southern Arkansas University, Mogale Library (1956).
Monticello: University of Arkansas at Monticello Library (1956).
Pine Bluff: University of Arkansas, Watson Memorial Library (1976).
Russellville: Arkansas Tech University, Tomlinson Library (1925).
Searcy: Harding College, Beaumont Memorial Library (1963).
State College: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcadia: Arcadia Public Library (1975).
Arcata: Humboldt State College Library (1963).
Bakersfield:
California State College, Bakersfield Library (1974).
Kern County Library System (1943).
Berkeley:
University of California, General Library (1907).
University of California, Law Library, Earl Warren Legal Center (1963).
Carson: Carson Regional Library (1973).
Chico: Chico State University Library (1962).
Claremont: Pomona College Documents Collection, Honnold Library (1913).
Compton: Compton Library (1972).
Culver City: Culver City Library (1966).
Davis:
University of California at Davis Library (1953).
University of California at Davis, School of Law Library (1972).
Dominguez Hills: California State College, Dominguez Hills, Educational Resources Center (1973).
Downey: Downey City Library (1963).
Fresno:
Fresno County Free Library (1920).
California State University Library (1962).
Fullerton: California State University at Fullerton Library (1963).
Garden Grove: Garden Grove Regional Library (1963).
Gardena: Gardena Public Library (1966).
Hayward: California State College at Hayward Library (1963).
Huntington Park: Huntington Park Library, San Antonio Region (1970).

Inglewood: Inglewood Public Library (1963).
Irvine: University of California at Irvine Library (1963).
La Jolla: University of California, San Diego, University Library (1963).
Lakewood: Angelo Iacoboni Public Library (1970).
Lancaster: Lancaster Regional Library (1967).
Long Beach:
California State College at Long Beach Library (1962).
Long Beach Public Library (1933).
Los Angeles:
California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
Los Angeles County Law Library (1963).
Los Angeles Public Library (1891).
Loyola University of Los Angeles Library (1933).
Occidental College, Mary Norton Clapp Library (1941).
Pepperdine University Library (1963).
Southwestern University, School of Law Library (1975).
University of California at Los Angeles Library (1932).
University of California at Los Angeles, Law Library (1958).
University of Southern California Library (1933).
Menlo Park: Department of the Interior, Geological Survey Library (1962).
Montebello: Montebello Library (1966).
Monterey: Naval Postgraduate School Library (1963).
Monterey Park: Bruggemeyer Memorial Library (1964).
Northridge: California State University at Northridge Library (1958).
Norwalk: Los Cerritos Regional Library (1973).
Oakland:
Mills College Library (1966).
Oakland Public Library (1923).
Ontario: Ontario City Library (1974).
Pasadena:
California Institute of Technology, Millikan Memorial Library (1933).
Pasadena Public Library (1963).
Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands, Armacost Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
Riverside Public Library (1947).
University of California at Riverside Library (1963).
Sacramento:
California State Library (1895) – REGIONAL.
Sacramento City-County Library (1880).
Sacramento County Law Library (1963).
Sacramento State College Library (1963).
San Bernardino: San Bernardino County Free Library (1964).
San Diego:
San Diego State University, Love Library (1962).
San Diego County Law Library (1973).
San Diego County Library (1966).
San Diego Public Library (1895).
University of San Diego Law Library (1967).
San Francisco:
Mechanics' Institute Library (1889).
San Francisco Public Library (1889).
San Francisco State College, Social Science and Business Library (1955).
Supreme Court of California Library (1972).
U.S. Court of Appeals for Ninth Circuit Library (1971).
University of San Francisco, Richard A. Gleeson Library (1963).
San Jose: San Jose State College Library (1962).
San Leandro: San Leandro Community Library Center (1961).
San Luis Obispo: California Polytechnic State University Library (1969).
San Rafael: Marin County Free Library (1975).
Santa Ana:
Orange County Law Library (1975).
Santa Ana Public Library (1959).
Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz Library (1963).
Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
Stanford: Stanford University Libraries (1895).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Civic Center Library (1969).
Turlock: Stanislaus State College Library (1964).
Valencia: Valencia Regional Library (1972).
Van Nuys: Los Angeles Valley College Library (1970).
Ventura: Ventura County Library Services Agency (1975).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

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

COLORADO

Alamosa: Adams State College Learning Resources Center (1963).
Boulder: University of Colorado Libraries (1879) – REGIONAL.
Colorado Springs:
Colorado College, Charles Leaming Tutt Library (1880).
University of Colorado, Colorado Springs Library (1974).
Denver:
Colorado State Library (unknown).
Denver Public Library (1884) – REGIONAL.
Department of Interior, Bureau of Reclamation Library (1962).
Regis College, Dayton Memorial Library (1915).
University of Denver, Penrose Library (1909).
U.S. Court of Appeals for Tenth Circuit Library (1973).
Fort Collins: Colorado State University Library (1907).
Golden: Colorado School of Mines, Arthur Lakes Library (1939).
Greeley: University of Northern Colorado Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Lakewood: Jefferson County Public Library, Lakewood Regional Library (1968).
Pueblo:
Pueblo Regional Library (1893).
University Southern Colorado Library (1965).
U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

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

Hartford:
- Connecticut State Library (unknown) – REGIONAL.
- Hartford Public Library (1945).
- Trinity College Library (1895).

Middletown: Wesleyan University Library (1906).

Mystic: Marine Historical Association, Inc., G. W. Blunt White Library (1964).

New Britain: Central Connecticut State College, Elihu Burritt Library (1973).

New Haven:
- Southern Connecticut State College Library (1968).
- Yale University Library (1859).

New London:
- Connecticut College Library (1926).
- U.S. Coast Guard Academy Library (1939).

Stamford: Stamford Public Library (1973).

Storrs: University of Connecticut, Wilbur Cross Library (1907).

Waterbury: Silas Bronson Library (1869).

West Haven: University of New Haven Library (1971).

DELAWARE

Dover:
- Delaware State College, William C. Jason Library (1962).
- State Department of Community Affairs and Economic Development, Division of Libraries (1972).
- State Law Library in Kent County (unknown).

Georgetown:
- Delaware Technical and Community College, Southern Branch Library (1968).
- Sussex County Law Library (1976).

Newark:
- University of Delaware, Morris Library (1907).
- Delaware Law School Library (1976).

Wilmington:
- New Castle County Law Library (1974).
- Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

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

FLORIDA

Boca Raton: Florida Atlantic University Library (1963).

Clearwater: Clearwater Public Library (1972).

Coral Gables: University of Miami Library (1939).

Daytona Beach: Volusia County Public Libraries (1963).

DeLand: Stetson University, duPont-Ball Library (1887).

Fort Lauderdale:
- Broward County Library (1967).
- Nova University Library (1967).

Gainesville: University of Florida Libraries (1907) – REGIONAL.

Jacksonville:
- Haydon Burns Library (1914).
- Jacksonville University, Swisher Library (1962).
- University of North Florida Library (1972).

Lakeland: Lakeland Public Library (1928).

Leesburg: Lake-Sumter Community College Library (1963).

Melbourne: Florida Institute of Technology Library (1963).

Miami:
- Florida International University Library (1970).
- Miami Public Library (1952).

Opa Locka: Biscayne College Library (1966).

Orlando: Florida Technological University Library (1966).

Palatka: St. Johns River Junior College Library (1963).

Pensacola: University of West Florida, John C. Pace Library (1966).

Port Charlotte: Charlotte County Library System (1973).

St. Petersburg:
- St. Petersburg Public Library (1965).
- Stetson University College Law Library (1975).

Sarasota: Sarasota Public Library (1970).

Tallahassee:
- Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
- State Library of Florida (1929).
- Florida State University, R. M. Stozier Library (1941).
- Florida Supreme Court Library (1974).

Tampa:
- Tampa Public Library (1965).
- University of South Florida Library (1962).
- University of Tampa, Merle Kelce Library (1953).

Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

Albany: Albany Public Library (1964).

Americus: Georgia Southwestern College, James Earl Carter Library (1966).

Athens: University of Georgia Libraries (1907).

Atlanta:
- Atlanta Public Library (1880).
- Atlanta University, Trevor Arnett Library (1962).
- Emory University, Robert W. Woodruff Library (1928).
- Emory University, School of Law Library (1968).
- Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
- Georgia State Library (unknown).
- Georgia State University Library (1970).

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

GUAM

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

HAWAII

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

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

IDAHO

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

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

ILLINOIS

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

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

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

INDIANA

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

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

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

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

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

IOWA

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

KANSAS

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

KENTUCKY

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

LOUISIANA

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

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

MAINE

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

MARYLAND

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

MASSACHUSETTS

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

MICHIGAN

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

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

MINNESOTA

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

MISSISSIPPI

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

MISSOURI

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

MONTANA

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

NEBRASKA

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

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

NEVADA

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

NEW HAMPSHIRE

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

NEW JERSEY

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

NEW MEXICO

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

NEW YORK

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

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

NORTH CAROLINA

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

NORTH DAKOTA

Bismarck:
State Historical Society of North Dakota (1907).
North Dakota State Law Library (unknown).
State Library Commission Library (1971).
Veterans Memorial Public Library (1967).
Dickinson: Dickinson State College Library (1968).
Fargo:
Fargo Public Library (1964).
North Dakota State University Library (1907) – REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.
Grand Forks: University of North Dakota, Chester Fritz Library (1890).
Minot: Minot State College, Memorial Library (1925).
Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
Akron:
Akron Public Library (1952).
University of Akron Library (1963).
Alliance: Mount Union College Library (1888).
Ashland: Ashland College Library (1938).
Athens: Ohio University Library (1886).
Batavia: Clermont General and Technical College Library (1973).
Bluffton: Bluffton College, Musselman Library (1951).
Bowling Green: Bowling Green State University Library (1933).
Canton: Malone College, Everett L. Cattell Library (1970).
Chardon: Geauga County Public Library (1971).
Cincinnati:
Public Library of Cincinnati and Hamilton County (1884).
University of Cincinnati Library (1929).
Cleveland:
Case Western Reserve University, Freiberger Library (1913).
Cleveland Heights-University Heights Public Library (1970).
Cleveland Public Library (1886).
Cleveland State University Library (1966).
John Carroll University, Grasselli Library (1963).
Municipal Reference Library (1970).
Columbus:
Capital University Library (1968).
Columbus Public Library (1885).
Ohio State Library (unknown) – REGIONAL.
Ohio State University Library (1907).
Ohio Supreme Court Law Library (1973).
Dayton:
Dayton and Montgomery County Public Library (1909).
University of Dayton, Albert Emanuel Library (1969).
Wright State University Library (1965).
Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
Elyria: Elyria Public Library (1966).
Findlay: Findlay College, Shafer Library (1969).
Gambier: Kenyon College Library (1873).
Granville: Denison University Library (1884).
Hiram: Hiram College, Teachout-Price Memorial Library (1874).
Kent: Kent State University Library (1962).
Marietta: Marietta College, Dawes Memorial Library (1884).
Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).
New Concord: Muskingum College Library (1966).
Oberlin: Oberlin College Library (1858).
Oxford: Miami University, Alumni Library (1909).
Portsmouth: Portsmouth Public Library (unknown).
Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).
Springfield: Warder Public Library (1884).
Steubenville:
College of Steubenville, Starvaggi Memorial Library (1971).
Public Library of Steubenville and Jefferson County (1950).
Tiffin: Heidelberg College, Beeghly Library (1964).
Toledo:
Toledo-Lucas County Public Library (1884).
University of Toledo Library (1963).
Westerville: Otterbein College, Centennial Library (1967).
Wooster: College of Wooster, the Andrews Library (1966).
Youngstown:
Public Library of Youngstown and Mahoning County (1923).
Youngstown State University Library (1971).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).
Alva: Northwestern State College Library (1907).
Bartlesville: United States ERDA-BERC Library (1962).
Bethany: Bethany Nazarene College, R. T. Williams Library (1971).
Durant: Southeastern State College Library (1929).
Edmond: Central State University Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Muskogee: Muskogee Public Library (1971).
Norman: University of Oklahoma Libraries (1893).
Oklahoma City:
Oklahoma County Libraries (1974).
Oklahoma City University Library (1963).
Oklahoma Department of Libraries (1893) – REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907).
Tahlequah: Northeastern State College, John Vaughan Library (1923).
Tulsa:
Tulsa City-County Library (1963).
University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene: University of Oregon Library (1883).
Forest Grove: Pacific University Library (1897).
La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Oregon College of Education Library (1967).
Portland:
Department of the Interior, Bonneville Power Administration Library (1962).
Lewis and Clark College, Aubrey R. Watzek Library (1967).
Library Association of Portland (1884).
Portland State University Library (1963) – REGIONAL.
Reed College Library (1912).
Salem:
Oregon State Library (unknown).
Oregon Supreme Court Library (1974).

Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
Altoona: Altoona Public Library (1969).
Bethlehem: Lehigh University, Linderman Library (1876).
Blue Bell: Montgomery County Community College, Learning Resources Center Library (1975).
Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College, Myrin Library (1963).
Doylestown: Bucks County Free Library, Center County Library (1970).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: State Library of Pennsylvania (unknown) – REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
- Drexel University Library (1963).
- Free Library of Philadelphia (1897).
- St. Joseph's College Library (1974).
- Temple University, Samuel Paley Library (1947).
- U.S. Court of Appeals, Third Circuit (1973).
- University of Pennsylvania, Biddle Law Library (1974).
- University of Pennsylvania Library (1886).

Pittsburgh:
- Bureau of Mines, Pittsburgh Research Center Library (1962).
- Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
- Carnegie Library of Pittsburgh (1895).
- La Roche College, John J. Wright Library (1974).
- University of Pittsburgh, Hillman Library (1910).

Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College, Corgan Library (1949).
Williamsport: Lycoming College Library (1970).
York: York Junior College Library (1963).
Youngwood: Westmoreland County Community College, Learning Resource Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
- Brown University, John D. Rockefeller, Jr. Library (unknown).
- Providence College, Phillips Memorial Library (1969).
- Providence Public Library (1884).
- Rhode Island College Library (1965).
- Rhode Island State Library (before 1895).

Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).

SOUTH CAROLINA

Charleston:
- Baptist College at Charleston Library (1967).
- College of Charleston Library (1869).
- The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).
Columbia:
- Benedict College, Learning Resources Center (1969).
- South Carolina State Library (before 1895).
- University of South Carolina Undergraduate Library (1884).

Conway: University of South Carolina, Coastal Carolina Regional Campus Library (1974).
Due West: Erskine College, McCain Library (1968).
Florence:
- Florence County Library (1967).
- Francis Marion College, James A. Rogers Library (1970).

Greenville:
- Furman University Library (1962).
- Greenville County Library (1966).

Greenwood: Lander College Library (1967).
Orangeburg: South Carolina State College, Whittaker Library (1953).
Rock Hill: Winthrop College Library (1896).
Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).
Brookings: South Dakota State University, Lincoln Memorial Library (1889).
Pierre: South Dakota State Library (1973).
Rapid City:
- Rapid City Public Library (1963).
- South Dakota School of Mines and Technology Library (1963).

Sioux Falls:

Augustana College, Mikkelsen Library and Learning Resources Center (1969).
Sioux Falls Public Library (1903).
Spearfish: Black Hills State College Library (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

Bristol: King College Library (1970).
Chattanooga:
Chattanooga-Hamilton County Bicentennial Library (1907).
TVA Technical Library (1976).
Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
Cleveland: Cleveland State Community College Library (1973).
Columbia: Columbia State Community College Library (1973).
Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville:
Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).
University of Tennessee Law Library (1971).
University of Tennessee Library (1907).
Martin: University of Tennessee at Martin Library (1957).
Memphis:
Memphis and Shelby County Public Library and Information Center (1896).
Memphis State University, John W. Brister Library (1966).
Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
Nashville:
Fisk University Library (1965).
Joint University Libraries (1884).
Public Library of Nashville and Davidson County (1884).
Tennessee State Law Library (1976).
Tennessee State Library and Archives, State Library Division (unknown).
Tennessee State University, Martha M. Brown Memorial Library (1972).
Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene: Hardin-Simmons University Library (1940).
Arlington:
Arlington Public Library (1970).
University of Texas at Arlington Library (1963).
Austin:
Texas State Law Library (1972).
Texas State Library (unknown)—REGIONAL.
University of Texas at Austin Library (1884).
University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
University of Texas, School of Law Library (1965).
Baytown: Lee College Library (1970).
Beaumont: Lamar University Library (1957).
Brownwood: Howard Payne College, Walker Memorial Library (1964).
Canyon: West Texas State University Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
Corsicana: Navarro Junior College Library (1965).
Dallas:
Bishop College, Zale Library (1966).
Dallas Baptist College Library (1967).
Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center Library at Dallas (1975).
Denton: North Texas State University Library (1948).
Edinburg: Pan American University Library (1959).
El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary Couts Burnett Library (1916).
Galveston: Rosenberg Library (1909).
Houston:
Houston Public Library (1884).
North Harris County College, Learning Resource Center (1974).
Rice University, Fondren Library (1967).
University of Houston Library (1957).
Huntsville: Sam Houston State University, Estill Library (1949).
Irving: Irving Municipal Library (1974).
Kingsville: Texas Arts and Industries University Library (1944).
Lake Jackson: Brazosport College Library (1969).
Laredo: Laredo Junior College Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Tech University Library (1935)—REGIONAL.
Marshall: Wiley College, Cole Library (1962).
Mesquite: Mesquite Public Library (1975).
Nacogdoches: Stephen F. Austin State University Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
San Antonio College Library (1972).
San Antonio Public Library, Business and Science Department (1899).
St. Mary's University Library (1964).
Trinity University Library (1964).
University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: University of Houston, Victoria Center Library (1973).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)—REGIONAL.
Ogden: Weber State College Library (1962).
Provo:
Brigham Young University, Lee Library (1908).

Brigham Young University Law Library (1972).
Salt Lake City:
Utah State Supreme Court Law Library (1975).
University of Utah, Eccles Medical Sciences Library (1970).
University of Utah, Law Library (1966).
University of Utah, Marriott Library (1893).
Utah State Library Commission, Documents Library (unknown).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
St. Thomas Public Library (1968).
Christiansted (St. Croix): Christiansted Public Library (1974).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
University of Virginia, Alderman Library (1910) – REGIONAL.
University of Virginia Law Library (1964).
Chesapeake: Chesapeake Public Library System (1970).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College Library (1884).
Fairfax: George Mason College of the University of Virginia, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Harrisonburg: Madison College, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
Virginia Military Institute, Preston Library (1874).
Washington and Lee University, Cyrus Hall McCormick Library (1910).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
Armed Forces Staff College Library (1963).
Norfolk Public Library (1895).
Old Dominion University Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico:
Federal Bureau of Investigation Academy Library (1970).
Marine Corps Schools, James Carson Breckinridge Library (1967).
Reston: Department of the Interior, Geological Survey Library (1962).
Richmond:
State Law Library (1973).
University of Richmond, Boatwright Memorial Library (1900).
U.S. Court of Appeals, Fourth Circuit Library (1973).
Virginia Commonwealth University, James Branch Cabell Library (1971).
Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia:
Evergreen State College Library (1972).
Washington State Library (unknown) – REGIONAL.
Port Angeles: North Olympic Library System (1965).
Pullman: Washington State University Library (1907).
Seattle:
Seattle Public Library (1908).
University of Washington Library (1890).
University of Washington, School of Law Library (1969).
Spokane: Spokane Public Library (1910).
Tacoma:
Tacoma Public Library (1894).
University of Puget Sound, Collins Memorial Library (1938).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Bluefield: Bluefield State College Library (1972).
Charleeton:
Kanawha County Public Library (1952).
West Virginia Library Commission (unknown).
Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University Library (1925).
Institute: West Virginia State College Library (1907).
Morgantown: West Virginia University Library (1907) – REGIONAL.
Salem: Salem College Library (1921).
Shepherdstown: Shepherd College Library (1971).
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).
Beloit: Beloit College Libraries (1888).
Eau Claire: University of Wisconsin, Eau Claire, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).

Green Bay: University of Wisconsin at Green Bay Library (1968).

La Crosse:

La Crosse Public Library (1883).

University of Wisconsin-La Crosse, Murphy Library (1965).

Madison:

Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).

Madison Public Library (1965).

State Historical Society Library (1870)—REGIONAL, in cooperation with University of Wisconsin, Memorial Library.

University of Wisconsin, Memorial Library (1939).

Wisconsin State Library (unknown).

Milwaukee:

Alverno College Library (1971).

Milwaukee County Law Library (1934).

Milwaukee Public Library (1861)—REGIONAL.

Mount Mary College Library (1964).

University of Wisconsin-Milwaukee Library (1960).

Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).

latteville: University of Wisconsin-Platteville, Elton S. Karrmann Library (1964).

Racine: Racine Public Library (1898).

River Falls: University of Wisconsin-River Falls, Chalmer Davee Library (1962).

Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).

Superior:

Superior Public Library (1908).

University of Wisconsin-Superior, Jim Dan Hill Library (1935).

Waukesha: Waukesha Public Library (1966).

Wausau: Marathon County Public Library (1971).

Whitewater: University of Wisconsin-Whitewater, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).

Cheyenne: Wyoming State Library (unknown)—REGIONAL.

Laramie: University of Wyoming, Coe Library (1907).

Powell::Northwest Community College Library (1967).

Riverton: Central Wyoming College Library (1969).

Rock Springs: Western Wyoming College Library (1969).

Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

APPENDIX B. LIST OF FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

ALABAMA

Birmingham—Gayle C. Shelton, Jr., Director, Suite 200-201, 908 South 20th Street 35205, Area Code 205 Tel 254-1331, FTS 229-1331

ALASKA

****Anchorage**—Sara L. Haslett, Director, 412 Hill Building, 632 Sixth Avenue 99501, Area Code 907 Tel 265-5307

ARIZONA

Phoenix—Donald W. Fry, Director, 508 Greater Arizona Savings Building, 112 North Central Avenue 85004, Area Code 602 Tel 261-3285, FTS 261-3285

ARKANSAS

***Little Rock (Dallas, Texas District)**—1100 North University, Suite 109 72207, Area Code 501 Tel 378-5157, FTS 740-5157

CALIFORNIA

Los Angeles—Eric C. Silberstein, Director, Room 800, 11777 San Vicente Boulevard 90049, Area Code 213 Tel 824-7591, FTS 799-7591

***San Diego**—233 A Street, Suite 310 92101, Area Code 714 Tel 293-5395, FTS 895-5395

San Francisco—Philip M. Creighton, Director, Federal Building, Box 36013, 450 Golden Gate Avenue 94102, Area Code 415 Tel 556-5860, FTS 556-5868

COLORADO

Denver—Norman Lawson, Director, Room 165, New Customhouse, 19th & Stout Street 80202, Area Code 303 Tel 837-3246, FTS 327-3246

CONNECTICUT

Hartford—Richard C. Kilbourn, Director, Room 610-B, Federal Office Building, 450 Main Street 06103, Area Code 203 Tel 244-3530, FTS 244-3530

FLORIDA

Miami—Roger J. LaRoche, Director, Room 821, City National Bank Building, 25 West Flagler Street 33130, Area Code 305 Tel 350-5267, FTS 350-5267

***Clearwater**—128 North Osceola Avenue 33515, Area Code 813 Tel 446-4081

***Jacksonville**—604 North Hogan Street 32202, Area Code 904 Tel 791-2796, FTS 946-2796

***Tallahassee**—Collins Building, Rm. G-20 32304, Area Code 904 Tel 488-6469, FTS 946-4320

GEORGIA

Atlanta—David S. Williamson, Director, Suite 600, 1365 Peachtree Street, N.E. 30309, Area Code 404 Tel 526-6000, FTS 285-6000

Savannah—James W. McIntire, Director, 235 U.S. Courthouse & P.O. Building, 125-29 Bull Street 31402, Area Code 912 Tel 232-4321, Ext. 204, FTS 287-4204

HAWAII

Honolulu—John S. Davies, Director, 286 Alexander Young Building, 1015 Bishop Street 96813, Area Code 808 Tel 546-8694

IDAHO

***Boise (Portland, Oregon District)**—P.O. Box 9366, 83707, Area Code 208 Tel 342-2711, FTS 588-2326

ILLINOIS

Chicago—Gerald M. Marks, Director, 1406 Mid Continental Plaza Building, 55 East Monroe Street 60603, Area Code 312 Tel 353-4450, FTS 353-6957

INDIANA

Indianapolis—Mel R. Sherar, Director, 357 U.S. Courthouse & Federal Office Building, 46 East Ohio Street 46204, Area Code 317 Tel 269-6214, FTS 331-6214

IOWA

Des Moines—Jesse N. Durden, Director, 609 Federal Building, 210 Walnut Street 50309, Area Code 515 Tel 284-4222, FTS 862-4222

KANSAS

***Wichita (St. Louis, Missouri District)**—Wichita State University, Clinton Hall, Room 341, 67208, Area Code 316 Tel 267-6160, FTS 752-6160

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