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Assessment of the 1991 NEHRP Provisions for Nonstructural Components and Recommended Revisions

by

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March 1, 1993

Technical Report NCEER-93-0003

NCEER Project Numbers 91-5221 and 92-3201

NSF Master Contract Number BCS 90-25010
and
NYSSTF Grant Number NEC-91029

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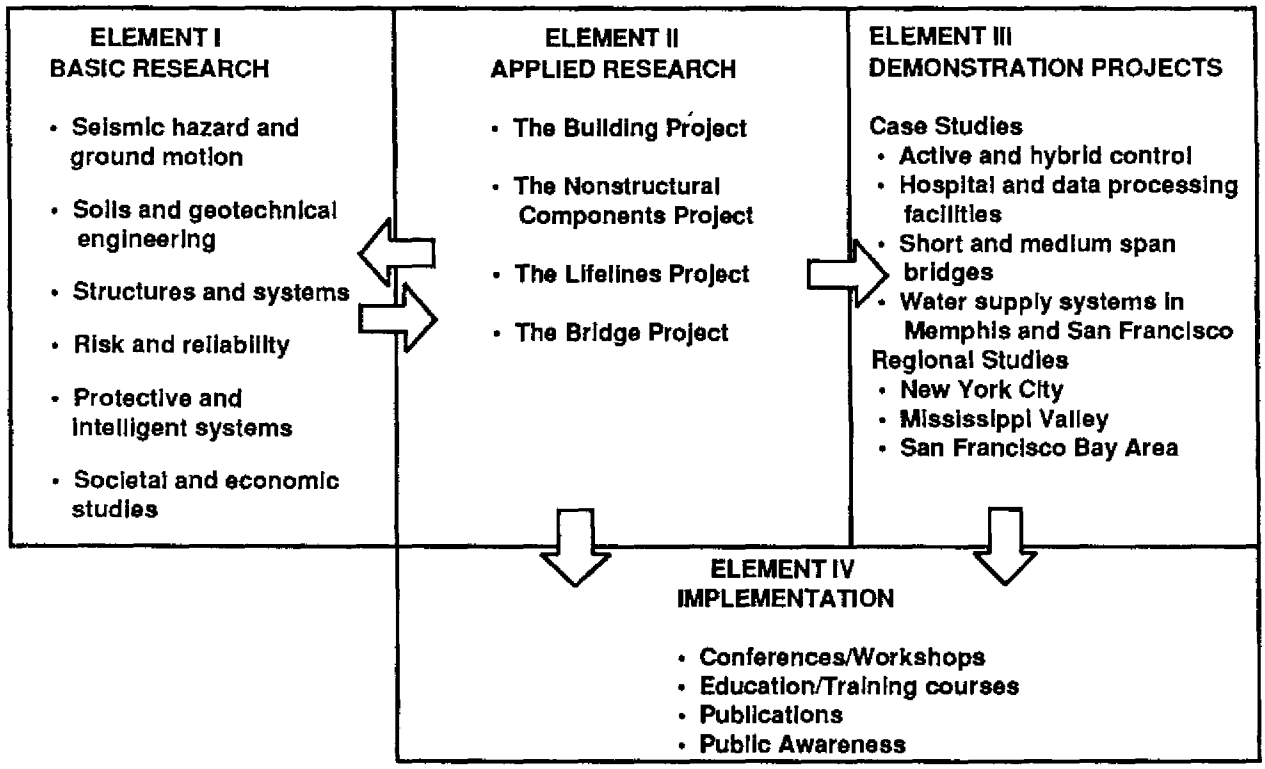
PREFACE

The National Center for Earthquake Engineering Research (NCEER) was established to expand and disseminate knowledge about earthquakes, improve earthquake-resistant design, and implement seismic hazard mitigation procedures to minimize loss of lives and property. The emphasis is on structures in the eastern and central United States and lifelines throughout the country that are found in zones of low, moderate, and high seismicity.

NCEER's research and implementation plan in years six through ten (1991-1996) comprises four interlocked elements, as shown in the figure below. Element I, Basic Research, is carried out to support projects in the Applied Research area. Element II, Applied Research, is the major focus of work for years six through ten. Element III, Demonstration Projects, have been planned to support Applied Research projects, and will be either case studies or regional studies. Element IV, Implementation, will result from activity in the four Applied Research projects, and from Demonstration Projects.



Research tasks in the **Nonstructural Components Project** focus on analytical and experimental investigations of seismic behavior of secondary systems, investigating hazard mitigation through optimization and protection, and developing rational criteria and procedures for seismic design and performance evaluation. Specifically, tasks are being performed to: (1) provide a risk analysis of a selected group of nonstructural elements; (2) improve simplified analysis so that research results can be readily used by practicing engineers; (3) protect sensitive equipment and critical subsystems using passive, active or hybrid systems; and (4) develop design and performance evaluation guidelines.

The end product of the **Nonstructural Components Project** will be a set of simple guidelines for design, performance evaluation, support design, and protection and mitigation measures in the form of handbooks or computer codes, and software and hardware associated with innovative protection technology.

The work presented in this report represents one part of the 1994 update effort of the 1991 NEHRP provisions. The seismic design formulas for nonstructural components as they exist in 1991 NEHRP are critically reviewed and various levels of improvements to these formulas are recommended based on analyses and experiments, performed by NCEER researchers and elsewhere, as well as on observation data from past earthquakes. The recommended revisions thus bring the existing formulas more in line with the state-of-the-knowledge in the area of seismic behavior of nonstructural components. Also proposed in this report is a set of displacement equations which can be useful in the design process.

ABSTRACT

As one part of the 1994 update effort of the 1991 NEHRP provisions, the seismic design force formulas for nonstructural components as they exist in the 1991 provisions are critically assessed and some of their shortcomings are identified. Various levels of improvements to these formulas are then presented which, on the one hand, preserve the equivalent lateral force format for design applicability and, on the other, correct some of their deficiencies on the basis of analyses, experimental results and observation data from past earthquakes.

Based on different interpretations of the component seismic coefficients as well as different degrees of simplicity required in practical design, three recommendations are proposed. The first recommended revision is the most comprehensive in that both effects of nonstructural component anchorage detailing and its supporting structural characteristics are taken into account. The second recommendation is a structure-driven type of modification of the current provisions and is motivated by the possibility that nonstructural component information during a design process is not available. The third revision, however, mainly concentrates on the effect of nonstructural component characteristics on the design force although it partially implies structural effects in the process of determining the response modification coefficient. The maximum and minimum design forces in the three recommendations are compared with those produced by the 1991 NEHRP provisions, the 1991 UBC, and the 1985 Tri-Service codes. Case studies of a parapet, a storage rack and a general equipment attached to a reinforced concrete shear wall structure are provided to show the relative conservatism involved in different codes and the importance of the factors ignored in the current provisions.

Simple displacement equations are also developed in this report to provide deformation information needed in some cases of practical design.

ACKNOWLEDGEMENTS

This work was supported in part by the National Center for Earthquake Engineering Research under Grant Nos. NCEER-91-5221 and NCEER-92-3201; by the State University of New York at Buffalo; and by the IBM Corporation under the NCEER/IBM Joint Research Program on Seismic Performance and Safety Enhancement of Computer and Data Processing Equipment.

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