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Optimum Seismic Protection for New Building Construction in Eastern Metropolitan Areas

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Internal Progress Report #2

PROGRESS THROUGH FEBRUARY

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It is the intent of the staff to prepare a brief progress report at the end of each two-month period. This is the third such report.

The current listing of work tasks appears on the following pages. This list is still in flux, with new tasks being added and existing tasks being modified.

The following sheets then summarize the status of the work under each task, enumerating the main accomplishments to date and the main efforts currently under way. As major progress is made upon tasks, detailed internal study reports are prepared. A list of such reports to date appears on the final sheet.

WORK TASKS

Group IA	Identification of building types		
a.	Inventory of buildings	LeMessurier	Complete. Internal Study Report to be issued.
b.	Comparison of wind and earthquake loadings	Biggs	Complete. See I.S.R. # 4.
c.	Choice of building categories	LeMessurier	
Group IB	Earthquake intensity study	Cornell	Boston area risk analysis complete. Internal study report to be issued.
Group IC	Effect of local soil conditions upon ground motions		
a.	Identification of typical soil profiles and their locations	Christian	Complete. See I.S.R. # 3.
b.	Microtremor studies	Christian	
c.	In-situ shear wave velocities (Weston Geophysical)	Christian	
d.	Basic amplification studies	Whitman	
e.	Preparation of input for dynamic analysis of structures	Christian	
f.	Suggested building code proposals	Christian	
Group ID	Identification of design strategies		
a.	Comparison of building codes	Biggs	
b.	Choice of design strategies	Biggs	
c.	Costs associated with design strategies	Biggs	

Group II	Dynamic response of buildings		
a.	Computer program for non-linear analysis	Roesset	
b.	Ductility study	Roesset	
c.	Relate dynamic response to damage	Biggs	
d.	Soil-structure interaction	Roesset	
e.	Pile-supported buildings	Whitman	
Group III	Damage state probability and associated cost matrices		
a.	Choice of matrices	Whitman	Complete. See I.S.R. # 5.
b.	Data from San Fernando quake	Reed	
c.	Data from other quakes	Reed	
Group IV	Analysis		
a.	Preliminary analysis	Vanmarcke	
b.	Study of non-physical costs	Not assigned	
c.	Study of discount rate	Not assigned	

Group IA Identification of building types

a. Inventory of buildings

Building survey has been completed and sample report has been distributed. (LeMessurier Associates)

b. Comparison of wind and earthquake loadings

A comparison for tall buildings has been completed and described in Internal Study Report No. 4 (J.M. Biggs).

c. Choice of building categories

Building categories to be studied are currently under investigation. Redesign of prototype for various design strategies is in progress. (LeMessurier Associates)

Group IB Earthquake intensity study

A semi-final draft of the report on the risk analysis of Boston was distributed for comments. These comments have been returned by all but Mr. Richard Holt. Several additional parameter studies were made in response to comments with no change in conclusions. The draft will be revised and expanded to reflect the comments, and distributed as a project report.

Based on the risk analysis conclusion that a close source is most threatening, parameters for a simulated ground motion model were selected. A "smoothed" sample accelerogram was prepared by Professor Vanmarcke for use by those needing to do dynamic analyses. (C.A. Cornell, H. Merz)

Group IC Effect of local soil conditions upon ground motions

a. Identification of typical soil profiles and their locations

Since Internal Study Report No. 3 was issued in November 1971, there has been no further effort here. Reporting on this item will be discontinued unless and until further study in other parts of the project reveal a need for better definition of the profile. (J.T. Christian, P.J. Trudeau).

b. Microtremor studies

Bolt, Baranek and Newman have apparently found the trouble with their equipment, but no further studies have been made. There is now a possibility that LNEC of Portugal may be able to do the work.

c. In-situ shear wave velocities

Four borings were completed in February 1972 near Westgate on the MIT campus. Weston Geophysical Research, Inc., will conduct the measurements around March 20 to 24, 1972. Some undisturbed samples from the borings will be used for resonant column tests (J.T. Christian).

d. Basic amplification studies

The studies of the errors arising from use of modal superposition and from the flexible rock approximation have been completed. Several months will be necessary for preparation of a report (R.V. Whitman).

e. Preparation of input for dynamic analysis of structures

Work continued on analyzing typical profiles. An Internal Study Report is being drafted on the work to date. Most of the effort has concentrated on determining the effect of soft shale under the clay and on identifying which profiles are most important from the point of view of amplification effects. (R.V. Whitman, J.T. Christian, J. Protonotarios)

f. Suggested building code proposals

No further progress.

Group ID Identification of design strategies

a. Comparison of building codes

Currently a comparison of 9 international seismic provisions (U.S. UBC '70, Canada, Chile, France, Greece, Italy, Japan, New Zealand, USSR) is being completed. (J.M. Biggs, S.K. Leslie).

b. Choice of design strategies

No new modifications

c. Costs associated with design strategies

The reanalysis, redesign, and costing of structural elements of the prototype building for different seismic intensities is progressing. For the framing system the redesign is nearly completed for zone 2 (Z = 1/2); for zone 3 (Z = 1) redesign will be completed shortly. For a special intensity (Z = 2) a decision on design strategy (reanalysis and redesign --new STRESS runs) or redesign from the original building design has not been made. Costing of the foundation, floor diaphragms, walls, core, present exterior panels, and the single story attached structure for intensity zones 2,3, and special will be completed shortly.

The costing for nonstructural items for the prototype building is being started by the firm of Ayres, Cohen & Hayakawa (California).

A decision has not yet been made on whether we shall have Ayres, Cohen & Hayakawa model nonstructural general packages (HVAC, electrical lights, etc.) for an apartment building and for an office building. If modelled these general packages will be costed for zones 3,2 and the special zones. (J.M. Biggs, S.K. Leslie)

Group II Dynamic Response of Buildings

a. Computer program for non-linear analysis

The first version of the computer program for the non-linear analysis is ready and the data for the typical building to be analyzed have been prepared. By the time you read this the first results will have probably been obtained. This version of the program treats close-coupled systems with three degrees of freedom per floor (two translations and one rotation). Six different types of load-deflection curves are used to represent the non-linear behavior of the different structural and non-structural elements. These models include such factors as stiffness and/or strength degradation, following laws that best fit experimental data.

Before the program was implemented, an evaluation of four different numerical integration procedures was carried out. We were concerned with stability, accuracy and speed of the different methods for systems with a relatively large number of degrees of freedom. It was found that the "impulse acceleration method" was much faster than the other methods (4th order Runge Kutta, Wilson's) and gives very good results (at least for the type of problem we are interested in).

Features to be implemented in the future:

1. Evaluation of damage
2. Far-coupled elements
3. Soil springs (J.M. Roesset, S. Anagnostopoulos)

b. Ductility Study

This part of the study will start in the next week (J.M. Roesset, S. Anagnostopoulos).

c. Relate dynamic response to damage

Work on this area is carried out by Bob Czarnecki. Results of his investigations will be used in the implementation of the damage prediction component of the above program (part a). (J.M. Biggs, J.W. Reed, S. Anagnostopoulos, R. Czarnecki)

d. Soil-structure interaction

No further progress.

e. Pile-supported buildings

Survey of the literature and consideration of the general characteristics of this problem are complete. A short report summarizing this information is planned. No further studies are contemplated during the next several months (R.V. Whitman, R. Flores).

Group III Damage State Probability and Associated Cost Matrices

a. Choice of matrices

Internal study report number 5 shows the matrix formulation which will now be used for the project (R.V. Whitman, E.H. Vanmarcke, J.W. Reed).

b. Data from San Fernando quake

100 questionnaires out of 250 were filled out by building owners. Additional questionnaires will be sent to owners by a joint group, consisting of: MIT, The Building Owners Managers Association (BOMA), and Steinbrugge's group. Ayres has submitted to us all detailed damage reports (total 16). Currently damage matrices are being prepared based on information to date. (J.W. Reed, R. Czarnecki, E. Kausel)

c. Data from other quakes

The damage states (see following page) have been revised to reflect the information from Ayres'detailed damage reports on the San Fernando quake. Study of the Caracas earthquake has been completed (with damage matrices). Alaska (1964) quake is partially completed. Work on other quakes is progressing at a slower pace. The effort will be stepped up later this term and summer. (J.W. Reed, R. Czarnecki, E. Kausel, P. Marshall)

Suggested Damage States

	Description of Level of Damage	Ratio to Replacement Cost
0	No Damage	0
1	Minor non-structural damage--a few walls and partitions cracked, incidental mechanical and electrical damage	.001
2	Localized non-structural damage--more extensive cracking (but still not widespread); possibly damage to elevators and/or other mechanical/ electrical components	.005
3	Widespread non-structural damage--possibly a few beams and columns cracked, although not noticeable	.02
4	Minor structural damage--obvious cracking or yielding in a few structural members; substantial non-structural damage with widespread cracking	.05
5	Substantial structural damage requiring repair or replacement of some structural members; associated extensive non-structural damage	.10
6	Major structural damage requiring repair or replacement of many structural members; associated non-structural damage requiring repairs to major portion of interior; building vacated during repairs	.30
7	Building condemned	1.0
8	Collapse	1.0

Group IV Analysis

a. Preliminary analysis

We studied the data structure, storage requirements and input-output format for the computer program to evaluate expected future losses and to determine optimal strategies for all building categories. Dennis Roth and Debbie Walther are now writing the program, the first version of which will be used for the preliminary sensitivity study.

List of Internal Study Reports

1. R.V. Whitman, "Preliminary Work Plans and Schedules," August 1971.

2. E.H. Vanmarcke and R.V. Whitman, "Background for Preliminary Expected Future Loss Computations," October, 1971.

3. P.J. Trudeau, "Identification of Typical Soil Profiles in the Boston Basin Area," November, 1971.

4. J.M. Biggs, "Comparison of Wind and Seismic Forces on Tall Buildings," December, 1971.

5. R.V. Whitman, "Contribution to State-of-the-Art Report of the Earthquake Committee of the IABSE-ASCE Tall Buildings Committee--Economic and Social Aspects," March, 1972.