

RESEARCH IN EARTHQUAKE HAZARDS REDUCTION
AT THE NATIONAL BUREAU OF STANDARDS

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ABSTRACT

Current and planned Earthquake Hazards Reduction programs for Research and Standards Development at the National Bureau of Standards are being conducted in order to meet the responsibilities assigned to NBS under the President's National Earthquake Hazards Reduction Program. These responsibilities to:

- (1) provide technical support to the building community in the development of seismic design and construction provisions for building codes and national standards
- (2) provide technical support to the Federal agencies in development of seismic design and construction provisions for Federal programs and
- (3) perform research on performance criteria and supporting measurement technology for earthquake resistant construction,

are being carried out in cooperation with the Federal and private sectors.

INTRODUCTION

The National Bureau of Standards' (NBS) Earthquake Hazards Reduction Program is part of the national effort to reduce the risks to life and property from future earthquakes in the United States. The President's National Earthquake Hazards Reduction Program [1]*, issued June 22, 1978, to implement the Earthquake Hazards Reduction Act of 1977 [2], assigned NBS the following continuing responsibilities:

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- o provide technical support to the building community, including the Federal agencies involved in construction, "in continuing the development, testing, and improvement of model seismic design and construction provisions suitable for incorporation in local codes, standards (including Federal standards) and practices."
- o perform "research on performance criteria and supporting measurement technology for earthquake resistant construction."

NBS has participated in the planning of Federal programs in earthquake hazard reduction since 1971 and played a major role in drafting the National Earthquake Hazards Reduction Program.

OBJECTIVES

In order to meet its responsibilities under the President's National Earthquake Hazards Reduction Program, NBS is concentrating its efforts in (1) Research for Standards and (2) Standards Development. The objectives are:

Research for Standards - Improve building design and construction practices by conducting fundamental research necessary to establish consistent standards that include reliable measures of the performance of buildings during an earthquake.

Standards Development - Provide technical support in the "development of seismic design and construction standards for consideration and subsequent application in Federal construction, and encouragement for the adoption of improved seismic provisions in state and local building codes."

Both of these objectives are consistent with past NBS efforts in the development of technical bases for standards and on measurement technology and with the interagency effort among the U. S. Geological Survey (USGS), National Science Foundation (NSF) and NBS to develop program options for Fiscal years 1981-1984 [3].

RESEARCH FOR STANDARDS

A research program at NBS to develop technical bases for performance criteria and the supporting measurement technology is a new element of the national earthquake research program. Earth sciences research led by the USGS and NSF provides greatly improved understanding of ground shaking and displacement. To be suitable for use in design, knowledge must be further developed to loading criteria for the various types of structures and components. Structural, geotechnical, mechanical, architectural and economic studies supported by NSF have provided substantial advances in abilities to model and predict the earthquake responses of various built elements and their consequences. This knowledge must be synthesized to develop design criteria that will provide consistent safety among the various built elements and various materials or technologies for each. Evaluation and measurement methods consistent with practices of design, manufacture, construction and inspection, must be developed to implement the design criteria.

The NBS research program is essential to the NBS standards development role, such a program will complement the research conducted or funded by USGS and NSF and will contribute substantially to the implementation of the latter research. The NBS research program also provides for an enhanced Federal expertise in the area of earthquake engineering research which is vital for effective Federal participation with the building community during the establishment of public policy.

Research for standards is divided into four tasks:

Task 1 - Research for Earthquake Loading Standards -

Develop methods for use in standards to characterize ground motions and the acceleration, velocity, and displacement time-histories of those motions for engineering analysis, planning and design. The effects of the earthquake source, transmission path, amplification caused by local site conditions, and soil-structure interaction will be considered.

Task 2 - Research for New Building Standards -

Develop methods for use in standards to characterize the performance of buildings in four areas:

- i) Develop laboratory and in-situ techniques for characterizing the dynamic properties of soils, develop analytical methods to evaluate soil failures, and investigate the design of various types of foundations in order to develop criteria for selection and design of appropriate foundations.
- ii) Develop procedures for characterizing the dynamic behavior of structures and components up to the ultimate limit state and develop a technical basis for the formulation and validation of nonlinear and inelastic methods of analysis and design.
- iii) Develop methods to characterize the response of nonstructural systems to earthquake loadings and develop test methods for evaluating these characteristics. Methods to obtain loadings, for use in evaluating nonstructural systems, as a transfer from the structural and site response information will be developed. Critical response parameters will be formulated and test methods will be developed for evaluating the characteristics of nonstructural systems and components such as machines, luminaires, piping, elevators, etc. System design conflicts arising from nonstructural response (secondary hazards, such as fire) will also be examined.
- iv) Develop the basis for performance criteria for occupant safety and building functional requirements during and after earthquakes by relating casualties to both structural and nonstructural response to earthquake motion, and by

determining functionality requirements both during and after earthquakes for various types of building uses.

Task 3 - Research for Existing Building Standards -

Develop nondestructive methods to determine the properties of older buildings and components in place, for use in determining realistic values of structural parameters and evaluation of the strength of existing buildings and repairs. Analytical and laboratory studies on components will be followed by field studies on whole buildings, taking advantage of buildings scheduled for demolition where possible.

Task 4 - Research for Assessment of Standards -

Develop methods for assessing the impacts of standards for improved seismic resistance. Methodologies will be developed for assessing the benefits of earthquake hazard reduction and for defining risk for both building and community scales. The influence of building type and configuration on serviceability and costs will be considered. Costs and benefits of improved practices for seismic resistance associated with planning, design, construction and regulation will be included. Methods for assessing the clarity, consistency, and completeness of standards will also be improved.

Research is currently concentrating on Task 2 in the development of procedures for characterizing the dynamic behavior of structures, particularly for masonry construction.

STANDARDS DEVELOPMENT

A program for the development of standards for buildings is an important element in the implementation of the substantial research programs at USGS and NSF. Criteria for the earthquake-resistant design of new construction used in many current Federal, State, and local building codes, standards and practices do not reflect the current state of the art and should be updated. These codes and standards and professional practices underlying them should not only represent our best knowledge, but be adaptable to different areas of the United States according to differing seismic risks and the costs and benefits they entail.

Under the President's program, an Interagency Committee on Seismic Safety in Construction was organized in 1978. The Federal Emergency Management Agency (FEMA) has the leadership responsibility for the Interagency Committee as part of its overall disaster-related responsibilities. All Federal agencies involved in construction under the leadership of FEMA, working through the Interagency Committee on Seismic Safety in Construction, will develop seismic design standards for Federal building construction. NBS is providing technical support to several of the subcommittees of the Interagency Committee in the development of unified Federal standards [3].

The vast majority of the construction in the United States is undertaken by the private sector and regulated by local government. To assist State and local governments, industry, and the public in developing construction standards, criteria, and practices, the National Bureau of

Standards will work with other Federal agencies, the National Institute of Building Sciences, professional organizations, model code groups, State and local building departments, and the newly formed Building Seismic Safety Council. The Bureau will assist and cooperate with these groups in continuing the development, evaluation, and improvement of model seismic design provisions suitable for incorporation into local codes and practices. Incorporation of these seismic design provisions into local codes is, of course, voluntary, but the provisions must be flexible and must give consideration to costs and benefits, regional variation of seismic hazard, and adaptation to local conditions. The provisions must also be adequately tested for effectiveness.

The Building Seismic Safety Council formed in April 1979 when more than fifty professional societies, trade associations, model code organizations and public interest organizations met under the auspices of the National Institute of Building Sciences. The Council provides a national forum to foster improved seismic provisions for use by the building community. NBS will conduct technical studies in support of the Council. In turn, the Council will base its recommendations for provisions in building standards and codes on these studies.

Standards Development is divided into three tasks:

Task 1 - Seismic Design Provisions for Consensus Standards and Model Codes -

Provide technical studies and draft provisions to assist the building community in the development and implementation of seismic design provisions in State and local building codes. This will be accomplished by working through the existing systems of voluntary standards and model building codes, making appropriate use of the assessments of the Federal building standards in Task 2.

Task 2 - Seismic Design Standards for Federal Building Construction -

Develop seismic design standards for Federal building construction, test and assess the safety and economic consequences of their use, improve the standards following assessment and implement in Federal programs.

Task 3 - Standards for Evaluation and Strengthening of Hazardous Existing Buildings -

Provide technical assistance in the development of methods for the evaluation of seismic safety of existing buildings and in the development of practices and criteria for strengthening existing buildings or removing them from service.

Efforts are now under way to assess the "Tentative Provisions for the Development of Seismic Regulations for Buildings [4]," prepared by the Applied Technology Council as part of the NBS and NSF Cooperative Federal Program in Building Practices for Disaster Mitigation. This effort will be in cooperation with the Building Seismic Safety Council and will involve both the Federal and private sectors.

CONCLUSION

The role of the NBS under the National Earthquake Hazards Reduction Program includes the responsibility to:

- (1) provide technical support to the building community in the development of seismic design and construction provisions for building codes and national standards
- (2) provide technical support to the Federal agencies in development of seismic design and construction provisions for Federal programs and
- (3) perform research on performance criteria and supporting measurement technology for earthquake resistant construction.

These responsibilities are being met by conducting (1) Research for Standards and (2) Standards Development. Current efforts are concentrating on (1) developing procedures for characterizing the dynamic behavior of structures, particularly masonry construction, and (2) working with the Interagency Committee on Seismic Safety in Construction to develop uniform Federal criteria and with the Building Seismic Safety Council to assess the newly prepared Tentative Provisions for the Development of Seismic Regulations for Buildings.

Current and future plans are consistent with the interagency effort among NSF, USGS, and NBS to develop program options for Fiscal years 1981-1984.

REFERENCES

- [1] National Earthquake Hazards Reduction Program, Office of Science and Technology Policy, Executive Office of the President, June 22, 1978.
- [2] U. S. Congress, Public Law 95-124, October 7, 1977, also printed as Appendix I of Earthquake Hazards Reduction: Issues for an Implementation Plan, Office of Science and Technology Policy, Executive Office of the President, Washington, D. C., 1978.
- [3] Thiel, C. C., "New Initiatives in Earthquake Hazards Mitigation," in Wind and Seismic Effects, Proceedings of the Eleventh Joint UJNR Panel Conference, National Bureau of Standards Special Publication (in press), National Bureau of Standards, Washington, D. C., 1980.
- [4] Applied Technology Council, Tentative Provisions for the Development of Seismic Regulations for Buildings, National Bureau of Standards Special Publication 510, National Bureau of Standards, Washington, D. C., 1978.