GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ____

Project No. E-20-632 GTRI/~~GTX~~ DATE 1/4/83

Project Director: Dr. Barry J. Goodno School/~~Lab~~ Civil Engineering

Sponsor: National Science Foundation

Type Agreement: Grant No. CEE - 8213803

Award Period: From 12/1/82 To 11/30/84* (Performance) 2/28/85 (Reports)

Sponsor Amount: Total Estimated: $ 68,891 Funded: $ 68,891

Cost Sharing Amount: $ 3,802 Cost Sharing No: E-20-315

Title: Seismic Evaluation of Low - Rise Office Buildings in Zones of Moderate Seismicity

ADMINISTRATIVE DATA OCA Contact Faith G. Costello

1) Sponsor Technical Contact:

Michael P. Gaus
Design Research Program
Earthquake Hazard Mitigation Section
Division of Civil and Environmental Eng.g
Directorate for Engineering
NSF
Washington, DC 20550

2) Sponsor Admin/Contractual Matters:

Lois A. Shapiro
AAEO/ENG Branch, Section 1
Division of Grants & Contacts
Directorate for Administration
NSF
Washington, DC 20550

Defense Priority Rating: N/A Military Security Classification: N/A

(or) Company/Industrial Proprietary: ____

RESTRICTIONS

See Attached NSF Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS:

*Includes a 6 month unfunded flexibility period.

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FORM OCA 4:781 (Rev 982)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 2/3/86

Project No. E-20-632 School ~~XXX~~ CE

Includes Subproject No.(s) N/A

Project Director(s) B. J. Goodno GTRI / ~~XXX~~

Sponsor National Science Foundation

Title Seismic Evaluation of Low Rise Office Buildings in Zones of Moderate Seismicity

Effective Completion Date: 5/31/85 (Performance) 8/31/85 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [ ] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [X] ~~XXXXXXXXXXXXXXXXXXXX~~ Patent Questionnaire
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. N/A Continued by Project No. N/A

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Other A. Jones; M. Heyser; R. Embry

Form OCA 60:1028

E-20-632

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I–PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
School of Civil Engr Georgia Institute of Technology Atlanta, Georgia 30332	Erathquake Hazards Mitigation	CEE-8213803
	4. Award Period From 12/82 To 5/85	5. Cumulative Award Amount $68,891.

6. Project Title: Seismic Evaluation of Low Rise Buildings in Zones of Moderate Seismicity

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

The large inventory of existing low rise building construction in the eastern U.S. has been designed for minimum wind force levels only, and may represent a substantial hazard in the event of even a moderate earthquake in the region. The aim of this study was to conduct an in-depth evaluation of one type of low rise building in the class, namely one-to-four story office structures comprised of a lightweight steel frame, bar joist roof, and precast panel or brick masonry exterior facade, and to assess its potential vulnerability to seismic forces. First, the performance of this category of construction during past earthquakes was reviewed as reported in the literature. Then, a general purpose analytical model for dynamic analysis of low rise buildings was developed for implementation on either mainframe or microcomputers. Two candidate structures representative of regional design practice were selected for in-depth evaluation, one a well-designed two story building with brick masonry facade and, the second, a two story structure of marginal design clad with brick masonry at the first level and precast panels above. The first structure was the subject of ambient field vibration measurements to determine frequencies and damping, and was also represented by two and three dimensional computer models which accounted for diaphragm rigidity and soil-structure interaction effects. The lateral stiffness of the architectural precast panels was accounted for in the computer models of the second structure, and several structural alterations were studied which would reduce the effects of accidental torsion in this building. Both structures were evaluated using 1982 UBC and ATC-3-06 provisions as well as elastic and inelastic response spectrum force levels. Results of all seismic analyses were checked for code compliance and were compared to wind force levels used in the actual designs. Results of the study offer guidance in the assemblage of realistic models of existing low rise structures and procedures for their seismic evaluation. The findings of the study are expected to contribute to a better understanding of the seismic performance of this class of construction and to methods for its improvement.

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USE)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (✓)	Approx. Date
a. Abstracts of Theses		X			
b. Publication Citations		X			
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results				X	Jan. 1986
f. Other *(specify)*					

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date
Dr. Barry J. Goodno		11/15/85

NSF Form 98A (3-83) Supersedes All Previous Editions

Form Approved OMB No. 3145-0056

FINAL PROJECT REPORT

NSF Award No. CEE-8213803
"Seismic Evaluation of Low Rise Buildings
in Zones of Moderate Seismicity"

PART III - TECHNICAL INFORMATION

a. Abstracts of Theses

The following MSCE Special Problem Reports were written based on research performed on the grant. Abstracts for reports 1-3 are attached; report 4 will be completed by January 1986.

1. Pinelli, J., "Seismic Evaluation of Low-Rise Steel Office Buildings - Case Study II," MSCE Special Problem Report, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, April 1984

2. Naman, S., "Seismic Evaluation of Low-Rise Steel Office Buildings - Case Study I," MSCE Special Problem Report, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, May 1984

3. Streit, M., "An Analytical Model for Seismic Response Analysis of Low-Rise Steel Buildings Using Microcomputers," MSCE Special Problem Report, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, December 1985

4. Hasbun, L., "Soil-Structure Interaction Effects in the Seismic Response Evaluation of a Low-Rise Steel Office Building," MSCE Special Problem Report, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, January 1986 (estimated completion date)

b. Publication Citations

1. Naman, S., and Goodno, B., "Seismic Evaluation of a Low Rise Steel Building," to appear in Engineering Structures, Butterworth Scientific Ltd., Surrey, UK

2. Naman, S., and Goodno, B., "Seismic Performance of Low Rise Steel Office Buildings," presented by S. Naman at the ASCE Spring Convention held on April 29-May 3, 1985, in Denver, CO

3. Goodno, B. J., "Earthquake Analysis of Lowrise Buildings in Zones of Moderate Seismicity," to be presented at the Eighth European Conference on Earthquake Engineering, to be held in Lisbon, Portugal, on September 7-12, 1986

4. Goodno, B. J., and Pinelli, J. P., "The Role of Cladding in Seismic Response of Lowrise Buildings in the Southeastern U.S.," abstract submitted in September 1985 for review for possible presentation at the Third U.S. National Conference on Earthquake Engineering, to be held in Charleston, S.C., on August 24-28, 1986

c. Scientific Collaborators

1. Dr. M. Meyyappa, Post-doctoral Fellow, School of Aerospace Engineering

2. Ms. Shatha K. Naman, Graduate Research Assistant, School of Civil Engineering

3. Mr. Jean P. Pinelli, Graduate Research Assistant, School of Civil Engineering

4. Mr. Mark C. Streit, Graduate Research Assistant, School of Civil Engineering

5. Mr. Luis R. Hasbun, Graduate Research Assistant, School of Civil Engineering

Title: Seismic Evaluation of Low-Rise Steel Office Buildings - Case Study I

Author: Shatha K. Naman

ABSTRACT

A large percentage of low rise buildings in the United States, while actually a composite of several different materials, can be classified as steel buildings. Many of these buildings in the Southeastern U.S. are designed for wind forces only, and few are designed for even code seismic load levels. Structures in this category house the day-to-day activities of a large number of people and must be able to withstand a moderate earthquake without loss of life or excessive damage.

The primary objective of this research was to study the seismic performance of this class of buildings, namely one to four-story office buildings with steel framing, bar joist roof, and either lightweight precast or glass panel or medium weight masonry facade. First, the performance of this type of building during past earthquakes was reviewed as reported in the literature. Then, as a case study, a particular building under construction in the Atlanta area was selected for detailed evaluation. The dynamic properties of the candidate building were obtained through analyses of two and three-dimensional computer models.

A code evaluation of the case study building was carried out using the 1982 UBC and the ATC-3 seismic load provisions. Finally, the response of the analytical model to moderate earthquake motions representative of those in the Southeastern region was determined. Results of the dynamic analyses and code studies were compared, and the implications for aseismic design of this large and important class of structures were discussed.

Title: Seismic Evaluation of Low-Rise Steel Office Buildings - Case Study II

Author: Jean P. Pinelli

ABSTRACT

In the U.S.A., as much as 80% of the office buildings are low-rise buildings. In zones of moderate seismicity most of them are designed for wind load only and very few if any, outside California, are designed for code level seismic loads. However, since these structures serve so many people in their daily activities they must be designed and constructed to resist moderate earthquakes without loss of life or excessive damage.

In the Atlanta area, a typical two story office building was selected for seismic evaluation. It is a steel frame structure with bar joist roof, precast panels and masonry facade. A code evaluation of the building with U.B.C. '82 and A.T.C. 3-06 was carried out. Computer models of the structure were formulated and response spectrum analyses of the models were performed to study its response to moderate earthquakes.

Results of code evaluations and dynamic analyses were compared. The implications of the study with regard to improved seismic design of low-rise steel-frame office buildings were discussed.

Title: An Analytical Model for Seismic Response Analysis of Low-rise Steel Buildings using Microcomputers
Author: Mark C. Streit

ABSTRACT

As the efficiency and capability of the microcomputer increases, so does the scope of its application in structural engineering computation. One particular application, structural dynamic analysis, has inherently required efficient memory usage and computational algortihms due to the large arrays and tedious numerical computation involved. A coarse breakdown illustrating some of the computations invloved would consist of: dynamic matrix formulation, solution of an algebraic eigenvalue problem, coordinate transformations and numerical solution for time history dynamic response which may include displacements, velocities, accelerations, and force resultants.

The primary focus of this special research has been to develop a computer program which would be implemented on a microcomputer to effectively model low-rise steel-framed buildings and calculate their seismic response to earthquake excitation. This class of buildings, one to five stories in height, has been modelled considering both rigid and flexible floor diaphragm-action. An assemblage of two dimensional frames and/or trusses is employed to develop the stiffness properties of a building model. Inertia properties are user- specified and are processed within the program to account for any required translation-of-axes. A dynamic analysis is performed to compute the response time history of the system subjected to seismic excitation in the form of applied ground accelerations. Using the resulting displacement response, the forces at the dynamic degrees of freedom are determined and a vector of maximum lateral forces is computed for each frame. The computed results are compared against those obtained using a program based on the response spectrum method (RSPECB). The response spectrum method is a more approximate, although more widely used method of analysis. An evaluation of the effect of base fixity, mass distribution, and type of excitation is also discussed.

To provide a realistic test model, a low-rise steel framed office building in the Atlanta area was selected for evaluation. The selected building had been used in a response spectrum analysis conducted by a previous researcher. A comparison is made between the two analytical methods, namely modal analysis and response spectrum. The modelling procedures, assumptions, and program implementation are discussed. Information on microcomputer compilation and execution along with a discussion of the limitations of the program is also included.