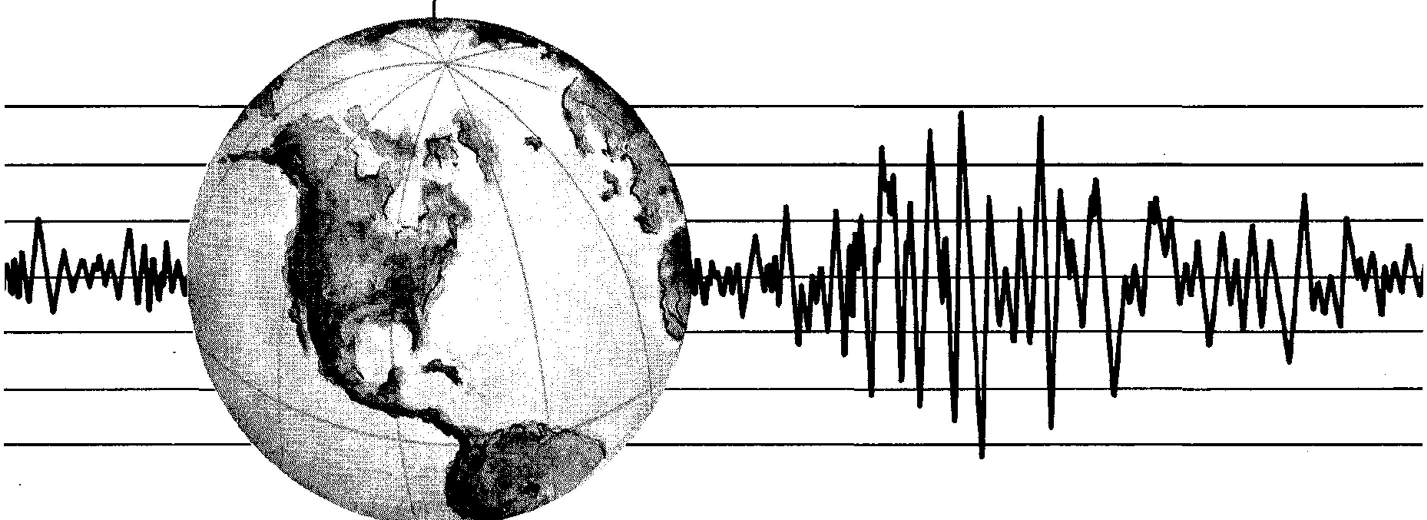
REPORT NO.
UCB/EERC-80/31
OCTOBER 1980

EARTHQUAKE ENGINEERING RESEARCH CENTER

PREDICTIVE DYNAMIC RESPONSE OF PANEL TYPE STRUCTURES UNDER EARTHQUAKES

by
J.P. KOLLEGGER
J.G. BOUWKAMP

Report to the National Science Foundation



COLLEGE OF ENGINEERING
UNIVERSITY OF CALIFORNIA · Berkeley, California

For sale by the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

See back of report for up to date listing of EERC reports.

BIBLIOGRAPHIC DATA SHEET

1. Report No. NSF/RA-800296

2.

3. Recipient's Accession No. PB81 152316

4. Title and Subtitle
Predictive Dynamic Response of Panel Type Structures Under Earthquakes

5. Report Date
October 1980

6.

7. Author(s)
J. P. Kollegger and J. G. Bouwkamp

8. Performing Organization Rept. No. UCB/EERC-80/31

9. Performing Organization Name and Address
Earthquake Engineering Research Center
Unviersity of Calif., Berkeley, R.F.S.
47th Street & Hoffman Boulevard
Richmond, Calif. 94804

10. Project/Task/Work Unit No.

11. Contract/Grant No.
PFR-7908257

12. Sponsoring Organization Name and Address
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

The potential coupling of translational and rotational motions of prefabricated panel systems under earthquake ground excitation is studied for several 12-story-high apartment buildings. Placement of apartments along the short end of these buildings and limiting the number of apartments along the long sides resulted in twelve different floor plans. The foundation flexibility was captured mathematically through introduction of a four-story-high "dummy story". Resonance and modal analyses were performed indicating considerable coupling of the longitudinal translational and torsional modal components. Under earthquake conditions both uncoupled and coupled translational and rotational motions were identified. The observed behavior was found to depend on both the degree of coupling of translational and rotational modal components of the buildings at the fundamental frequencies, as well as on the earthquake frequency response spectrum. A hypothesis regarding the anticipated behavior under earthquake excitation was developed and successfully tested against the analytical predicted structural response.

18. Availability Statement
Release Unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page
UNCLASSIFIED

21. No. of Pages

22. Price

EARTHQUAKE ENGINEERING RESEARCH CENTER

PREDICTIVE DYNAMIC RESPONSE OF PANEL TYPE STRUCTURES UNDER EARTHQUAKES

A Report to the
National Science Foundation

by

J. P. Kollegger
J. G. Bouwkamp

Report No. UCB/EERC-80/31
College of Engineering
Department of Civil Engineering
University of California
Berkeley, California
October 1980

i.a

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The potential coupling of translational and rotational motions of prefabricated panel systems under earthquake ground excitation is studied for several 12-story-high apartment buildings. Placement of apartments along the short end of these buildings and limiting the number of apartments along the long sides resulted in twelve different floor plans. The foundation flexibility was captured mathematically through introduction of a four-story-high "dummy story." Resonance and modal analyses were performed indicating considerable coupling of the longitudinal translational and torsional modal components. Under earthquake conditions both uncoupled and coupled translational and rotational motions were identified. The observed behavior was found to depend on both the degree of coupling of translational and rotational modal components of the buildings at the fundamental frequencies, as well as on the earthquake frequency response spectrum. A hypothesis regarding the anticipated behavior under earthquake excitation was developed and successfully tested against the analytical predicted structural response.

1. INTRODUCTION

1.1 General

Modern multistory apartment buildings are often an assembly of prefabricated wall and floor elements. Results of several forced and ambient vibration studies of such buildings indicate that these structures have quite different dynamic characteristics than earthquake codes would tend to imply [1,2]. Advanced computer techniques permit prediction of the earthquake response provided that the computer model formulation is accurate. In that respect, the formulation of the foundation stiffness is particularly critical. Experimental results have shown a potentially dangerous coupling of translational and torsional modes, a phenomenon that could lead to serious earthquake damages. Hence, the paper focuses on the influence of the floor plan layout on the basic dynamic characteristics of typical panel-type structures.

Considering the overall floor plan of panel type structures an often rectangular shape can be noted. Invariably, the apartment layout along the front and back of a building calls for structural walls and partitions oriented in the short direction of the building. Furthermore, outside walls along the length of the building are often non-structural. Longitudinal structural walls are typically located along the interior central corridor and also, as partitions between apartments, at either end of the building. With such wall layouts, the stiffness in the shorter transverse direction, contrary to normal expectations, is commonly found to be larger than the stiffness in the longitudinal direction. In addition, longitudinal motion seems to be particularly susceptible to rotational coupling. Hence, the transverse story deflections at the end of the building may become a predominant factor under earthquake excitation. This phenomenon becomes particularly pronounced when the longitudinal wall layout is non-symmetric with respect to the mass center of the typical floors.

In order to study the potential coupling of translational and rotational response of prefab systems as affected by the overall floor plan configuration, several floor plans will be considered. The selected variants will allow an assessment of the effect of the relative translational and torsional stiffnesses on the overall response of these structures under different earthquake ground excitations.

1.2 Acknowledgement

The authors gratefully acknowledge the financial support provided by the National Science Foundation under Grant PFR-7908257.

2. DESCRIPTION OF THE ANALYZED STRUCTURES

Recently two apartment buildings, 12 and 8 stories in height, have been tested under forced and ambient vibrations [1,2]. The structures were of the "Forest City Dillon" prefab system. The vertical and horizontal load resistance was provided by reinforced concrete shear walls, oriented in both transverse and longitudinal directions. The wall dimensions were constant over the entire height of these buildings. Both structures were found on piles with lengths varying from 32 to 50 feet.

Incorporating the basic panel elements of the above prefab system, three structural variants, A1, B1, and C1, with different floor plans, were formulated for this study (Fig. 2.1). The A1 floor plan is very similar to the two experimentally tested buildings. Considering the A1 variant and rotating the two extreme apartments, facing south by 90 degrees, led to a floor plan with three apartments on either end of the building (variant B1). This arrangement results in an increase in the longitudinal stiffness and a reduction of the transverse and torsional stiffnesses. Adding one more unit on either end of the building resulted in variant C1. This arrangement effectively increases, in comparison with B1, both the torsional and longitudinal stiffness.

In order to further evaluate the effect of the longitudinal stiffness relative to the transverse and torsional stiffnesses, three more basic layouts were considered. Two of these variations were developed by eliminating transverse walls in the central portion of each of the three basic floor plans A1, B1, and C1. Elimination of one set of transverse

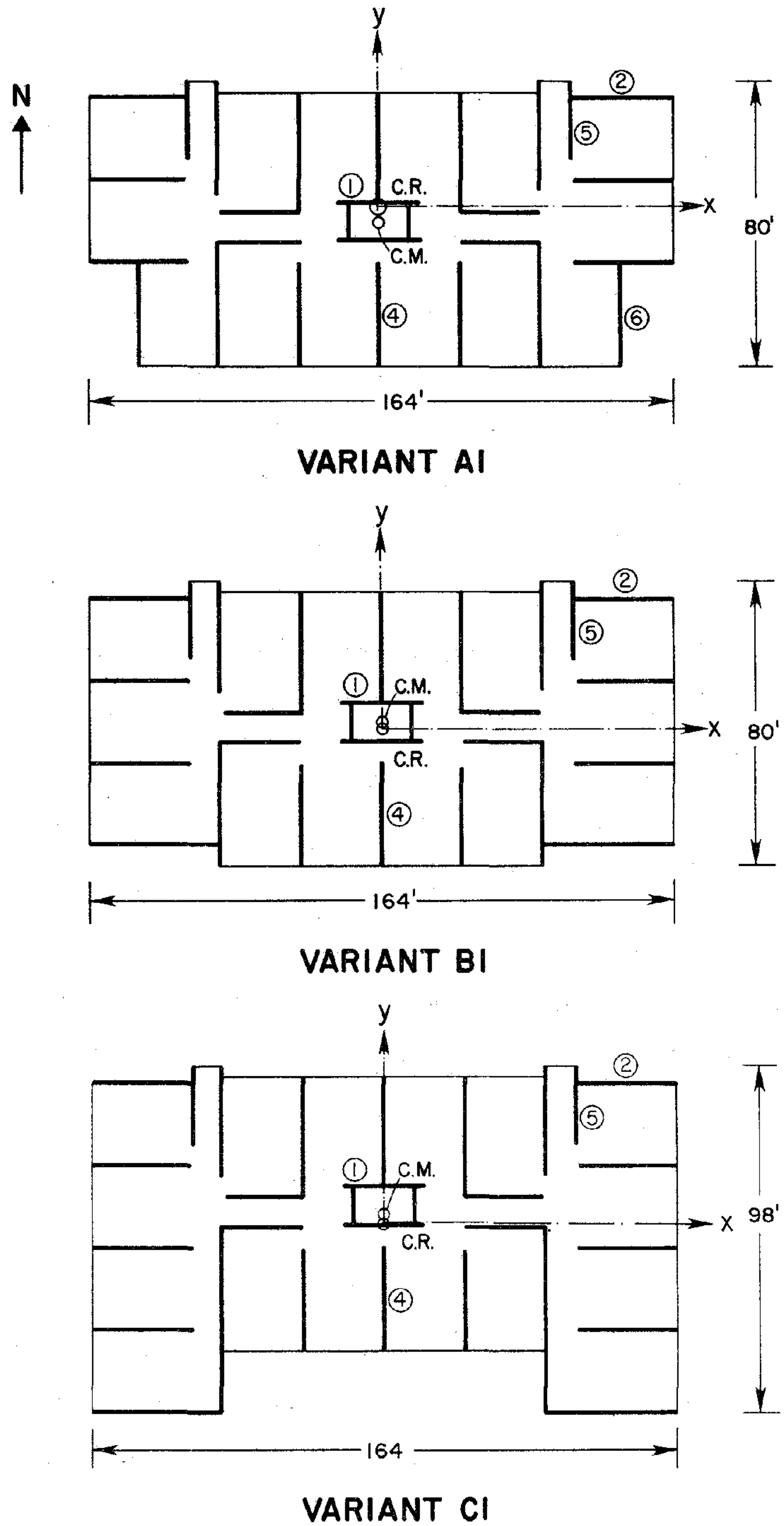
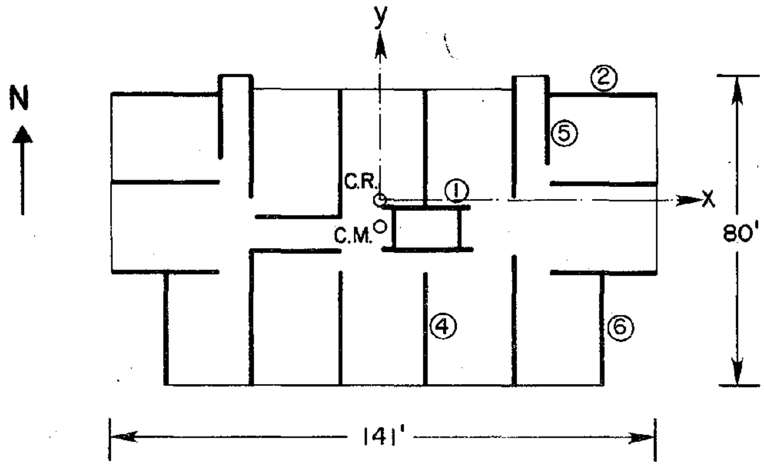
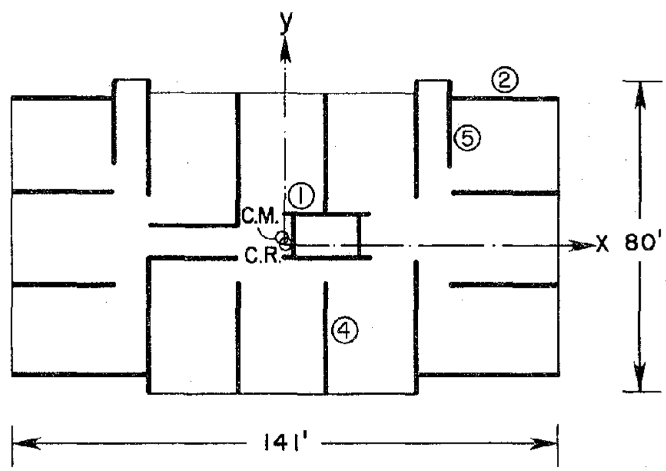


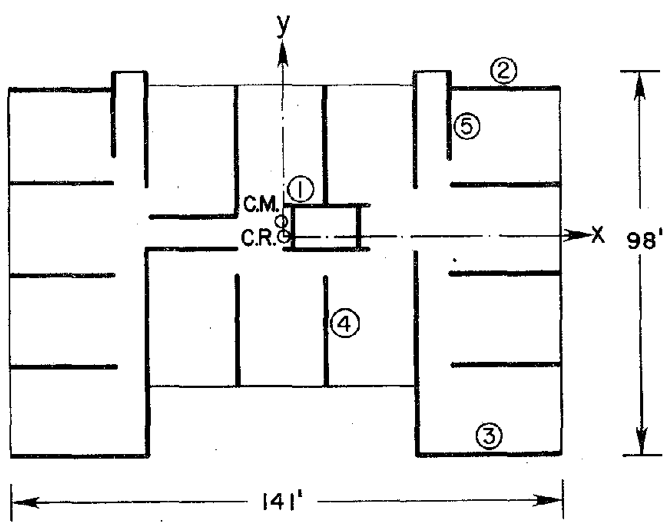
FIG. 2.1. FLOOR PLANS STRUCTURES A1, B1 AND C1.



VARIANT A2

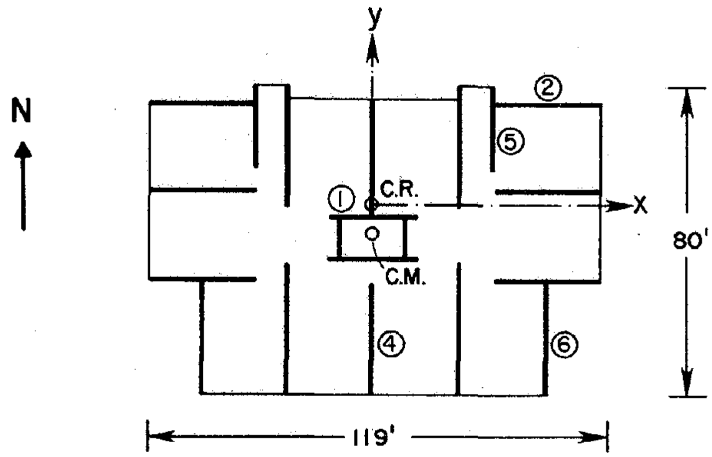


VARIANT B2

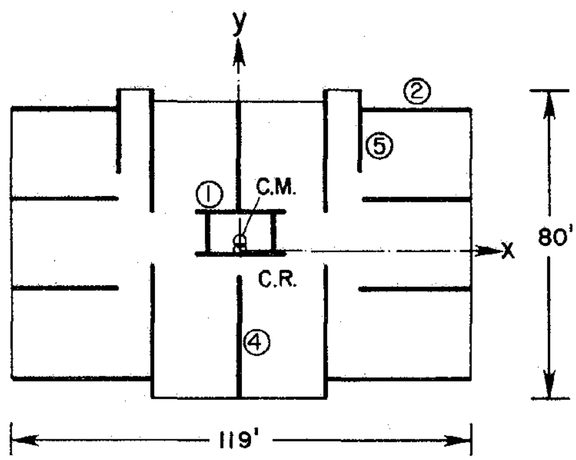


VARIANT C2

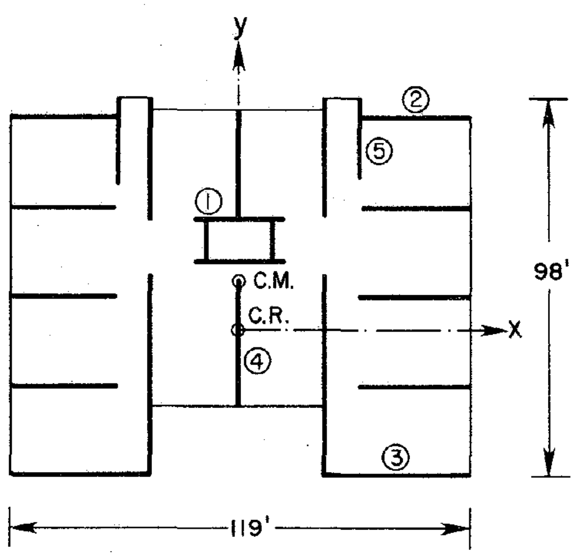
FIG. 2.2. FLOOR PLANS STRUCTURES A2, B2 AND C2



VARIANT A3

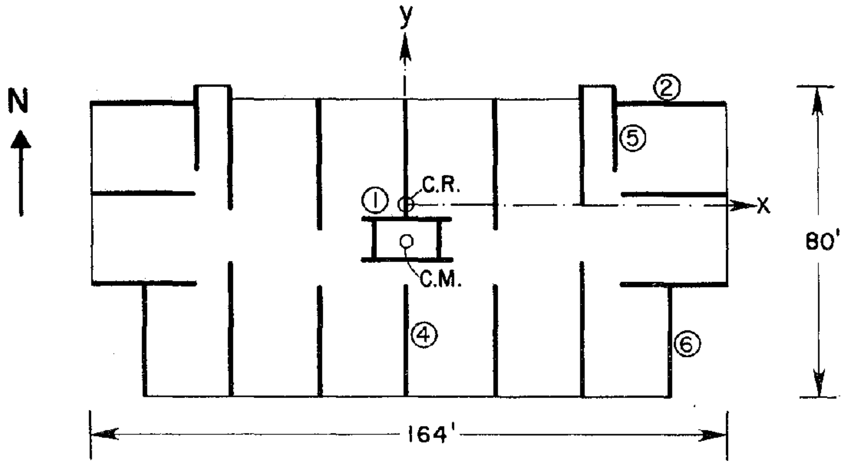


VARIANT B3

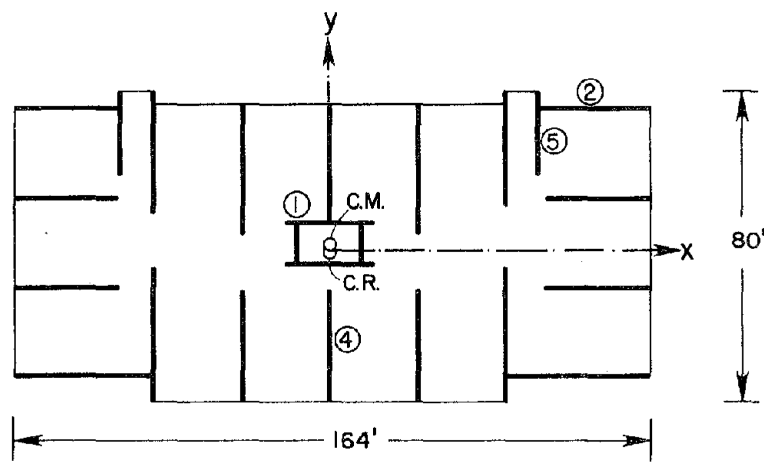


VARIANT C3

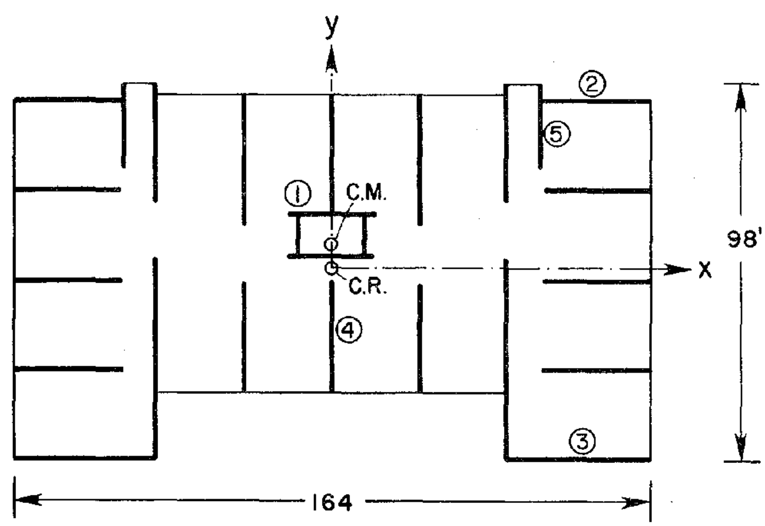
FIG. 2.3. FLOOR PLANS STRUCTURES A3, B3 AND C3



VARIANT A1-D



VARIANT B1-D



VARIANT C1-D

FIG. 2.4. FLOOR PLANS STRUCTURES A1-D, B1-D, C1-D

walls, or effectively removing one bay with two apartments, resulted in variants A2, B2, and C2 (Fig. 2.2). These structures were no longer symmetric with respect to the Y-axis and thus would effectively exhibit torsional coupling under both x and y excitation. A further reduction of the transverse stiffness was introduced by eliminating a second set of transverse walls. This resulted in variants A3, B3, and C3 (Fig. 2.3).

A further variation in layout, resulting in a reduction of both the longitudinal and, because of the flange action in perpendicular oriented walls, the transverse stiffness, was achieved by deleting four walls along the interior corridor of structures A1, B1, and C1. Compared with structures A1, B1, and C1, the resulting torsional stiffness of the variants, identified as A1-D, B1-D, C1-D, and shown in Fig. 2.4, remained basically unchanged because the deleted walls were positioned closely to the center of rigidity of the floor layout.

Typically, all structures studied in this investigation were 12 stories. With heights of 9.67 feet for the first story and 8.67 feet for the other stories, the overall building height was 105 feet.

3. MODELING OF THE STRUCTURES

Analytic computer models of the twelve different structures shown in Figs. 2.1 through 2.4 were developed to determine their dynamic characteristics. The models were formulated using both a rigid and an flexible base. TABS-77, a general purpose computer program [3], was used to calculate frequencies and mode shapes, as well as the linear elastic time-history response under earthquake ground excitation.

The program considers the floors to act as rigid diaphragms with zero transverse stiffness. All elements are assembled initially into planar frames and then transformed, using the rigid-diaphragm assumption, to three degrees of freedom (2 translational and 1 rotational) at the center of rigidity of each story level. The assumption of a rigid floor diaphragm for the subject studies was fully supported by the experimental results of the forced vibration studies of two Forest Dillon type buildings.

The basic model of each building was formulated as a system of frames and shear-wall elements interconnected by floor diaphragms which were rigid in their own plane. All walls were treated as "wide columns." This required a reduction of properties (I, A) to the elastic centroid of each wall. Where a wall is met by a perpendicularly oriented wall, a portion of the latter wall is assumed acting as a flange and is thus included in the moment of inertia calculation. For a "half-flange" condition, where two panels form a single corner, the effective width is taken as 1/6 of the overall building height, or 17.5 feet. In the case of a "full flange" condition, the effective width is assumed to be 1/3 of the height, or 35 feet. The above assumption is based on the fact that the walls are effectively interconnected at each floor level. The resulting dowel action over the height of the building seems to justify the assumed wall coupling, particularly for relatively small displacement conditions. A value of 4,000 ksi was used for the modulus of elasticity of the concrete. The reinforcing steel area was not included in calculating the moment of inertia of the shear walls; thus, the wall properties were the same for each of the 12 stories.

Wherever shear walls were positioned in one line, parallel to the direction of motion, it was assumed that those walls would be coupled by a portion of the floor slab with a width of 18 times the thickness of the floor. The effective span of the coupling girders was identical to the clear distance between the walls. Also, the effective height of the walls was taken as the clear height between two stories.

The masses, lumped at each story level, were calculated neglecting non-structural elements with a concrete weight of 0.15 kips/ft^3. The locations of the center of mass and the center of resistance, which is calculated on the assumption that the wall panels are clamped at both ends, are shown in Figs. 2.1 through 2.4.

4. MODELING OF THE FOUNDATION

During the experimental building tests on the 12-story building, significant horizontal motion--up to 10% of the top story displacement--was recorded at the ground floor level. Therefore, it was considered necessary to develop analytical building models which would properly reflect the observed flexible base condition.

Combining the forced vibration test measurements of the horizontal ground displacements with the base overturning rotations, as estimated from the mode shapes, the following approach was used to model the base flexibility. The measured floor accelerations times the floor masses gave the elastic forces for each floor level, from which the base shear and the overturning moment could be computed. Comparing base shear and moment with the experimentally determined displacement and rotation at the ground floor allowed an evaluation of the translational and rotational stiffness of the foundation for both directions.

The lateral and rotational foundation stiffnesses for the two apartment buildings tested are presented in Table 4.1. In order to account for the foundation flexibility, the TABS program permits the introduction of a dummy story fixed at the base. The heights of these dummy stories as based on the different experimental stiffness values for the two test structures are also shown in Table 4.1. As the results were found to be rather similar for these structures, a representative height of approximately 32 feet was selected for the 12-story-high buildings under investigation, or, 30% of the structural height.

TABLE 4.1 ROTATIONAL AND LATERAL FOUNDATION STIFFNESSES

BUILDING	f [CPS]	FORCING DIRECTION	$K_\theta \times 10^9$ (k.ft/rad)	$K \times 10^7$ (k/ft)	HEIGHT Dummy Story [ft]
12-STORY	2.18	TRANSVERSE	4.54	1.31	32.3
12-STORY	1.76	LONGITUDINAL	3.29	1.73	23.9
12-STORY	2.09	LONGITUDINAL	5.65	1.18	38.0
8-STORY	3.41	TRANSVERSE	3.70	0.87	35.6
8-STORY	2.68	LONGITUDINAL	1.78	1.15	21.6
CURRENT	-	TRANSVERSE	4.54	1.32	32.2
ANALYSIS	-	LONGITUDINAL	6.02	1.75	32.2

5. FREQUENCY AND MODE SHAPE ANALYSES

In the first part of the dynamic analysis, frequencies and mode shapes for the twelve different structures were evaluated considering both a rigid and flexible foundation. Panel structures are quite rigid, and their seismic response is basically determined by the fundamental modal responses. Hence, only three fundamental resonant frequences were considered; namely, $f_{x\theta_1}$, $f_{x\theta_2}$, and f_y. Of these three frequencies, two frequencies exhibit significant coupling between the translational x-motion and rotation (θ). The frequency at which the torsional effect is most pronounced has been termed the "torsional frequency."

A compilation of the mass and stiffness data for each of the twelve structures is presented in Table 5.1, where the lateral and rotational stiffnesses have been calculated for an 8.67-foot-high story on the assumption that the wall panels are clamped at both ends. The resonant frequencies for a flexible-base condition are also shown in Table 5.1. The "torsional frequencies" are specifically identified in this table. Also shown are the eccentricity distances e_x and e_y between the center of mass (C.M.) and the center of rigidity (C.R.). The e_y values are a direct indication of the potential coupling of the longitudinal x-motion and rotation. The small variations in the natural frequencies of the twelve structures seem to indicate that the effect of the different layouts is relatively small.

For each structure the three basic frequencies for both a rigid base condition, disregarding any soil-structure interaction, and a flexible base condition, are presented in Table 5.2. As expected, the frequencies for the structures with a 32-foot-high dummy story, reflecting the flexible base, are smaller than the rigid-base values. For each of the structures the percentage change for the two fundamental x-θ coupled frequencies and the y-frequency are presented in the same table. In general, the frequencies for the flexible base condition are from 70% to 80% of those for the rigid base condition.

From these findings one can conclude that the effect of the dummy story on the frequencies can be captured by introducing the height of the dummy story as an addition to the total structural height of the building. Considering that the height of the dummy story is 32 ft., or basically four stories, the rigid and flexible base conditions represent structures with 12 and 16 stories, respectively. With experimental results from full-scale vibration studies carried out on prefabricated panel type buildings [1,2] indicating a proportionality between height and period, the fundamental frequencies of a 16-story structure would be only 75% of those of a 12-story structure with the same floor plan. This is in excellent agreement with the noted percentages in Table 5.1.

The previously noted x-θ coupling at resonance can be observed most clearly through normalized floor modes at the 12th floor level. The floor modes for the 12th floor and the resonant frequencies for both the rigid and flexible base conditions are presented in Tables 5.3, 5.4, and 5.5 for the x-, torsional-, and y-modes, respectively. Examples of such x- and y-normalized mode shapes are shown in Fig. 5.1 for structures A1 and C2. The results shown reflect the generally observed behavior of the several structures considered in this study.

Because of the y-axis symmetry of the floor plan in the ABC-1, ABC-3, and ABC-1-D type structures (see Figs. 2.1, 2.3, 2.4), these structures typically exhibit, as illustrated by structure A1 in Fig. 5.1, a pure translational y-mode. However, for these structures, the other two frequencies typically show a significant coupling of the x and torsional modal components. In this respect, the results shown in Fig. 5.1, as well as the mode identification noted in Table 5.2, indicate that the base flexibility may change the torsional contribution in the two x-θ coupled modes. In certain instances (A1, C1, A2, and C2), the flexible base condition alters the torsional contribution to the extent that the first fundamental frequency becomes the frequency with a predominant torsional modal component. In a few instances, such as for variants C1, C2, and C3, the foundation flexibility also causes a reversal of the y and one x-θ frequency. This behavior is illustrated by the floor-mode shapes for structure C2 as shown in Fig. 5.1. This structure also illustrates the torsional y-coupling effect typical for the ABC-2 structures. This phenomenon is a direct result of the non-symmetric layout of these structures with respect to both the x and y axes (see Fig. 2.2).

The relative magnitude of the rotation of the x-mode with respect to the rotation of the torsional mode at the 12th floor was computed for each building. The resulting percentage values of the relative degree of rotational coupling (C) for the twelve buildings studied on a flexible base are presented in Table 5.6. The same table also shows the results for the three buildings ABC-1 with an assumed rigid base condition. The percentages for the B-type structures, with consistently lower torsional stiffness (Table 5.1), are all smaller than 22%, whereas the A- and C-type variants have all higher values, ranging from 26% to 82%. These values seem to correlate also with the degree of eccentricity; e.g., the distance between the center of mass and the center of rigidity.

The fundamental uncoupled y frequency and the lower frequency of the coupled x-θ mode for the different structures with flexible base, thus reflecting the appropriate foundation-structure interaction, are presented in Table 5.7. Also shown for comparison are the fundamental translational frequencies for by the x and y direction of these buildings using the period T as given by the Uniform Building Code ($T = 0.05\ h/\sqrt{D}$). The latter frequencies were calculated using the basic structural building height of 105 feet as specified by the UBC. Also indicated are the frequencies for a building with an effective height of 137 feet (structural height plus height of dummy story). The results show poor agreement between the analytical and UBC frequencies. In fact, in a total reversal of the UBC derived fundamental frequencies, the analytical frequencies are larger for resonance in the y-direction than for resonance in the x-direction.

TABLE 5.1 STRUCTURE PROPERTIES AND RESONANT FREQUENCIES FOR FLEXIBLE BASE CONDITION

VARIANT	M (k-sec²/ft)	$M_\theta \times 10^3$ (k-ft sec²)	e_x (ft)	e_y (ft)	$K_x \times 10^7$ (k/ft)	$K_y \times 10^7$ (k/ft)	$K_\theta \times 10^{10}$ (k-ft/rad)	$fx\theta_1$ (cps)	$fx\theta_2$ (cps)	f_y (cps)
A1	55.44	135.56	0.	4.73	0.55	0.67	1.26	1.70*	2.01	2.07
B1	57.00	153.10	0.	-1.30	0.67	0.58	0.95	1.60*	2.13	2.01
C1	64.54	182.07	0.	-2.84	0.75	0.64	1.39	1.83*	2.09	2.03
A2	46.94	89.55	0.43	6.69	0.44	0.58	0.80	1.64*	2.03	2.14
B2	48.49	102.07	0.85	-1.71	0.56	0.49	0.65	1.60*	2.15	2.05
C2	56.03	126.80	0.80	-3.56	0.65	0.54	1.00	1.76*	2.18	2.05
A3	38.39	55.54	0.	7.50	0.34	0.48	0.47	1.50	2.10*	2.18
B3	39.98	64.29	0.	-2.29	0.45	0.39	0.43	1.66*	2.22	2.01
C3	47.52	85.43	0.	-12.39	0.54	0.45	0.81	1.77	2.27*	2.11
A1-D	51.96	127.05	0.	8.44	0.34	0.67	1.25	1.41	1.91*	2.68
B1-D	53.52	143.74	0.	-1.70	0.45	0.58	0.95	1.51*	1.89	1.92
C1-D	61.06	172.25	0.	-5.72	0.54	0.64	1.38	1.62	2.03*	1.97

* = "torsional frequency" - maximum torsional contribution

TABLE 5.2 FOUNDATION EFFECT

VARIANT	BASE CONDITION	f1(CPS)	f2(CPS)	f3(CPS)
A1	RIGID	2.23	2.57*	2.90y
	FLEXIBLE	1.70* (0.76)	2.01 (0.78)	2.07y (0.71)
B1	RIGID	2.17*	2.74	2.78y
	FLEXIBLE	1.60* (0.74)	2.01y (0.72)	2.13 (0.78)
C1	RIGID	2.53	2.86*	3.17y
	FLEXIBLE	1.83* (0.72)	2.03y (0.64)	2.09 (0.73)
A2	RIGID	2.04	2.52*	2.85y
	FLEXIBLE	1.64* (0.80)	2.03 (0.80)	2.14y (0.75)
B2	RIGID	2.07*	2.66y	2.72
	FLEXIBLE	1.60* (0.77)	2.05y (0.77)	2.15 (0.79)
C2	RIGID	2.37	2.78*	3.07y
	FLEXIBLE	1.76* (0.74)	2.05y (0.68)	2.18 (0.78)
A3	RIGID	1.79	2.49*	2.76y
	FLEXIBLE	1.50 (0.84)	2.10* (0.84)	2.18y (0.79)
B3	RIGID	2.06*	2.45y	2.75
	FLEXIBLE	1.66* (0.81)	2.01y (0.82)	2.22 (0.81)
C3	RIGID	2.27	2.87*	2.88y
	FLEXIBLE	1.77 (0.78)	2.11y (0.73)	2.27* (0.79)
A1-D	RIGID	1.67	2.42*	2.68y
	FLEXIBLE	1.41 (0.84)	1.91* (0.79)	2.03y (0.76)
B1-D	RIGID	1.92*	2.35	2.45y
	FLEXIBLE	1.51* (0.79)	1.89 (0.80)	2.45y (0.78)
C1-D	RIGID	2.11	2.64*	2.79y
	FLEXIBLE	1.62 (0.77)	1.97y (0.75)	2.03* (0.73)

y = translational frequency f_y * = "torsional frequency" f_θ

( ) = number between parentheses denotes % change

TABLE 5.3 RESONANT FREQUENCIES (f_x) AND FLOOR MODES FOR THE X-MODE

VARIANT	BASE CONDITION	FREQUENCY (CPS)	FLOOR MODES FOR THE 12th STORY		
			x-DIRECTION	y-DIRECTION	TORSION
A1	RIGID	2.23	1.000	0.	-0.0118
	FLEXIBLE	2.01	1.000	0.	0.0111
B1	RIGID	2.74	1.000	0.	-0.0045
	FLEXIBLE	2.01	1.000	0.	-0.0040
C1	RIGID	2.53	1.000	0.	0.0114
	FLEXIBLE	2.09	1.000	0.	-0.0122
A2	RIGID	2.04	1.000	0.002	-0.0142
	FLEXIBLE	2.03	1.000	-0.012	0.0196
B2	RIGID	2.72	1.000	-0.241	-0.0070
	FLEXIBLE	2.15	1.000	-0.150	-0.0069
C2	RIGID	2.37	1.000	-0.170	0.0188
	FLEXIBLE	2.18	1.000	-0.875	-0.0225
A3	RIGID	1.79	1.000	0.	-0.0172
	FLEXIBLE	1.50	1.000	0.	-0.0220
B3	RIGID	2.75	1.000	0.	-0.0108
	FLEXIBLE	2.22	1.000	0.	-0.0117
C3	RIGID	2.27	1.000	0.	0.0199
	FLEXIBLE	1.77	1.000	0.	0.0209
A1-D	RIGID	1.67	1.000	0.	-0.0060
	FLEXIBLE	1.41	1.000	0.	-0.0099
B1-D	RIGID	2.35	1.000	0.	-0.0080
	FLEXIBLE	1.89	1.000	0.	-0.0080
C1-D	RIGID	2.11	1.000	0.	0.0101
	FLEXIBLE	1.62	1.000	0.	0.0133

TABLE 5.4 RESONANT FREQUENCIES (f*) AND FLOOR MODES FOR THE TORSIONAL MODE

VARIANT	BASE CONDITION	FREQUENCY (CPS)	FLOOR MODES FOR THE 12th STORY		
			x-DIRECTION	y-DIRECTION	TORSION
A1	RIGID	2.57	1.000	0.	0.0347
	FLEXIBLE	1.70	1.000	0.	-0.0354
B1	RIGID	2.17	1.000	0.	0.0809
	FLEXIBLE	1.60	1.000	0.	0.0910
C1	RIGID	2.86	1.000	0.	-0.0299
	FLEXIBLE	1.83	1.000	0.	0.0280
A2	RIGID	2.52	1.000	-0.010	0.0366
	FLEXIBLE	1.64	1.000	0.003	-0.0256
B2	RIGID	2.07	1.000	-0.332	0.0719
	FLEXIBLE	1.60	1.000	-0.477	0.0727
C2	RIGID	2.78	1.000	0.455	-0.0213
	FLEXIBLE	1.76	1.000	-0.479	0.0275
A3	RIGID	2.49	1.000	0.	0.0397
	FLEXIBLE	2.10	1.000	0.	0.0301
B3	RIGID	2.06	1.000	0.	0.0561
	FLEXIBLE	1.66	1.000	0.	0.0524
C3	RIGID	2.87	1.000	0.	-0.0275
	FLEXIBLE	2.27	1.000	0.	-0.0262
A1-D	RIGID	2.42	1.000	0.	0.0675
	FLEXIBLE	1.91	1.000	0.	0.0384
B1-D	RIGID	1.92	1.000	0.	0.0462
	FLEXIBLE	1.51	1.000	0.	0.0461
C1-D	RIGID	2.64	1.000	0.	-0.0346
	FLEXIBLE	2.03	1.000	0.	-0.0258

TABLE 5.5 RESONANT FREQUENCIES (f_y) AND FLOOR MODES FOR THE Y-MODE

VARIANT	BASE CONDITION	FREQUENCY (CPS)	FLOOR MODES FOR THE 12th STORY		
			x-DIRECTION	y-DIRECTION	TORSION
A1	RIGID	2.90	0.	1.000	0.
	FLEXIBLE	2.07	0.	1.000	0.
B1	RIGID	2.78	0.	1.000	0.
	FLEXIBLE	2.01	0.	1.000	0.
C1	RIGID	3.17	0.	1.000	0.
	FLEXIBLE	2.03	0.	1.000	0.
A2	RIGID	2.85	0.002	1.000	0.0001
	FLEXIBLE	2.14	0.005	1.000	0.0002
B2	RIGID	2.66	0.252	1.000	0.0005
	FLEXIBLE	2.05	0.183	1.000	0.0021
C2	RIGID	3.07	-0.128	1.000	0.0068
	FLEXIBLE	2.05	0.742	1.000	-0.0037
A3	RIGID	2.76	0.	1.000	0.
	FLEXIBLE	2.18	0.	1.000	0.
B3	RIGID	2.45	0.	1.000	0.
	FLEXIBLE	2.01	0.	1.000	0.
C3	RIGID	2.88	0.	1.000	0.
	FLEXIBLE	2.11	0.	1.000	0.
A1-D	RIGID	2.68	0.	1.000	0.
	FLEXIBLE	2.03	0.	1.000	0.
B1-D	RIGID	2.45	0.	1.000	0.
	FLEXIBLE	1.92	0.	1.000	0.
C1-D	RIGID	2.79	0.	1.000	0.
	FLEXIBLE	1.97	0.	1.000	0.

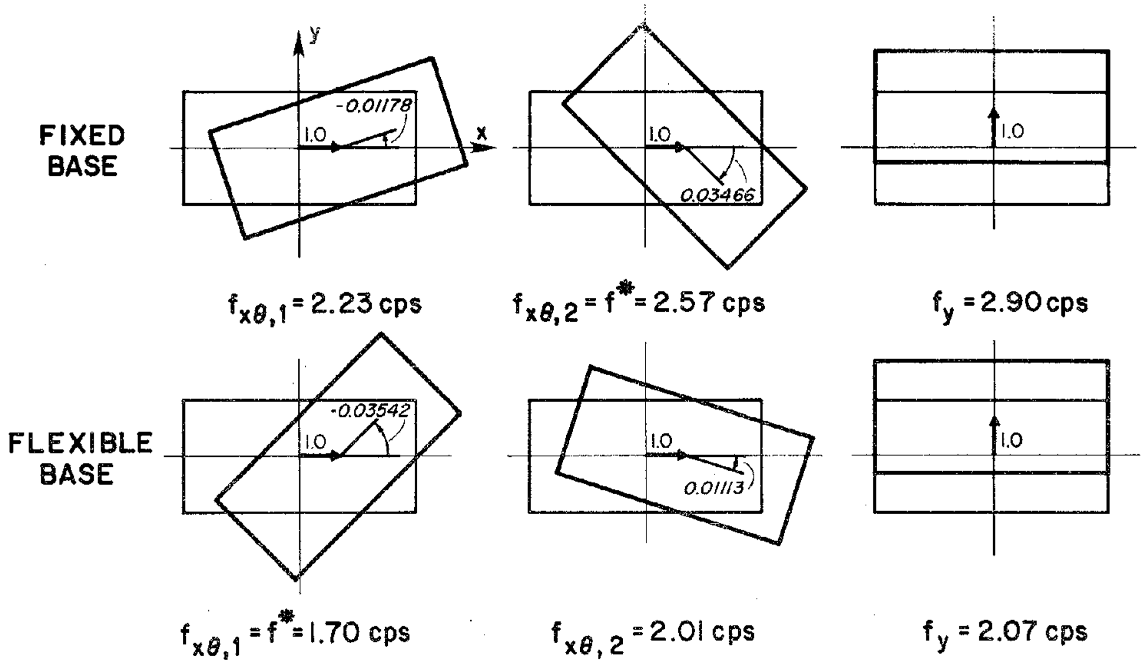
TABLE 5.6 DEGREE OF TORSIONAL COUPLING

VARIANT	BASE CONDITION	PERCENTAGE RATIO C*
A1	RIGID FLEXIBLE	34.0% 31.4%
B1	RIGID FLEXIBLE	5.6% 4.4%
C1	RIGID FLEXIBLE	38.1% 43.6%
A2	FLEXIBLE	76.6%
B2	FLEXIBLE	9.5%
C2	FLEXIBLE	81.8%
A3	FLEXIBLE	73.1%
B3	FLEXIBLE	22.3%
C3	FLEXIBLE	79.8%
A1-D	FLEXIBLE	25.8%
B1-D	FLEXIBLE	17.4%
C1-D	FLEXIBLE	51.6%

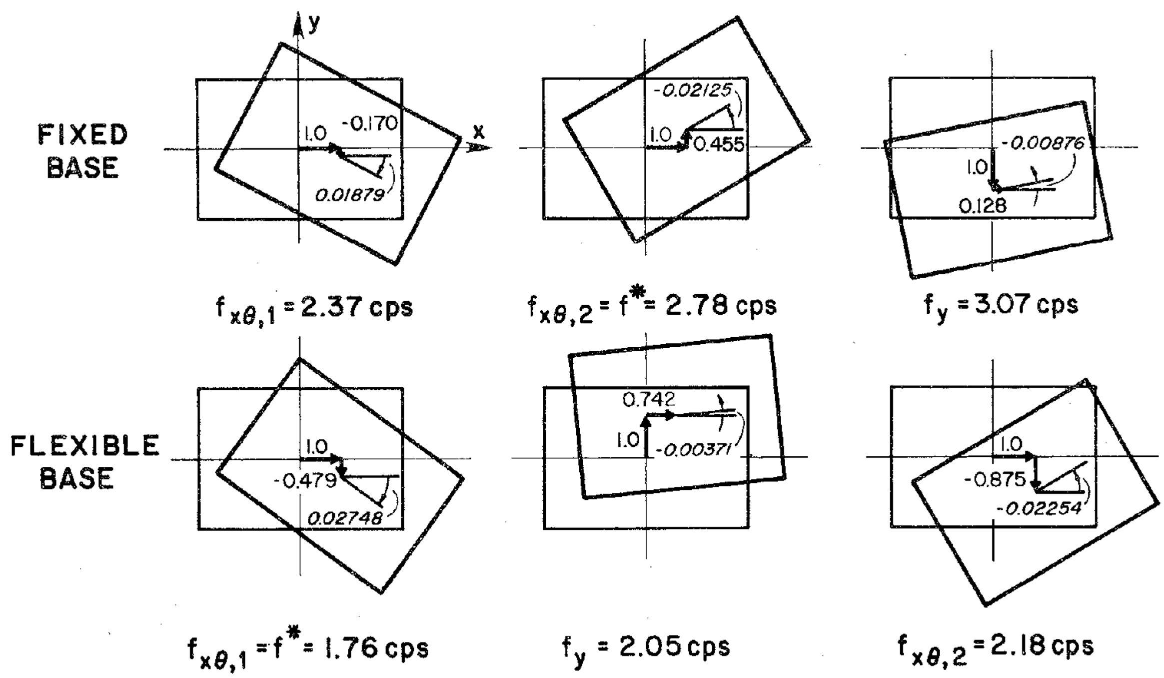
$$* \; C = \frac{\text{ROTATIONAL COMPONENT OF THE X-MODE}}{\text{ROTATIONAL COMPONENT OF THE } \theta\text{-MODE}} \times 100$$

TABLE 5.7 ANALYTICAL AND UBC FREQUENCIES

VARIANT	f_x (CPS)			f_y (CPS)		
	ANAL.	UBC-105[1]	UBC-137[1]	ANAL.	UBC-105[1]	UBC-137[1]
A1	1.70			2.07	1.70	1.30
B1	1.60	2.44	1.87	2.01		
C1	1.83			2.03	1.89	1.44
A2	1.64			2.14	1.70	1.30
B2	1.60	2.26	1.73	2.05		
C2	1.76			2.05	1.89	1.44
A3	1.50			2.18	1.70	1.30
B3	1.66	2.08	1.59	2.01		
C3	1.77			2.11	1.89	1.44
A1-D	1.41			2.03	1.70	1.30
B1-D	1.89	2.44	1.87	1.92		
C1-D	1.62			1.97	1.89	1.44



STRUCTURE A1



STRUCTURE C2

FIG. 5.1. MODE SHAPES 12th FLOOR - STRUCTURES A1 & C2

6. EARTHQUAKE TIME-HISTORY ANALYSIS

In order to gain information about the effect of longitudinal and torsional coupling of panel-type structures during seismic excitation, linear-elastic time-history analyses of the twelve structural variants were performed by submitting the buildings to longitudinal (E-W) directed ground excitation. In the first instance all structures were subjected to the N-S component of the 1940 El Centro earthquake with a maximum acceleration of 0.35 g. Subsequently, in order to study the effect of different ground excitations on the building response, structures ABC-1, with both flexible and rigid base conditions, were subjected to two additional earthquake ground-motion records; namely, the S69E component of the 1952 Kern County (Taft) earthquake with a peak acceleration of 0.18 g, and Pacoima Dam S14W record of the 1971 San Fernando earthquake with a scaled down peak acceleration of 0.35 g.

Selecting a linear-elastic time-history was considered to be justified as it will capture the important initial phase of the structural response. Another justification for the selected procedure was the notion that the principally localized nature of structural damages, short of collapse, will not alter the general building behavior from the analytically predicted response, particularly for the selected ground-motions. Admittedly, the non-linear soil-foundation characteristics can alter drastically the overall dynamic behavior.

The response of the structures for the first eight seconds of seismic excitation of the El Centro earthquake and for the first 12 seconds of the Taft and Pacoima Dam records resulting from an E-W excitation at the dummy story base level, was evaluated. The ground motion was assumed to be constant over the length of the buildings, and no torsional earthquake components were considered. Under those conditions, a structure with coincident center of mass and center of resistance would not experience any torsional motion during such ground-motion. However, because of uncertainties in both the calculation of the mass and stiffness centers and the load distribution, as well as a result of structural imperfections, non-linear behavior, and other factors, it would be unreasonable to assume that torsional motion under earthquake excitation could be prevented.

Although the response to the three fundamental modes is predominant, the contribution of the first fifteen modes was included in the analysis. The damping ratios for the three fundamental modes were based on the results of actual tests of a 12-story building; namely, 2% for the first mode and 1.4% for the second and third modes. The damping ratios for all other modes were taken at 2%.

The results of the time-history response studies under El Centro earthquake ground motion are presented in Figs. 6.1 through 6.4. These figures show for each of the variants the x and y displacements of the center of resistance at the 12th-floor level and the associated floor rotations versus time. Also indicated in these figures are the two basically coupled resonance frequencies and the frequencies of the translational and torsional response during the earthquake. These response frequencies were found by averaging the frequencies calculated from each half-cycle of structural response over the entire time-history.

Of the two coupled structural resonance frequencies, the torsional frequency f_θ is defined as the translational resonance frequency with the highest degree of rotational coupling. Although also coupled, the other frequency is labeled as the translational frequency f_x. Fundamental and response frequencies for the structures with a flexible base subjected to the El Centro ground-motion are compared in Table 6.1. Under the x-directed excitation, the structures always responded in an x-motion with a frequency close to the fundamental x-mode frequency. This was true even for structures where the difference between the rotational contributions in the x- and θ-mode was quite small (A2, C2, A3, and C3). However, the torsional response of the structures to seismic excitation occurred at a frequency close to either the fundamental torsional or the fundamental translational (f_x) frequency. In the first instance, the translational and rotational motions would, in fact, be uncoupled. However, in case the torsional motions occur at the fundamental translational frequency of the structure, the translational and torsional motions of the building are, in fact, coupled.

Reviewing the time-history results for the structures on flexible base subjected to the El Centro ground-motion, it can be observed that each building during the first few seconds of the earthquake responds in an uncoupled manner; i.e., the translational and torsional motions are 90° out of phase. For buildings A1, C1, A2, and C2, this uncoupled response continues for most of the earthquake; only for a few cycles did a temporary in-phase response develop. Contrary to this favorable behavior, the initially uncoupled motion does not prevail for buildings B1 and B2. In those two cases, a virtually total in-phase response develops after a few seconds. However, fortunately the effect of the torsional response for these two structures is small in comparison to the translational response. This combined in-phase behavior is also supported by the two response frequencies f_x and f_θ of both buildings, as noted in the same figures. It is obvious that the tuning of both response frequencies with the resonance frequency f_x causes this coupled effect. In fact, the uncoupled response frequencies for buildings A1, C1, A2, and C2, as noted also in Table 6.1, seem to support the previously noted out-of-phase response of the torsional and translational components of motion.

The above noted differences in response appear to be directly related to the degree of torsional coupling associated with the translational resonance frequency f_x, as compared with the maximum torsional coupling associated with the so-called rotational resonance frequency f_θ. For instance, for buildings A1, C1, A2, and C2, which exhibit an out-of-phase response, the torsional coupling (C) for the f_x frequencies amounted to, respectively, 31, 43, 77, and 82% of the torsional components of the f_θ frequency (see Table 6.1). However, for buildings B1 and B2 these percentages were only 4 and 9%, respectively. Hence, it seems that significant torsional coupling at the translational resonance frequency results in an uncoupled response under earthquake excitation. On the other hand, a small degree of torsional coupling at resonance results in a combined in-phase translational and rotational response under earthquake conditions.

The above hypothesis is clearly supported by the in-phase response of buildings B3 and B1-D for which the previously noted rotational coupling percentages were only 22 and 17 percent, respectively. Also, for buildings A3, C3, A1-D, and C1-D, with rotational coupling percentages of 73, 80, 26, and 52 percent, respectively, the hypothesis seems to hold, as the response shows a predominantly out-of-phase behavior.

In order to investigate the general validity of the above hypothesis, as it may be affected by the ground-motion input, buildings ABC-1 on flexible base were also subjected to the first 12 seconds of the Taft and Pacoima Dam ground motion records. The resulting x displacements and rotations at the center of the resistance at the 12th floor level are presented in Figs. 6.5 and 6.6. The associated structural and response frequencies are presented in Table 6.2. The uncoupled or coupled manner of response, as determined by the comparison of the fundamental frequencies of the structure with the response frequencies, as shown in this table, correlates favorably to the observed response as shown in Figs. 6.5 to 6.6.

The results indicate that for both the El Centro and Taft ground-motions, the buildings A1 and C1 respond in an uncoupled fashion, while building B1 behaves in a coupled manner. However, in the case of the Pacoima Dam ground excitation, the three structures under study showed a coupled response, seemingly contradicting the above hypothesis. The reason for this different behavior, which reflects, in effect, a lack of excitation at the torsional resonance frequency, seems to be related to the energy of the earthquake record at this particular frequency.

The response spectra for the El Centro, Taft, and Pacoima Dam records are shown in Figs. 6.7 through 6.9, respectively. The fundamental x and θ frequencies of the ABC-1 structures are rather similar, averaging 2.1 cps for the translational and 1.70 cps for the torsional modes (Table 6.2). Considering the curves for 2% critical damping in each of the spectra for the corresponding averaged modal periods of 0.48 and 0.60 seconds, respectively, the spectral accelerations for these two modes are found to be approximately the same for the El Centro and Taft earthquakes. However, considering the Pacoima Dam spectrum, there is a distinct difference between the acceleration levels at these two fundamental periods. In fact, the spectral acceleration at about 0.48 secs, reflecting the x resonance period, is quite large. On the other hand, the acceleration level at about 0.6 secs. or the fundamental torsional period is a distinct minimum. Hence, it seems reasonable to expect that this earthquake would fail to cause significant rotations in these structures. However, instead, a predominantly translational, x-resonance, response will result. As noted earlier, in such instances a building would respond in a coupled fashion, with the maximum rotation occurring at the instant of maximum translation. This behavior under the Pacoima dam record is clearly illustrated in Fig. 6.6.

Finally, Tables 6.3 and 6.4 summarize the maximum displacements and rotations at the roof level for the 18 different combinations of structures and earthquake records that were used in this analysis. Comparing the maximum rotations for the A and C structures with those for the B variants shows that the rotations developed in the B-type structures are generally lower.

TABLE 6.1 STRUCTURAL AND RESPONSE FREQUENCIES FOR EL CENTRO RECORD

VARIANT	C [%]	MODE	FREQUENCY (CPS) FUNDAMENTAL	FREQUENCY (CPS) RESPONSE	MODE OF RESPONSE
A1	31	X θ	2.01 1.70	2.04 1.73	UNCOUPLED
B1	4	X θ	2.13 1.60	2.14 1.94	HIGHLY COUPLED
C1	43	X θ	2.09 1.83	2.08 1.88	UNCOUPLED
A2	77	X θ Y	2.03 1.64 2.14	2.06 1.79 --	UNCOUPLED
B2	9	X θ Y	2.15 1.60 2.05	2.16 2.01 2.10	COUPLED
C2	82	X θ Y	2.18 1.76 2.05	2.17 1.85 2.09	UNCOUPLED
A3	73	X θ	1.45 2.10	1.56 1.64	UNCOUPLED
B3	22	X θ	2.22 1.66	2.20 2.04	COUPLED
C3	80	X θ	1.77 2.27	1.78 1.92	UNCOUPLED
A1-D	26	X θ	1.41 1.91	1.48 1.67	PREDOMINANTLY UNCOUPLED
B1-D	17	X θ	1.89 1.51	1.87 1.73	PREDOMINANTLY COUPLED
C1-D	52	X θ	1.62 2.03	1.80 1.85	PREDOMINANTLY UNCOUPLED

C = Torsional coupling percentage of f_x versus f_r

TABLE 6.2 STRUCTURAL AND RESPONSE FREQUENCIES (FLEXIBLE BASE)

VARIANT	C [%]	MODE	FREQUENCY (CPS) STRUCTURE	FREQUENCY (CPS) RESPONSE	MODE OF RESPONSE	EXCITATION
A1	31	X θ	2.01 1.70	2.04 1.73	UNCOUPLED	EL CENTRO
B1	4	X θ	2.13 1.60	2.14 1.94	HIGHLY COUPLED	EL CENTRO
C1	43	X θ	2.09 1.83	2.08 1.88	UNCOUPLED	EL CENTRO
A1	31	X θ	2.01 1.70	2.03 1.83	PREDOMINANTLY UNCOUPLED	TAFT
B1	4	X θ	2.13 1.60	2.17 1.88	COUPLED	TAFT
C1	43	X θ	2.09 1.83	2.06 1.97	UNCOUPLED	TAFT
A1	31	X θ	2.01 1.70	2.08 1.94	COUPLED	PACOIMA DAM
B1	4	X θ	2.13 1.60	2.20 2.02	COUPLED	PACOIMA DAM
C1	43	X θ	2.09 1.83	2.10 2.03	COUPLED	PACOIMA DAM

TABLE 6.3 MAXIMUM DISPLACEMENTS AND ROTATIONS AT THE CENTER OF STIFFNESS OF THE ROOF

VARIANT	MAXIMUM DISPLACEMENT				MAXIMUM ROTATION		EXCITATION
	X-DIRECTION		Y-DIRECTION				
	(ft.)	t(sec)	(ft.)	t(sec)	(rad)	t(sec)	
A1	0.286	(2.40)	0.		0.0044	(3.10)	
B1	0.353	(5.10)	0.		0.0023	(2.55)	EL CENTRO
C1	0.340	(5.15)	0.		0.0040	(6.05)	
A2	0.279	(2.20)	0.090	(2.90)	0.0063	(2.85)	
B2	0.353	(5.10)	0.045	(6.90)	0.0034	(2.55)	EL CENTRO
C2	0.252	(2.15)	0.159	(6.40)	0.0040	(3.30)	
A3	0.314	(6.30)	0.		0.0085	(5.60)	
B3	0.283	(5.05)	0.		0.0053	(2.55)	EL CENTRO
C3	0.387	(3.60)	0.		0.0070	(5.25)	
A1-D	0.341	(6.10)	0.		0.0054	(2.65)	
B1-D	0.400	(5.15)	0.		0.0045	(5.65)	EL CENTRO
C1-D	0.324	(2.20)	0.		0.0050	(2.85)	

TABLE 6.4 MAXIMUM DISPLACEMENTS AND ROTATIONS AT CENTER OF STIFFNESS OF THE ROOF

VARIANT	MAXIMUM DISPLACEMENT				MAXIMUM ROTATION		EXCITATION
	X-DIRECTION		Y-DIRECTION				
	(ft.)	t(sec)	(ft.)	t(sec)	(rad)	t(sec)	
A1	0.286	(2.40)	0.		0.0044	(3.10)	EL CENTRO
B1	0.353	(5.10)	0.		0.0023	(2.55)	EL CENTRO
C1	0.340	(5.15)	0.		0.0040	(6.05)	EL CENTRO
A1	0.116	(11.10)	0.		0.0016	(9.60)	TAFT
B1	0.166	(8.10)	0.		0.0009	(6.25)	TAFT
C1	0.125	(6.75)	0.		0.0016	(7.65)	TAFT
A1	0.165	(8.60)	0.		0.0018	(9.60)	PACOIMA DAM
B1	0.153	(8.80)	0.		0.0010	(9.30)	PACOIMA DAM
C1	0.142	(8.60)	0.		0.0024	(9.30)	PACOIMA DAM

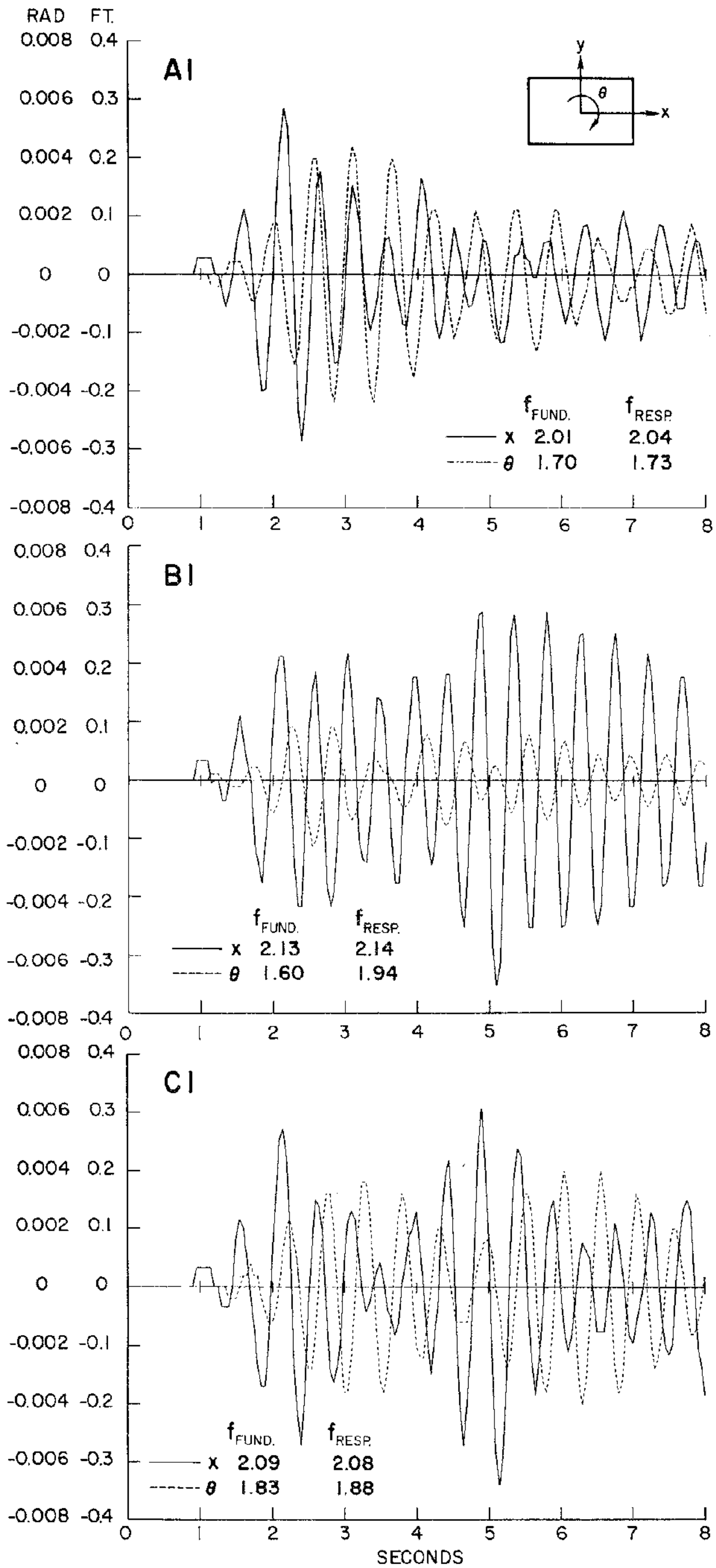


FIG. 6.1. EARTHQUAKE RESPONSE (EL CENTRO)

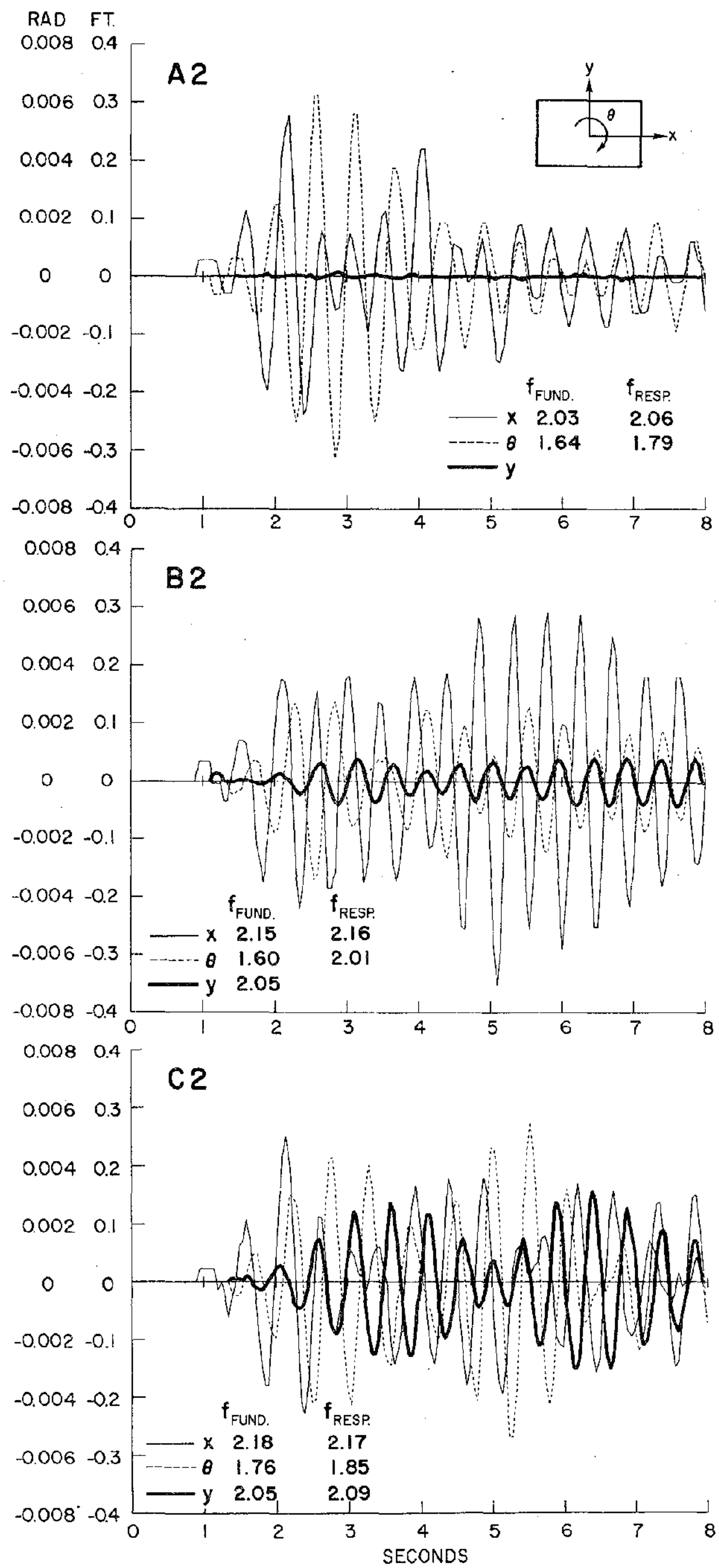


FIG. 6.2. EARTHQUAKE RESPONSE (EL CENTRO)

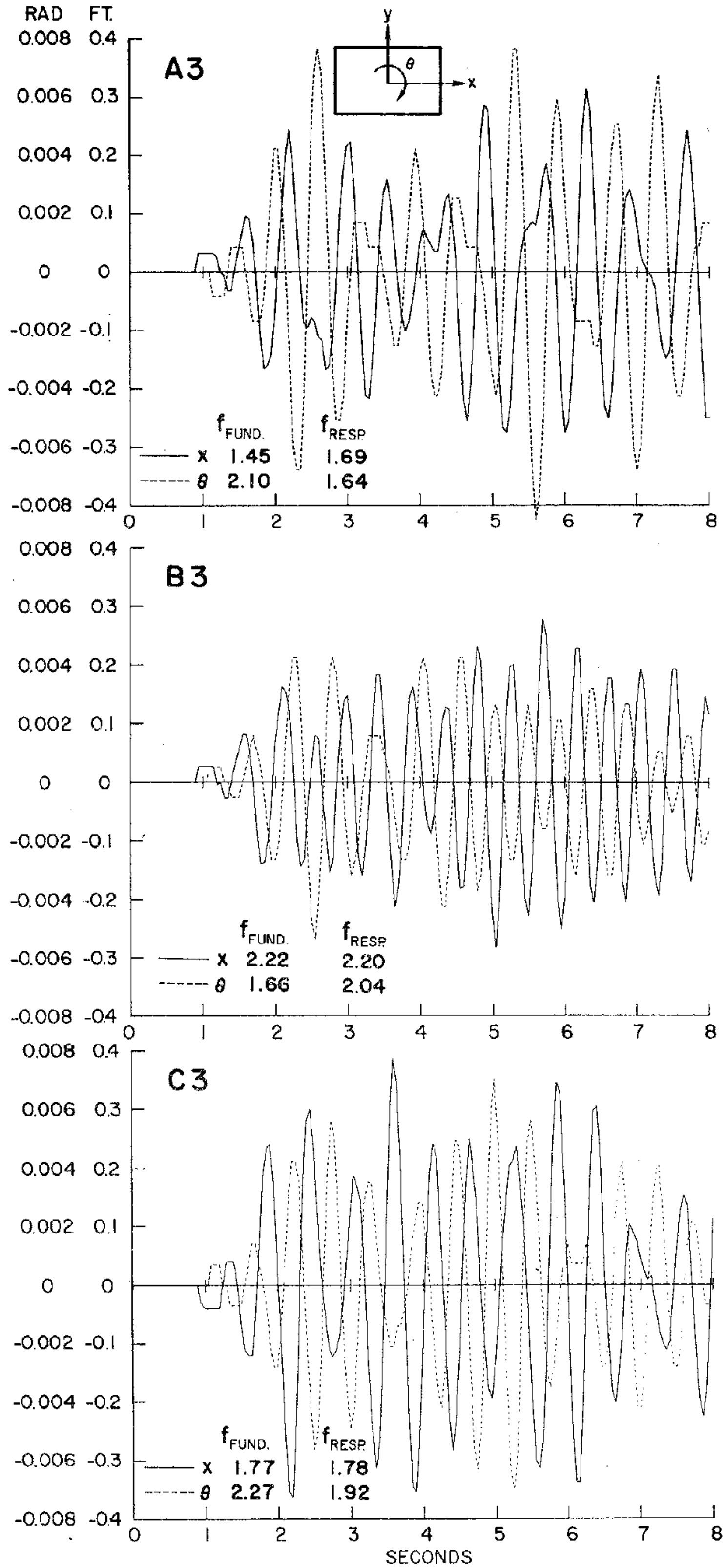


FIG. 6.3. EARTHQUAKE RESPONSE (EL CENTRO)

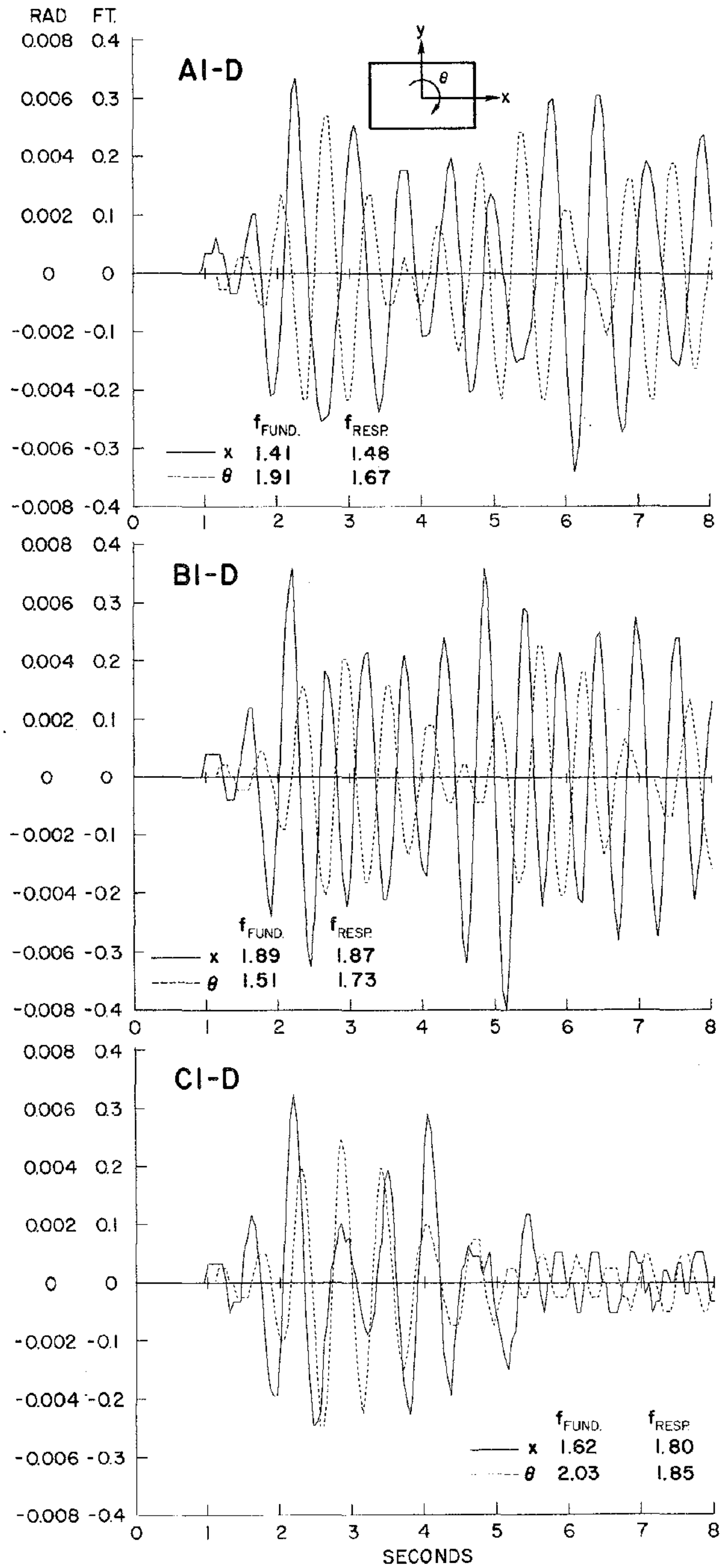


FIG. 6.4. EARTHQUAKE RESPONSE (EL CENTRO)

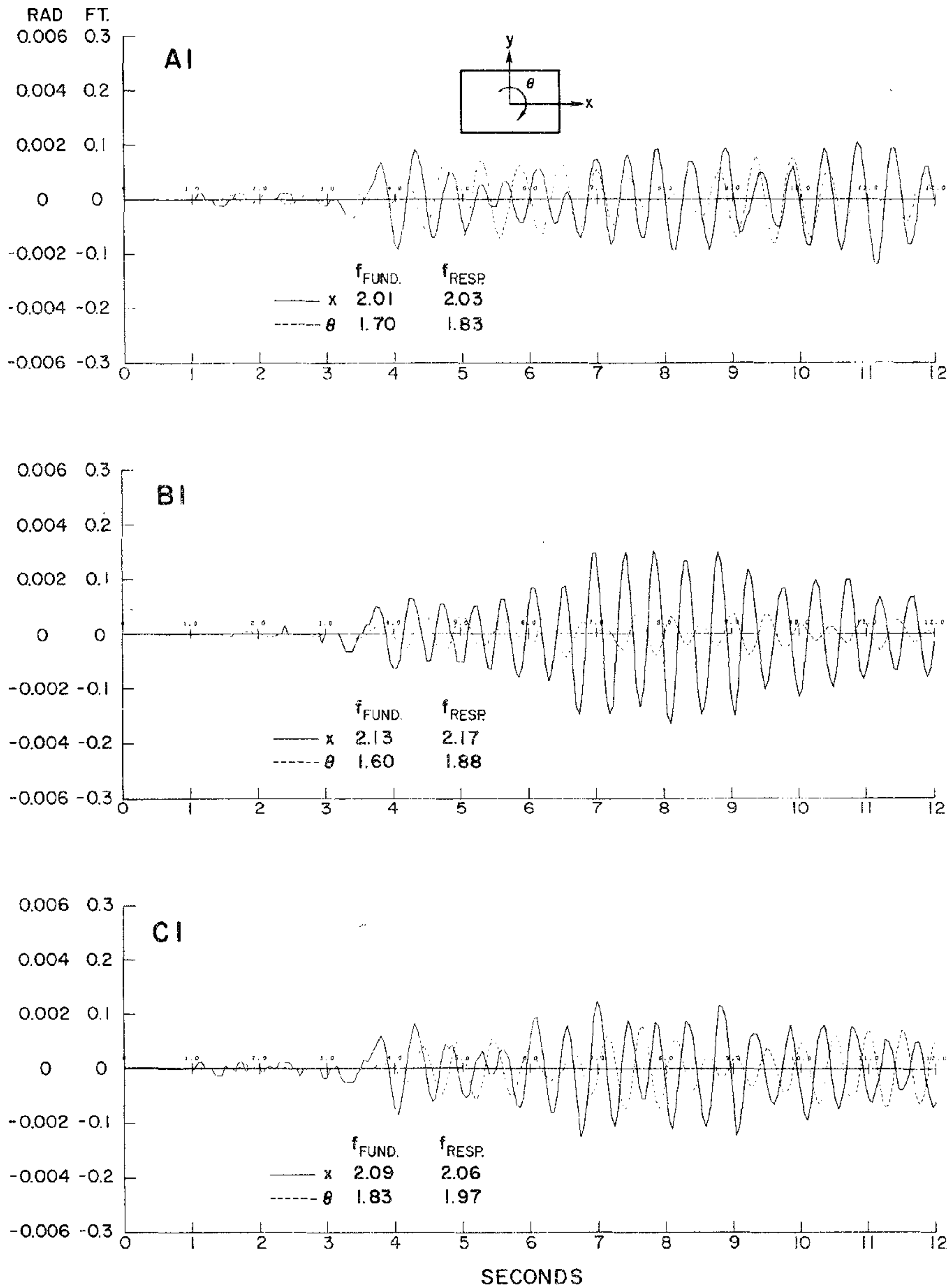


FIG. 6.5. EARTHQUAKE RESPONSE (TAFT)

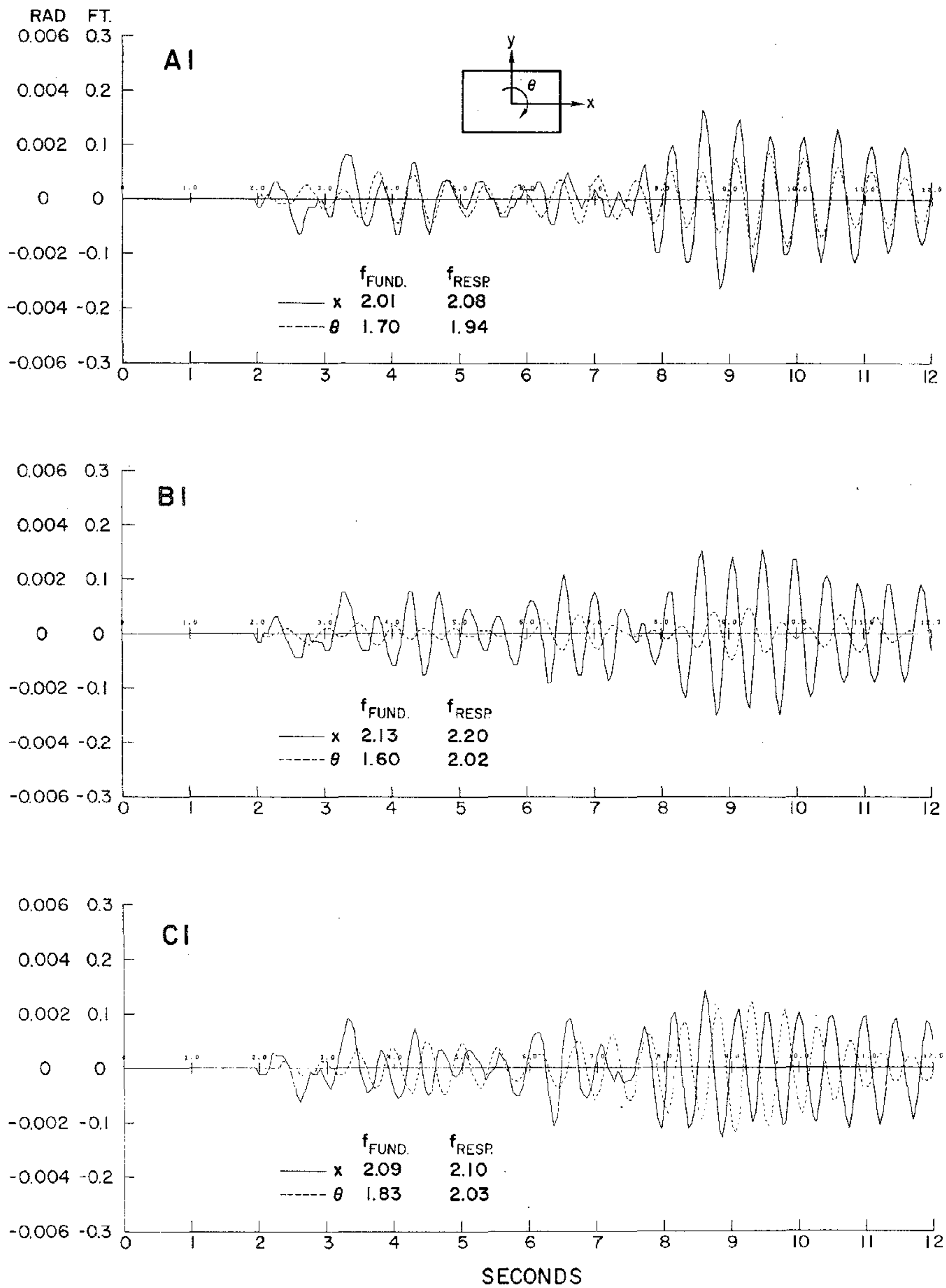


FIG. 6.6. EARTHQUAKE RESPONSE (PACOIMA DAM)

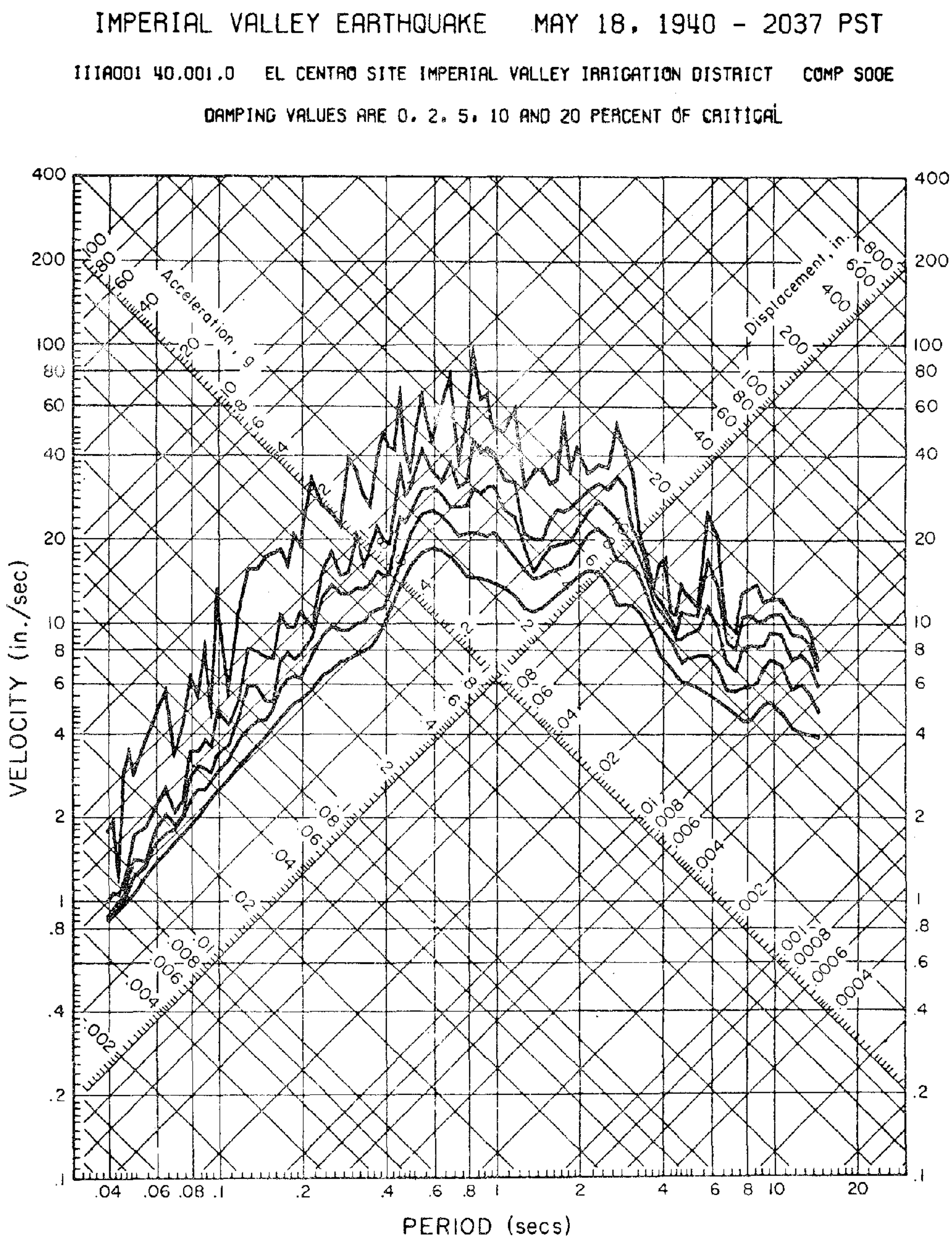


FIG. 6.7. RESPONSE SPECTRA - EL CENTRO RECORD

KERN COUNTY, CALIFORNIA EARTHQUAKE JULY 21, 1952 - 0453 PDT

IIIA004 52.002.0 TAFT LINCOLN SCHOOL TUNNEL COMP S69E

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

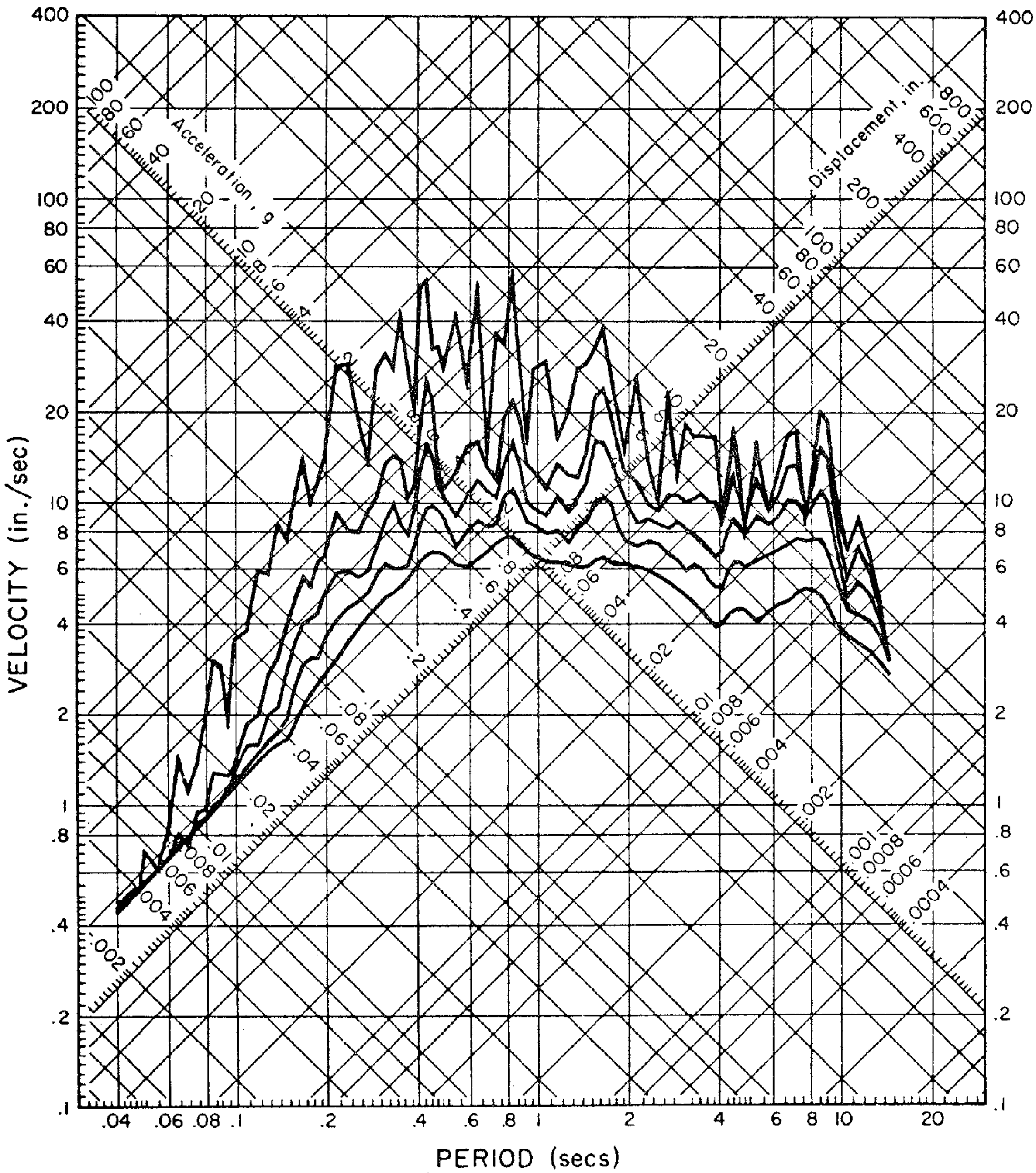


FIG. 6.8. RESPONSE SPECTRA - TAFT RECORD

SAN FERNANDO EARTHQUAKE FEB 9, 1971 - 0600 PST

IIIC041 71.001.0 PACOIMA DAM, CAL. COMP S14W

DAMPING VALUES ARE 0, 2, 5, 10 AND 20 PERCENT OF CRITICAL

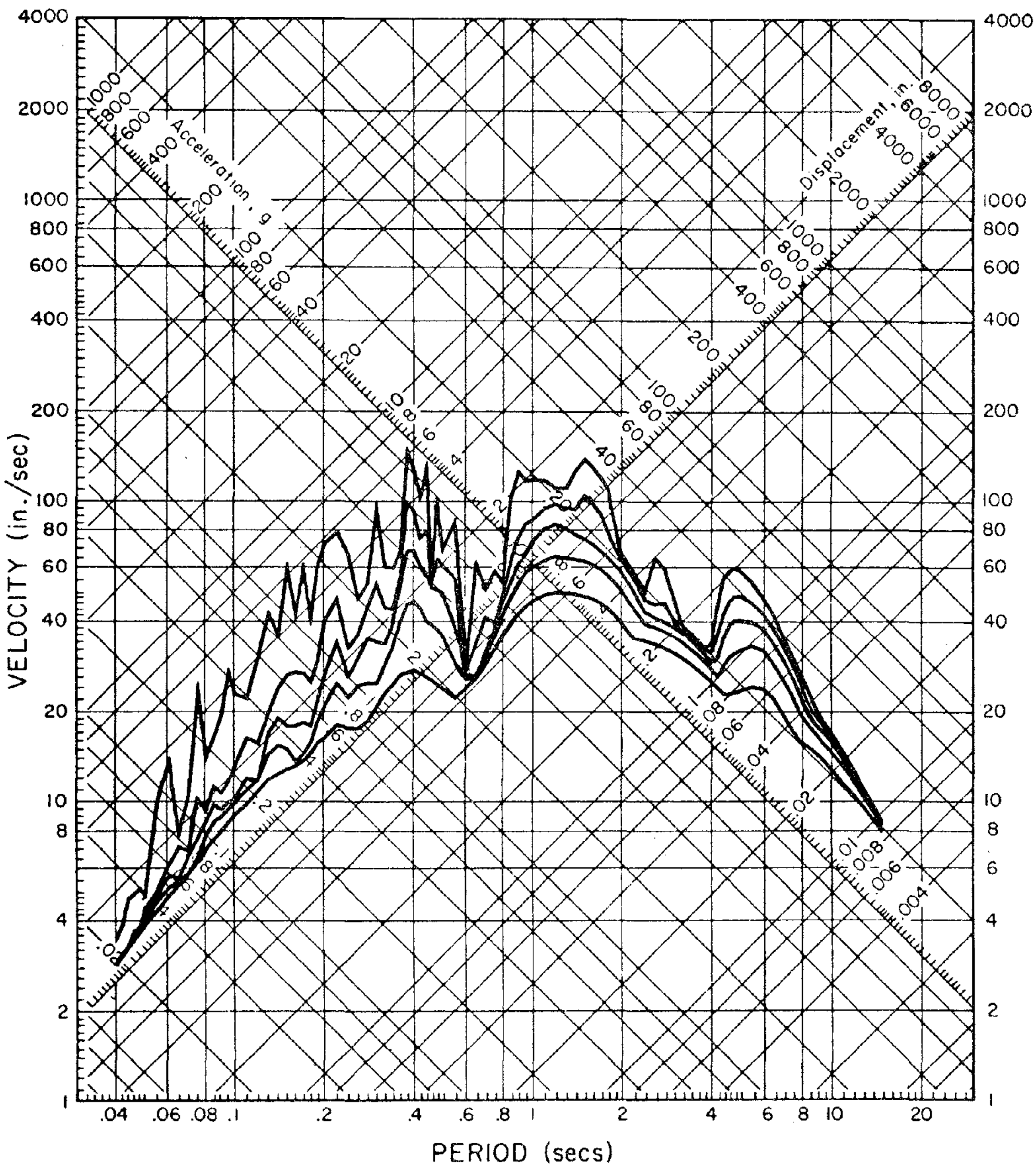


FIG. 6.9. RESPONSE SPECTRA - PACOIMA DAM RECORD

7. CONCLUSIONS

Results of full-scale vibration studies of prefabricated panel-type buildings indicated a considerable translational and rotational coupling at resonance. Soil-pile-structure interaction effects were found to contribute significantly to the overall building response. This phenomenon required the introduction of a so-called "dummy story" in the computer model formulation of the structure.

In order to achieve an appropriate correlation between experimental and analytical results, a dummy story height of 30% of the overall structure height was required. To assess the general dynamic characteristics of panel type buildings, a total of twelve 12-story-high structures with different floor plans were studied in an analytical investigation. The dummy story height for all buildings was selected as 30% of the overall building height. The results of resonance frequency and modal analyses indicated considerable translational and rotational coupling at resonance. Despite markedly different floor plans, the three fundamental resonance frequencies were rather closely spaced. In general, the effect of the foundation flexibility needs to be considered, as it affects not only the resonance frequencies but also the extent of the modal coupling. Analytical results for both a rigid and flexible foundation constitution indicated that the fundamental periods were directly proportional to the overall structural height, including the dummy story. UBC derived periods were found to be grossly different from computer analyzed values. This discrepancy is a direct result of the code's inability to account for the actual wall layout and associated lateral stiffness of panel buildings.

Depending on the symmetry of the floor plan, rotational coupling was observed at two or possibly three fundamental resonant frequencies. Two of these frequencies were invariably associated with x-normalized modes. The resonance frequency exhibiting the most pronounced rotational, or torsional, coupling was termed the "torsional" frequency. The other frequency, although exhibiting a smaller degree of rotational coupling, was termed the "translational" frequency. For the twelve structures studied, the degree of torsional coupling at resonance was found to have a direct bearing on the building response to earthquake excitation.

In case the torsional coupling at the translational resonance frequency was at least 25% of the torsional component at torsional resonance, the translational and rotational motions of the building under earthquake excitation were found to be uncoupled, or 90° out of phase. In the case of a smaller rotational coupling percentage at resonance, the translational and rotational components of motion of the building under earthquake excitation showed an in-phase response. Fortunately, the basically limited torsional contribution at resonance, as reflected by a low rotational percentage value, will also limit the rotational excursions of the building under ground excitations.

The above observation seems to hold, in general, provided that the earthquake acceleration at the fundamental structural periods is sufficient to excite the different structural modes. This energy dependent behavior was illustrated by the response of the buildings investigated under a Pacoima Dam excitation. In that case, both the translational and rotational motions occurred at the fundamental structural f_x-frequency, or in a coupled manner. The reason for this behavior was found in the frequency related energy of the Pacoima Dam earthquake, which lacks significant acceleration pulses at a period close to the fundamental torsional period. Hence, excitation in an uncoupled fashion was not possible.

The latter observation is particularly important as it may reflect the dependence of earthquake induced excitation on the energy level of the earthquake at specific fundamental periods, be it either torsional or translational. Initial studies under rigid base conditions, even for the El Centro and Taft earthquakes, seem to support their potential behavior for at least low coupled systems.

REFERENCES

1. Bouwkamp, J. G., Kollegger, J. P., and Stephen, R. M., "Dynamic Properties of a Twelve-Story Prefabricated Panel Building," Report No. EERC 80-29, Earthquake Engineering Research Center, University of California, Berkeley, 1980.

2. Bouwkamp, J. G., Kollegger, J. P., and Stephen, R. M., "Dynamic Properties of an Eight-Story Prefabricated Panel Building," Report No. EERC 80-30, Earthquake Engineering Research Center, University of California, Berkeley, 1980.

3. Wilson, E. L., Dovey, H. H., and Habibullah, A., "Three Dimensional Analysis of Building Systems--TABS-77," Report No. EERC 72-8, Earthquake Engineering Research Center, University of California, Berkeley, 1972.

EARTHQUAKE ENGINEERING RESEARCH CENTER REPORTS

NOTE: Numbers in parenthesis are Accession Numbers assigned by the National Technical Information Service; these are followed by a price code. Copies of the reports may be ordered from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia, 22161. Accession Numbers should be quoted on orders for reports (PB --- ---) and remittance must accompany each order. Reports without this information were not available at time of printing. Upon request, EERC will mail inquirers this information when it becomes available.

EERC 67-1 "Feasibility Study Large-Scale Earthquake Simulator Facility," by J. Penzien, J.G. Bouwkamp, R.W. Clough and D. Rea - 1967 (PB 187 905)A07

EERC 68-1 Unassigned

EERC 68-2 "Inelastic Behavior of Beam-to-Column Subassemblages Under Repeated Loading," by V.V. Bertero - 1968 (PB 184 888)A05

EERC 68-3 "A Graphical Method for Solving the Wave Reflection-Refraction Problem," by H.D. McNiven and Y. Mengi - 1968 (PB 187 943)A03

EERC 68-4 "Dynamic Properties of McKinley School Buildings," by D. Rea, J.G. Bouwkamp and R.W. Clough - 1968 (PB 187 902)A07

EERC 68-5 "Characteristics of Rock Motions During Earthquakes," by H.B. Seed, I.M. Idriss and F.W. Kiefer - 1968 (PB 188 338)A03

EERC 69-1 "Earthquake Engineering Research at Berkeley," - 1969 (PB 187 906)A11

EERC 69-2 "Nonlinear Seismic Response of Earth Structures," by M. Dibaj and J. Penzien - 1969 (PB 187 904)A08

EERC 69-3 "Probabilistic Study of the Behavior of Structures During Earthquakes," by R. Ruiz and J. Penzien - 1969 (PB 187 886)A06

EERC 69-4 "Numerical Solution of Boundary Value Problems in Structural Mechanics by Reduction to an Initial Value Formulation," by N. Distefano and J. Schujman - 1969 (PB 187 942)A02

EERC 69-5 "Dynamic Programming and the Solution of the Biharmonic Equation," by N. Distefano - 1969 (PB 187 941)A03

EERC 69-6 "Stochastic Analysis of Offshore Tower Structures," by A.K. Malhotra and J. Penzien - 1969 (PB 187 903)A09

EERC 69-7 "Rock Motion Accelerograms for High Magnitude Earthquakes," by H.B. Seed and I.M. Idriss - 1969 (PB 187 940)A02

EERC 69-8 "Structural Dynamics Testing Facilities at the University of California, Berkeley," by R.M. Stephen, J.G. Bouwkamp, R.W. Clough and J. Penzien - 1969 (PB 189 111)A04

EERC 69-9 "Seismic Response of Soil Deposits Underlain by Sloping Rock Boundaries," by H. Dezfulian and H.B. Seed 1969 (PB 189 114)A03

EERC 69-10 "Dynamic Stress Analysis of Axisymmetric Structures Under Arbitrary Loading," by S. Ghosh and E.L. Wilson 1969 (PB 189 026)A10

EERC 69-11 "Seismic Behavior of Multistory Frames Designed by Different Philosophies," by J.C. Anderson and V. V. Bertero - 1969 (PB 190 662)A10

EERC 69-12 "Stiffness Degradation of Reinforcing Concrete Members Subjected to Cyclic Flexural Moments," by V.V. Bertero, B. Bresler and H. Ming Liao - 1969 (PB 202 942)A07

EERC 69-13 "Response of Non-Uniform Soil Deposits to Travelling Seismic Waves," by H. Dezfulian and H.B. Seed - 1969 (PB 191 023)A03

EERC 69-14 "Damping Capacity of a Model Steel Structure," by D. Rea, R.W. Clough and J.G. Bouwkamp - 1969 (PB 190 663)A06

EERC 69-15 "Influence of Local Soil Conditions on Building Damage Potential during Earthquakes," by H.B. Seed and I.M. Idriss - 1969 (PB 191 036)A03

EERC 69-16 "The Behavior of Sands Under Seismic Loading Conditions," by M.L. Silver and H.B. Seed - 1969 (AD 714 982)A07

EERC 70-1 "Earthquake Response of Gravity Dams," by A.K. Chopra - 1970 (AD 709 640)A03

EERC 70-2 "Relationships between Soil Conditions and Building Damage in the Caracas Earthquake of July 29, 1967," by H.B. Seed, I.M. Idriss and H. Dezfulian - 1970 (PB 195 762)A05

EERC 70-3 "Cyclic Loading of Full Size Steel Connections," by E.P. Popov and R.M. Stephen - 1970 (PB 213 545)A04

EERC 70-4 "Seismic Analysis of the Charaima Building, Caraballeda, Venezuela," by Subcommittee of the SEAONC Research Committee: V.V. Bertero, P.F. Fratessa, S.A. Mahin, J.H. Sexton, A.C. Scordelis, E.L. Wilson, L.A. Wyllie, H.B. Seed and J. Penzien, Chairman - 1970 (PB 201 455)A06

EERC 70-5 "A Computer Program for Earthquake Analysis of Dams," by A.K. Chopra and P. Chakrabarti - 1970 (AD 723 994)A05

EERC 70-6 "The Propagation of Love Waves Across Non-Horizontally Layered Structures," by J. Lysmer and L.A. Drake 1970 (PB 197 896)A03

EERC 70-7 "Influence of Base Rock Characteristics on Ground Response," by J. Lysmer, H.B. Seed and P.B. Schnabel 1970 (PB 197 897)A03

EERC 70-8 "Applicability of Laboratory Test Procedures for Measuring Soil Liquefaction Characteristics under Cyclic Loading," by H.B. Seed and W.H. Peacock - 1970 (PB 198 016)A03

EERC 70-9 "A Simplified Procedure for Evaluating Soil Liquefaction Potential," by H.B. Seed and I.M. Idriss - 1970 (PB 198 009)A03

EERC 70-10 "Soil Moduli and Damping Factors for Dynamic Response Analysis," by H.B. Seed and I.M. Idriss - 1970 (PB 197 869)A03

EERC 71-1 "Koyna Earthquake of December 11, 1967 and the Performance of Koyna Dam," by A.K. Chopra and P. Chakrabarti 1971 (AD 731 496)A06

EERC 71-2 "Preliminary In-Situ Measurements of Anelastic Absorption in Soils Using a Prototype Earthquake Simulator," by R.D. Borcherdt and P.W. Rodgers - 1971 (PB 201 454)A03

EERC 71-3 "Static and Dynamic Analysis of Inelastic Frame Structures," by F.L. Porter and G.H. Powell - 1971 (PB 210 135)A06

EERC 71-4 "Research Needs in Limit Design of Reinforced Concrete Structures," by V.V. Bertero - 1971 (PB 202 943)A04

EERC 71-5 "Dynamic Behavior of a High-Rise Diagonally Braced Steel Building," by D. Rea, A.A. Shah and J.G. Bouwkamp 1971 (PB 203 584)A06

EERC 71-6 "Dynamic Stress Analysis of Porous Elastic Solids Saturated with Compressible Fluids," by J. Ghaboussi and E. L. Wilson - 1971 (PB 211 396)A06

EERC 71-7 "Inelastic Behavior of Steel Beam-to-Column Subassemblages," by H. Krawinkler, V.V. Bertero and E.P. Popov 1971 (PB 211 335)A14

EERC 71-8 "Modification of Seismograph Records for Effects of Local Soil Conditions," by P. Schnabel, H.B. Seed and J. Lysmer - 1971 (PB 214 450)A03

EERC 72-1 "Static and Earthquake Analysis of Three Dimensional Frame and Shear Wall Buildings," by E.L. Wilson and H.H. Dovey - 1972 (PB 212 904)A05

EERC 72-2 "Accelerations in Rock for Earthquakes in the Western United States," by P.B. Schnabel and H.B. Seed - 1972 (PB 213 100)A03

EERC 72-3 "Elastic-Plastic Earthquake Response of Soil-Building Systems," by T. Minami - 1972 (PB 214 868)A08

EERC 72-4 "Stochastic Inelastic Response of Offshore Towers to Strong Motion Earthquakes," by M.K. Kaul - 1972 (PB 215 713)A05

EERC 72-5 "Cyclic Behavior of Three Reinforced Concrete Flexural Members with High Shear," by E.P. Popov, V.V. Bertero and H. Krawinkler - 1972 (PB 214 555)A05

EERC 72-6 "Earthquake Response of Gravity Dams Including Reservoir Interaction Effects," by P. Chakrabarti and A.K. Chopra - 1972 (AD 762 330)A08

EERC 72-7 "Dynamic Properties of Pine Flat Dam," by D. Rea, C.Y. Liaw and A.K. Chopra - 1972 (AD 763 928)A05

EERC 72-8 "Three Dimensional Analysis of Building Systems," by E.L. Wilson and H.H. Dovey - 1972 (PB 222 438)A06

EERC 72-9 "Rate of Loading Effects on Uncracked and Repaired Reinforced Concrete Members," by S. Mahin, V.V. Bertero, D. Rea and M. Atalay - 1972 (PB 224 520)A08

EERC 72-10 "Computer Program for Static and Dynamic Analysis of Linear Structural Systems," by E.L. Wilson, K.-J. Bathe, J.E. Peterson and H.H.Dovey - 1972 (PB 220 437)A04

EERC 72-11 "Literature Survey - Seismic Effects on Highway Bridges," by T. Iwasaki, J. Penzien and R.W. Clough - 1972 (PB 215 613)A19

EERC 72-12 "SHAKE-A Computer Program for Earthquake Response Analysis of Horizontally Layered Sites," by P.B. Schnabel and J. Lysmer - 1972 (PB 220 207)A06

EERC 73-1 "Optimal Seismic Design of Multistory Frames," by V.V. Bertero and H. Kamil - 1973

EERC 73-2 "Analysis of the Slides in the San Fernando Dams During the Earthquake of February 9, 1971," by H.B. Seed, K.L. Lee, I.M. Idriss and F. Makdisi - 1973 (PB 223 402)A14

EERC 73-3 "Computer Aided Ultimate Load Design of Unbraced Multistory Steel Frames," by M.B. El-Hafez and G.H. Powell 1973 (PB 248 315)A09

EERC 73-4 "Experimental Investigation into the Seismic Behavior of Critical Regions of Reinforced Concrete Components as Influenced by Moment and Shear," by M. Celebi and J. Penzien - 1973 (PB 215 884)A09

EERC 73-5 "Hysteretic Behavior of Epoxy-Repaired Reinforced Concrete Beams," by M. Celebi and J. Penzien - 1973 (PB 239 568)A03

EERC 73-6 "General Purpose Computer Program for Inelastic Dynamic Response of Plane Structures," by A. Kanaan and G.H. Powell - 1973 (PB 221 260)A08

EERC 73-7 "A Computer Program for Earthquake Analysis of Gravity Dams Including Reservoir Interaction," by P. Chakrabarti and A.K. Chopra - 1973 (AD 766 271)A04

EERC 73-8 "Behavior of Reinforced Concrete Deep Beam-Column Subassemblages Under Cyclic Loads," by O. Küstü and J.G. Bouwkamp - 1973 (PB 246 117)A12

EERC 73-9 "Earthquake Analysis of Structure-Foundation Systems," by A.K. Vaish and A.K. Chopra - 1973 (AD 766 272)A07

EERC 73-10 "Deconvolution of Seismic Response for Linear Systems," by R.B. Reimer - 1973 (PB 227 179)A08

EERC 73-11 "SAP IV: A Structural Analysis Program for Static and Dynamic Response of Linear Systems," by K.-J. Bathe, E.L. Wilson and F.E. Peterson - 1973 (PB 221 967)A09

EERC 73-12 "Analytical Investigations of the Seismic Response of Long, Multiple Span Highway Bridges," by W.S. Tseng and J. Penzien - 1973 (PB 227 816)A10

EERC 73-13 "Earthquake Analysis of Multi-Story Buildings Including Foundation Interaction," by A.K. Chopra and J.A. Gutierrez - 1973 (PB 222 970)A03

EERC 73-14 "ADAP: A Computer Program for Static and Dynamic Analysis of Arch Dams," by R.W. Clough, J.M. Raphael and S. Mojtahedi - 1973 (PB 223 763)A09

EERC 73-15 "Cyclic Plastic Analysis of Structural Steel Joints," by R.B. Pinkney and R.W. Clough - 1973 (PB 226 843)A08

EERC 73-16 "QUAD-4: A Computer Program for Evaluating the Seismic Response of Soil Structures by Variable Damping Finite Element Procedures," by I.M. Idriss, J. Lysmer, R. Hwang and H.B. Seed - 1973 (PB 229 424)A05

EERC 73-17 "Dynamic Behavior of a Multi-Story Pyramid Shaped Building," by R.M. Stephen, J.P. Hollings and J.G. Bouwkamp - 1973 (PB 240 718)A06

EERC 73-18 "Effect of Different Types of Reinforcing on Seismic Behavior of Short Concrete Columns," by V.V. Bertero, J. Hollings, O. Küstü, R.M. Stephen and J.G. Bouwkamp - 1973

EERC 73-19 "Olive View Medical Center Materials Studies, Phase I," by B. Bresler and V.V. Bertero - 1973 (PB 235 986)A06

EERC 73-20 "Linear and Nonlinear Seismic Analysis Computer Programs for Long Multiple-Span Highway Bridges," by W.S. Tseng and J. Penzien - 1973

EERC 73-21 "Constitutive Models for Cyclic Plastic Deformation of Engineering Materials," by J.M. Kelly and P.P. Gillis 1973 (PB 226 024)A03

EERC 73-22 "DRAIN - 2D User's Guide," by G.H. Powell - 1973 (PB 227 016)A05

EERC 73-23 "Earthquake Engineering at Berkeley - 1973," (PB 226 033)A11

EERC 73-24 Unassigned

EERC 73-25 "Earthquake Response of Axisymmetric Tower Structures Surrounded by Water," by C.Y. Liaw and A.K. Chopra 1973 (AD 773 052)A09

EERC 73-26 "Investigation of the Failures of the Olive View Stairtowers During the San Fernando Earthquake and Their Implications on Seismic Design," by V.V. Bertero and R.G. Collins - 1973 (PB 235 106)A13

EERC 73-27 "Further Studies on Seismic Behavior of Steel Beam-Column Subassemblages," by V.V. Bertero, H. Krawinkler and E.P. Popov - 1973 (PB 234 172)A06

EERC 74-1 "Seismic Risk Analysis," by C.S. Oliveira - 1974 (PB 235 920)A06

EERC 74-2 "Settlement and Liquefaction of Sands Under Multi-Directional Shaking," by R. Pyke, C.K. Chan and H.B. Seed 1974

EERC 74-3 "Optimum Design of Earthquake Resistant Shear Buildings," by D. Ray, K.S. Pister and A.K. Chopra - 1974 (PB 231 172)A06

EERC 74-4 "LUSH - A Computer Program for Complex Response Analysis of Soil-Structure Systems," by J. Lysmer, T. Udaka, H.B. Seed and R. Hwang - 1974 (PB 236 796)A05

EERC 74-5 "Sensitivity Analysis for Hysteretic Dynamic Systems: Applications to Earthquake Engineering," by D. Ray 1974 (PB 233 213)A06

EERC 74-6 "Soil Structure Interaction Analyses for Evaluating Seismic Response," by H.B. Seed, J. Lysmer and R. Hwang 1974 (PB 236 519)A04

EERC 74-7 Unassigned

EERC 74-8 "Shaking Table Tests of a Steel Frame - A Progress Report," by R.W. Clough and D. Tang - 1974 (PB 240 869)A03

EERC 74-9 "Hysteretic Behavior of Reinforced Concrete Flexural Members with Special Web Reinforcement," by V.V. Bertero, E.P. Popov and T.Y. Wang - 1974 (PB 236 797)A07

EERC 74-10 "Applications of Reliability-Based, Global Cost Optimization to Design of Earthquake Resistant Structures," by E. Vitiello and K.S. Pister - 1974 (PB 237 231)A06

EERC 74-11 "Liquefaction of Gravelly Soils Under Cyclic Loading Conditions," by R.T. Wong, H.B. Seed and C.K. Chan 1974 (PB 242 042)A03

EERC 74-12 "Site-Dependent Spectra for Earthquake-Resistant Design," by H.B. Seed, C. Ugas and J. Lysmer - 1974 (PB 240 953)A03

EERC 74-13 "Earthquake Simulator Study of a Reinforced Concrete Frame," by P. Hidalgo and R.W. Clough - 1974 (PB 241 944)A13

EERC 74-14 "Nonlinear Earthquake Response of Concrete Gravity Dams," by N. Pal - 1974 (AD/A 006 583)A06

EERC 74-15 "Modeling and Identification in Nonlinear Structural Dynamics - I. One Degree of Freedom Models," by N. Distefano and A. Rath - 1974 (PB 241 548)A06

EERC 75-1 "Determination of Seismic Design Criteria for the Dumbarton Bridge Replacement Structure, Vol. I: Description, Theory and Analytical Modeling of Bridge and Parameters," by F. Baron and S.-H. Pang - 1975 (PB 259 407)A15

EERC 75-2 "Determination of Seismic Design Criteria for the Dumbarton Bridge Replacement Structure, Vol. II: Numerical Studies and Establishment of Seismic Design Criteria," by F. Baron and S.-H. Pang - 1975 (PB 259 408)A11 (For set of EERC 75-1 and 75-2 (PB 259 406))

EERC 75-3 "Seismic Risk Analysis for a Site and a Metropolitan Area," by C.S. Oliveira - 1975 (PB 248 134)A09

EERC 75-4 "Analytical Investigations of Seismic Response of Short, Single or Multiple-Span Highway Bridges," by M.-C. Chen and J. Penzien - 1975 (PB 241 454)A09

EERC 75-5 "An Evaluation of Some Methods for Predicting Seismic Behavior of Reinforced Concrete Buildings," by S.A. Mahin and V.V. Bertero - 1975 (PB 246 306)A16

EERC 75-6 "Earthquake Simulator Study of a Steel Frame Structure, Vol. I: Experimental Results," by R.W. Clough and D.T. Tang - 1975 (PB 243 981)A13

EERC 75-7 "Dynamic Properties of San Bernardino Intake Tower," by D. Rea, C.-Y. Liaw and A.K. Chopra - 1975 (AD/A008 406) A05

EERC 75-8 "Seismic Studies of the Articulation for the Dumbarton Bridge Replacement Structure, Vol. I: Description, Theory and Analytical Modeling of Bridge Components," by F. Baron and R.E. Hamati - 1975 (PB 251 539)A07

EERC 75-9 "Seismic Studies of the Articulation for the Dumbarton Bridge Replacement Structure, Vol. 2: Numerical Studies of Steel and Concrete Girder Alternates," by F. Baron and R.E. Hamati - 1975 (PB 251 540)A10

EERC 75-10 "Static and Dynamic Analysis of Nonlinear Structures," by D.P. Mondkar and G.H. Powell - 1975 (PB 242 434)A08

EERC 75-11 "Hysteretic Behavior of Steel Columns," by E.P. Popov, V.V. Bertero and S. Chandramouli - 1975 (PB 252 365)A11

EERC 75-12 "Earthquake Engineering Research Center Library Printed Catalog," - 1975 (PB 243 711)A26

EERC 75-13 "Three Dimensional Analysis of Building Systems (Extended Version)," by E.L. Wilson, J.P. Hollings and H.H. Dovey - 1975 (PB 243 989)A07

EERC 75-14 "Determination of Soil Liquefaction Characteristics by Large-Scale Laboratory Tests," by P. De Alba, C.K. Chan and H.B. Seed - 1975 (NUREG 0027)A08

EERC 75-15 "A Literature Survey - Compressive, Tensile, Bond and Shear Strength of Masonry," by R.L. Mayes and R.W. Clough - 1975 (PB 246 292)A10

EERC 75-16 "Hysteretic Behavior of Ductile Moment Resisting Reinforced Concrete Frame Components," by V.V. Bertero and E.P. Popov - 1975 (PB 246 388)A05

EERC 75-17 "Relationships Between Maximum Acceleration, Maximum Velocity, Distance from Source, Local Site Conditions for Moderately Strong Earthquakes," by H.B. Seed, R. Murarka, J. Lysmer and I.M. Idriss - 1975 (PB 248 172)A03

EERC 75-18 "The Effects of Method of Sample Preparation on the Cyclic Stress-Strain Behavior of Sands," by J. Mulilis, C.K. Chan and H.B. Seed - 1975 (Summarized in EERC 75-28)

EERC 75-19 "The Seismic Behavior of Critical Regions of Reinforced Concrete Components as Influenced by Moment, Shear and Axial Force," by M.B. Atalay and J. Penzien - 1975 (PB 258 842)A11

EERC 75-20 "Dynamic Properties of an Eleven Story Masonry Building," by R.M. Stephen, J.P. Hollings, J.G. Bouwkamp and D. Jurukovski - 1975 (PB 246 945)A04

EERC 75-21 "State-of-the-Art in Seismic Strength of Masonry - An Evaluation and Review," by R.L. Mayes and R.W. Clough 1975 (PB 249 040)A07

EERC 75-22 "Frequency Dependent Stiffness Matrices for Viscoelastic Half-Plane Foundations," by A.K. Chopra, P. Chakrabarti and G. Dasgupta - 1975 (PB 248 121)A07

EERC 75-23 "Hysteretic Behavior of Reinforced Concrete Framed Walls," by T.Y. Wong, V.V. Bertero and E.P. Popov - 1975

EERC 75-24 "Testing Facility for Subassemblages of Frame-Wall Structural Systems," by V.V. Bertero, E.P. Popov and T. Endo - 1975

EERC 75-25 "Influence of Seismic History on the Liquefaction Characteristics of Sands," by H.B. Seed, K. Mori and C.K. Chan - 1975 (Summarized in EERC 75-28)

EERC 75-26 "The Generation and Dissipation of Pore Water Pressures during Soil Liquefaction," by H.B. Seed, P.P. Martin and J. Lysmer - 1975 (PB 252 648)A03

EERC 75-27 "Identification of Research Needs for Improving Aseismic Design of Building Structures," by V.V. Bertero 1975 (PB 248 136)A05

EERC 75-28 "Evaluation of Soil Liquefaction Potential during Earthquakes," by H.B. Seed, I. Arango and C.K. Chan - 1975 (NUREG 0026)A13

EERC 75-29 "Representation of Irregular Stress Time Histories by Equivalent Uniform Stress Series in Liquefaction Analyses," by H.B. Seed, I.M. Idriss, F. Makdisi and N. Banerjee - 1975 (PB 252 635)A03

EERC 75-30 "FLUSH - A Computer Program for Approximate 3-D Analysis of Soil-Structure Interaction Problems," by J. Lysmer, T. Udaka, C.-F. Tsai and H.B. Seed - 1975 (PB 259 332)A07

EERC 75-31 "ALUSH - A Computer Program for Seismic Response Analysis of Axisymmetric Soil-Structure Systems," by E. Berger, J. Lysmer and H.B. Seed - 1975

EERC 75-32 "TRIP and TRAVEL - Computer Programs for Soil-Structure Interaction Analysis with Horizontally Travelling Waves," by T. Udaka, J. Lysmer and H.B. Seed - 1975

EERC 75-33 "Predicting the Performance of Structures in Regions of High Seismicity," by J. Penzien - 1975 (PB 248 130)A03

EERC 75-34 "Efficient Finite Element Analysis of Seismic Structure - Soil - Direction," by J. Lysmer, H.B. Seed, T. Udaka, R.N. Hwang and C.-F. Tsai - 1975 (PB 253 570)A03

EERC 75-35 "The Dynamic Behavior of a First Story Girder of a Three-Story Steel Frame Subjected to Earthquake Loading," by R.W. Clough and L.-Y. Li - 1975 (PB 248 841)A05

EERC 75-36 "Earthquake Simulator Study of a Steel Frame Structure, Volume II - Analytical Results," by D.T. Tang - 1975 (PB 252 926)A10

EERC 75-37 "ANSR-I General Purpose Computer Program for Analysis of Non-Linear Structural Response," by D.P. Mondkar and G.H. Powell - 1975 (PB 252 386)A08

EERC 75-38 "Nonlinear Response Spectra for Probabilistic Seismic Design and Damage Assessment of Reinforced Concrete Structures," by M. Murakami and J. Penzien - 1975 (PB 259 530)A05

EERC 75-39 "Study of a Method of Feasible Directions for Optimal Elastic Design of Frame Structures Subjected to Earthquake Loading," by N.D. Walker and K.S. Pister - 1975 (PB 257 781)A06

EERC 75-40 "An Alternative Representation of the Elastic-Viscoelastic Analogy," by G. Dasgupta and J.L. Sackman - 1975 (PB 252 173)A03

EERC 75-41 "Effect of Multi-Directional Shaking on Liquefaction of Sands," by H.B. Seed, R. Pyke and G.R. Martin - 1975 (PB 258 781)A03

EERC 76-1 "Strength and Ductility Evaluation of Existing Low-Rise Reinforced Concrete Buildings - Screening Method," by T. Okada and B. Bresler - 1976 (PB 257 906)A11

EERC 76-2 "Experimental and Analytical Studies on the Hysteretic Behavior of Reinforced Concrete Rectangular and T-Beams," by S.-Y.M. Ma, E.P. Popov and V.V. Bertero - 1976 (PB 260 843)A12

EERC 76-3 "Dynamic Behavior of a Multistory Triangular-Shaped Building," by J. Petrovski, R.M. Stephen, E. Gartenbaum and J.G. Bouwkamp - 1976 (PB 273 279)A07

EERC 76-4 "Earthquake Induced Deformations of Earth Dams," by N. Serff, H.B. Seed, F.I. Makdisi & C.-Y. Chang - 1976 (PB 292 065)A08

EERC 76-5 "Analysis and Design of Tube-Type Tall Building Structures," by H. de Clercq and G.H. Powell - 1976 (PB 252 220) A10

EERC 76-6 "Time and Frequency Domain Analysis of Three-Dimensional Ground Motions, San Fernando Earthquake," by T. Kubo and J. Penzien (PB 260 556)A11

EERC 76-7 "Expected Performance of Uniform Building Code Design Masonry Structures," by R.L. Mayes, Y. Omote, S.W. Chen and R.W. Clough - 1976 (PB 270 098)A05

EERC 76-8 "Cyclic Shear Tests of Masonry Piers, Volume 1 - Test Results," by R.L. Mayes, Y. Omote, R.W. Clough - 1976 (PB 264 424)A06

EERC 76-9 "A Substructure Method for Earthquake Analysis of Structure - Soil Interaction," by J.A. Gutierrez and A.K. Chopra - 1976 (PB 257 783)A08

EERC 76-10 "Stabilization of Potentially Liquefiable Sand Deposits using Gravel Drain Systems," by H.B. Seed and J.R. Booker - 1976 (PB 258 820)A04

EERC 76-11 "Influence of Design and Analysis Assumptions on Computed Inelastic Response of Moderately Tall Frames," by G.H. Powell and D.G. Row - 1976 (PB 271 409)A06

EERC 76-12 "Sensitivity Analysis for Hysteretic Dynamic Systems: Theory and Applications," by D. Ray, K.S. Pister and E. Polak - 1976 (PB 262 859)A04

EERC 76-13 "Coupled Lateral Torsional Response of Buildings to Ground Shaking," by C.L. Kan and A.K. Chopra - 1976 (PB 257 907)A09

EERC 76-14 "Seismic Analyses of the Banco de America," by V.V. Bertero, S.A. Mahin and J.A. Hollings - 1976

EERC 76-15 "Reinforced Concrete Frame 2: Seismic Testing and Analytical Correlation," by R.W. Clough and J. Gidwani - 1976 (PB 261 323)A08

EERC 76-16 "Cyclic Shear Tests of Masonry Piers, Volume 2 - Analysis of Test Results," by R.L. Mayes, Y. Omote and R.W. Clough - 1976

EERC 76-17 "Structural Steel Bracing Systems: Behavior Under Cyclic Loading," by E.P. Popov, K. Takanashi and C.W. Roeder - 1976 (PB 260 715)A05

EERC 76-18 "Experimental Model Studies on Seismic Response of High Curved Overcrossings," by D. Williams and W.G. Godden - 1976 (PB 269 548)A08

EERC 76-19 "Effects of Non-Uniform Seismic Disturbances on the Dumbarton Bridge Replacement Structure," by F. Baron and R.E. Hamati - 1976 (PB 282 981)A16

EERC 76-20 "Investigation of the Inelastic Characteristics of a Single Story Steel Structure Using System Identification and Shaking Table Experiments," by V.C. Matzen and H.D. McNiven - 1976 (PB 258 453)A07

EERC 76-21 "Capacity of Columns with Splice Imperfections," by E.P. Popov, R.M. Stephen and R. Philbrick - 1976 (PB 260 378)A04

EERC 76-22 "Response of the Olive View Hospital Main Building during the San Fernando Earthquake," by S. A. Mahin, V.V. Bertero, A.K. Chopra and R. Collins - 1976 (PB 271 425)A14

EERC 76-23 "A Study on the Major Factors Influencing the Strength of Masonry Prisms," by N.M. Mostaghel, R.L. Mayes, R. W. Clough and S.W. Chen - 1976 (Not published)

EERC 76-24 "GADFLEA - A Computer Program for the Analysis of Pore Pressure Generation and Dissipation during Cyclic or Earthquake Loading," by J.R. Booker, M.S. Rahman and H.B. Seed - 1976 (PB 263 947)A04

EERC 76-25 "Seismic Safety Evaluation of a R/C School Building," by B. Bresler and J. Axley - 1976

EERC 76-26 "Correlative Investigations on Theoretical and Experimental Dynamic Behavior of a Model Bridge Structure," by K. Kawashima and J. Penzien - 1976 (PB 263 388)A11

EERC 76-27 "Earthquake Response of Coupled Shear Wall Buildings," by T. Srichatrapimuk - 1976 (PB 265 157)A07

EERC 76-28 "Tensile Capacity of Partial Penetration Welds," by E.P. Popov and R.M. Stephen - 1976 (PB 262 899)A03

EERC 76-29 "Analysis and Design of Numerical Integration Methods in Structural Dynamics," by H.M. Hilber - 1976 (PB 264 410)A06

EERC 76-30 "Contribution of a Floor System to the Dynamic Characteristics of Reinforced Concrete Buildings," by L.E. Malik and V.V. Bertero - 1976 (PB 272 247)A13

EERC 76-31 "The Effects of Seismic Disturbances on the Golden Gate Bridge," by F. Baron, M. Arikan and R.E. Hamati - 1976 (PB 272 279)A09

EERC 76-32 "Infilled Frames in Earthquake Resistant Construction," by R.E. Klingner and V.V. Bertero - 1976 (PB 265 892)A13

UCB/EERC-77/01 "PLUSH - A Computer Program for Probabilistic Finite Element Analysis of Seismic Soil-Structure Interaction," by M.P. Romo Organista, J. Lysmer and H.B. Seed - 1977

UCB/EERC-77/02 "Soil-Structure Interaction Effects at the Humboldt Bay Power Plant in the Ferndale Earthquake of June 7, 1975," by J.E. Valera, H.B. Seed, C.F. Tsai and J. Lysmer - 1977 (PB 265 795)A04

UCB/EERC-77/03 "Influence of Sample Disturbance on Sand Response to Cyclic Loading," by K. Mori, H.B. Seed and C.K. Chan - 1977 (PB 267 352)A04

UCB/EERC-77/04 "Seismological Studies of Strong Motion Records," by J. Shoja-Taheri - 1977 (PB 269 655)A10

UCB/EERC-77/05 "Testing Facility for Coupled-Shear Walls," by L. Li-Hyung, V.V. Bertero and E.P. Popov - 1977

UCB/EERC-77/06 "Developing Methodologies for Evaluating the Earthquake Safety of Existing Buildings," by No. 1 - B. Bresler; No. 2 - B. Bresler, T. Okada and D. Zisling; No. 3 - T. Okada and B. Bresler; No. 4 - V.V. Bertero and B. Bresler - 1977 (PB 267 354)A08

UCB/EERC-77/07 "A Literature Survey - Transverse Strength of Masonry Walls," by Y. Omote, R.L. Mayes, S.W. Chen and R.W. Clough - 1977 (PB 277 933)A07

UCB/EERC-77/08 "DRAIN-TABS: A Computer Program for Inelastic Earthquake Response of Three Dimensional Buildings," by R. Guendelman-Israel and G.H. Powell - 1977 (PB 270 693)A07

UCB/EERC-77/09 "SUBWALL: A Special Purpose Finite Element Computer Program for Practical Elastic Analysis and Design of Structural Walls with Substructure Option," by D.Q. Le, H. Peterson and E.P. Popov - 1977 (PB 270 567)A05

UCB/EERC-77/10 "Experimental Evaluation of Seismic Design Methods for Broad Cylindrical Tanks," by D.P. Clough (PB 272 280)A13

UCB/EERC-77/11 "Earthquake Engineering Research at Berkeley - 1976," - 1977 (PB 273 507)A09

UCB/EERC-77/12 "Automated Design of Earthquake Resistant Multistory Steel Building Frames," by N.D. Walker, Jr. - 1977 (PB 276 526)A09

UCB/EERC-77/13 "Concrete Confined by Rectangular Hoops Subjected to Axial Loads," by J. Vallenas, V.V. Bertero and E.P. Popov - 1977 (PB 275 165)A06

UCB/EERC-77/14 "Seismic Strain Induced in the Ground During Earthquakes," by Y. Sugimura - 1977 (PB 284 201)A04

UCB/EERC-77/15 "Bond Deterioration under Generalized Loading," by V.V. Bertero, E.P. Popov and S. Viwathanatepa - 1977

UCB/EERC-77/16 "Computer Aided Optimum Design of Ductile Reinforced Concrete Moment Resisting Frames," by S.W. Zagajeski and V.V. Bertero - 1977 (PB 280 137)A07

UCB/EERC-77/17 "Earthquake Simulation Testing of a Stepping Frame with Energy-Absorbing Devices," by J.M. Kelly and D.F. Tsztoo - 1977 (PB 273 506)A04

UCB/EERC-77/18 "Inelastic Behavior of Eccentrically Braced Steel Frames under Cyclic Loadings," by C.W. Roeder and E.P. Popov - 1977 (PB 275 526)A15

UCB/EERC-77/19 "A Simplified Procedure for Estimating Earthquake-Induced Deformations in Dams and Embankments," by F.I. Makdisi and H.B. Seed - 1977 (PB 276 820)A04

UCB/EERC-77/20 "The Performance of Earth Dams during Earthquakes," by H.B. Seed, F.I. Makdisi and P. de Alba - 1977 (PB 276 821)A04

UCB/EERC-77/21 "Dynamic Plastic Analysis Using Stress Resultant Finite Element Formulation," by P. Lukkunapvasit and J.M. Kelly - 1977 (PB 275 453)A04

UCB/EERC-77/22 "Preliminary Experimental Study of Seismic Uplift of a Steel Frame," by R.W. Clough and A.A. Huckelbridge 1977 (PB 278 769)A08

UCB/EERC-77/23 "Earthquake Simulator Tests of a Nine-Story Steel Frame with Columns Allowed to Uplift," by A.A. Huckelbridge - 1977 (PB 277 944)A09

UCB/EERC-77/24 "Nonlinear Soil-Structure Interaction of Skew Highway Bridges," by M.-C. Chen and J. Penzien - 1977 (PB 276 176)A07

UCB/EERC-77/25 "Seismic Analysis of an Offshore Structure Supported on Pile Foundations," by D.D.-N. Liou and J. Penzien 1977 (PB 283 180)A06

UCB/EERC-77/26 "Dynamic Stiffness Matrices for Homogeneous Viscoelastic Half-Planes," by G. Dasgupta and A.K. Chopra - 1977 (PB 279 654)A06

UCB/EERC-77/27 "A Practical Soft Story Earthquake Isolation System," by J.M. Kelly, J.M. Eidinger and C.J. Derham - 1977 (PB 276 814)A07

UCB/EERC-77/28 "Seismic Safety of Existing Buildings and Incentives for Hazard Mitigation in San Francisco: An Exploratory Study," by A.J. Meltsner - 1977 (PB 281 970)A05

UCB/EERC-77/29 "Dynamic Analysis of Electrohydraulic Shaking Tables," by D. Rea, S. Abedi-Hayati and Y. Takahashi 1977 (PB 282 569)A04

UCB/EERC-77/30 "An Approach for Improving Seismic - Resistant Behavior of Reinforced Concrete Interior Joints," by B. Galunic, V.V. Bertero and E.P. Popov - 1977 (PB 290 870)A06

UCB/EERC-78/01 "The Development of Energy-Absorbing Devices for Aseismic Base Isolation Systems," by J.M. Kelly and D.F. Tsztoo - 1978 (PB 284 978)A04

UCB/EERC-78/02 "Effect of Tensile Prestrain on the Cyclic Response of Structural Steel Connections, by J.G. Bouwkamp and A. Mukhopadhyay - 1978

UCB/EERC-78/03 "Experimental Results of an Earthquake Isolation System using Natural Rubber Bearings," by J.M. Eidinger and J.M. Kelly - 1978 (PB 281 686)A04

UCB/EERC-78/04 "Seismic Behavior of Tall Liquid Storage Tanks," by A. Niwa - 1978 (PB 284 017)A14

UCB/EERC-78/05 "Hysteretic Behavior of Reinforced Concrete Columns Subjected to High Axial and Cyclic Shear Forces," by S.W. Zagajeski, V.V. Bertero and J.G. Bouwkamp - 1978 (PB 283 858)A13

UCB/EERC-78/06 "Inelastic Beam-Column Elements for the ANSR-I Program," by A. Riahi, D.G. Row and G.H. Powell - 1978

UCB/EERC-78/07 "Studies of Structural Response to Earthquake Ground Motion," by O.A. Lopez and A.K. Chopra - 1978 (PB 282 790)A05

UCB/EERC-78/08 "A Laboratory Study of the Fluid-Structure Interaction of Submerged Tanks and Caissons in Earthquakes," by R.C. Byrd - 1978 (PB 284 957)A08

UCB/EERC-78/09 "Model for Evaluating Damageability of Structures," by I. Sakamoto and B. Bresler - 1978

UCB/EERC-78/10 "Seismic Performance of Nonstructural and Secondary Structural Elements," by I. Sakamoto - 1978

UCB/EERC-78/11 "Mathematical Modelling of Hysteresis Loops for Reinforced Concrete Columns," by S. Nakata, T. Sproul and J. Penzien - 1978

UCB/EERC-78/12 "Damageability in Existing Buildings," by T. Blejwas and B. Bresler - 1978

UCB/EERC-78/13 "Dynamic Behavior of a Pedestal Base Multistory Building," by R.M. Stephen, E.L. Wilson, J.G. Bouwkamp and M. Button - 1978 (PB 286 650)A08

UCB/EERC-78/14 "Seismic Response of Bridges - Case Studies," by R.A. Imbsen, V. Nutt and J. Penzien - 1978 (PB 286 503)A10

UCB/EERC-78/15 "A Substructure Technique for Nonlinear Static and Dynamic Analysis," by D.G. Row and G.H. Powell - 1978 (PB 288 077)A10

UCB/EERC-78/16 "Seismic Risk Studies for San Francisco and for the Greater San Francisco Bay Area," by C.S. Oliveira - 1978

UCB/EERC-78/17 "Strength of Timber Roof Connections Subjected to Cyclic Loads," by P. Gülkan, R.L. Mayes and R.W. Clough - 1978

UCB/EERC-78/18 "Response of K-Braced Steel Frame Models to Lateral Loads," by J.G. Bouwkamp, R.M. Stephen and E.P. Popov - 1978

UCB/EERC-78/19 "Rational Design Methods for Light Equipment in Structures Subjected to Ground Motion," by J.L. Sackman and J.M. Kelly - 1978 (PB 292 357)A04

UCB/EERC-78/20 "Testing of a Wind Restraint for Aseismic Base Isolation," by J.M. Kelly and D.E. Chitty - 1978 (PB 292 833)A03

UCB/EERC-78/21 "APOLLO - A Computer Program for the Analysis of Pore Pressure Generation and Dissipation in Horizontal Sand Layers During Cyclic or Earthquake Loading," by P.P. Martin and H.B. Seed - 1978 (PB 292 835)A04

UCB/EERC-78/22 "Optimal Design of an Earthquake Isolation System," by M.A. Bhatti, K.S. Pister and E. Polak - 1978 (PB 294 735)A06

UCB/EERC-78/23 "MASH - A Computer Program for the Non-Linear Analysis of Vertically Propagating Shear Waves in Horizontally Layered Deposits," by P.P. Martin and H.B. Seed - 1978 (PB 293 101)A05

UCB/EERC-78/24 "Investigation of the Elastic Characteristics of a Three Story Steel Frame Using System Identification," by I. Kaya and H.D. McNiven - 1978

UCB/EERC-78/25 "Investigation of the Nonlinear Characteristics of a Three-Story Steel Frame Using System Identification," by I. Kaya and H.D. McNiven - 1978

UCB/EERC-78/26 "Studies of Strong Ground Motion in Taiwan," by Y.M. Hsiung, B.A. Bolt and J. Penzien - 1978

UCB/EERC-78/27 "Cyclic Loading Tests of Masonry Single Piers: Volume 1 - Height to Width Ratio of 2," by P.A. Hidalgo, R.L. Mayes, H.D. McNiven and R.W. Clough - 1978

UCB/EERC-78/28 "Cyclic Loading Tests of Masonry Single Piers: Volume 2 - Height to Width Ratio of 1," by S.-W.J. Chen, P.A. Hidalgo, R.L. Mayes, R.W. Clough and H.D. McNiven - 1978

UCB/EERC-78/29 "Analytical Procedures in Soil Dynamics," by J. Lysmer - 1978

UCB/EERC-79/01 "Hysteretic Behavior of Lightweight Reinforced Concrete Beam-Column Subassemblages," by B. Forzani, E.P. Popov, and V.V. Bertero - 1979

UCB/EERC-79/02 "The Development of a Mathematical Model to Predict the Flexural Response of Reinforced Concrete Beams to Cyclic Loads, Using System Identification," by J.F. Stanton and H.D. McNiven - 1979

UCB/EERC-79/03 "Linear and Nonlinear Earthquake Response of Simple Torsionally Coupled Systems," by C.L. Kan and A.K. Chopra - 1979

UCB/EERC-79/04 "A Mathematical Model of Masonry for Predicting Its Linear Seismic Response Characteristics," by Y. Mengi and H.D. McNiven - 1979

UCB/EERC-79/05 "Mechanical Behavior of Lightweight Concrete Confined by Different Types of Lateral Reinforcement," by M.A. Manrique, V.V. Bertero and E.P. Popov - 1979

UCB/EERC-79/06 "Static Tilt Tests of a Tall Cylindrical Liquid Storage Tank," by R.W. Clough and A. Niwa - 1979

UCB/EERC-79/07 "The Design of Steel Energy Absorbing Restrainers and Their Incorporation Into Nuclear Power Plants for Enhanced Safety: Volume 1 - Summary Report," by P.N. Spencer, V.F. Zackay, and E.R. Parker - 1979

UCB/EERC-79/08 "The Design of Steel Energy Absorbing Restrainers and Their Incorporation Into Nuclear Power Plants for Enhanced Safety: Volume 2 - The Development of Analyses for Reactor System Piping," "Simple Systems" by M.C. Lee, J. Penzien, A.K. Chopra, and K. Suzuki "Complex Systems" by G.H. Powell, E.L. Wilson, R.W. Clough and D.G. Row - 1979

UCB/EERC-79/09 "The Design of Steel Energy Absorbing Restrainers and Their Incorporation Into Nuclear Power Plants for Enhanced Safety: Volume 3 - Evaluation of Commerical Steels," by W.S. Owen, R.M.N. Pelloux, R.O. Ritchie, M. Faral, T. Ohhashi, J. Toplosky, S.J. Hartman, V.F. Zackay, and E.R. Parker - 1979

UCB/EERC-79/10 "The Design of Steel Energy Absorbing Restrainers and Their Incorporation Into Nuclear Power Plants for Enhanced Safety: Volume 4 - A Review of Energy-Absorbing Devices," by J.M. Kelly and M.S. Skinner - 1979

UCB/EERC-79/11 "Conservatism In Summation Rules for Closely Spaced Modes," by J.M. Kelly and J.L. Sackman - 1979

UCB/EERC-79/12 "Cyclic Loading Tests of Masonry Single Piers Volume 3 - Height to Width Ratio of 0.5," by P.A. Hidalgo, R.L. Mayes, H.D. McNiven and R.W. Clough - 1979

UCB/EERC-79/13 "Cyclic Behavior of Dense Coarse-Grained Materials in Relation to the Seismic Stability of Dams," by N.G. Banerjee, H.B. Seed and C.K. Chan - 1979

UCB/EERC-79/14 "Seismic Behavior of Reinforced Concrete Interior Beam-Column Subassemblages," by S. Viwathanatepa, E.P. Popov and V.V. Bertero - 1979

UCB/EERC-79/15 "Optimal Design of Localized Nonlinear Systems with Dual Performance Criteria Under Earthquake Excitations," by M.A. Bhatti - 1979

UCB/EERC-79/16 "OPTDYN - A General Purpose Optimization Program for Problems with or without Dynamic Constraints," by M.A. Bhatti, E. Polak and K.S. Pister - 1979

UCB/EERC-79/17 "ANSR-II, Analysis of Nonlinear Structural Response, Users Manual," by D.P. Mondkar and G.H. Powell - 1979

UCB/EERC-79/18 "Soil Structure Interaction in Different Seismic Environments," A. Gomez-Masso, J. Lysmer, J.-C. Chen and H.B. Seed - 1979

UCB/EERC-79/19 "ARMA Models for Earthquake Ground Motions," by M.K. Chang, J.W. Kwiatkowski, R.F. Nau, R.M. Oliver and K.S. Pister - 1979

UCB/EERC-79/20 "Hysteretic Behavior of Reinforced Concrete Structural Walls," by J.M. Vallenas, V.V. Bertero and E.P. Popov - 1979

UCB/EERC-79/21 "Studies on High-Frequency Vibrations of Buildings I: The Column Effects," by J. Lubliner - 1979

UCB/EERC-79/22 "Effects of Generalized Loadings on Bond Reinforcing Bars Embedded in Confined Concrete Blocks," by S. Viwathanatepa, E.P. Popov and V.V. Bertero - 1979

UCB/EERC-79/23 "Shaking Table Study of Single-Story Masonry Houses, Volume 1: Test Structures 1 and 2," by P. Gülkan, R.L. Mayes and R.W. Clough - 1979

UCB/EERC-79/24 "Shaking Table Study of Single-Story Masonry Houses, Volume 2: Test Structures 3 and 4," by P. Gülkan, R.L. Mayes and R.W. Clough - 1979

UCB/EERC-79/25 "Shaking Table Study of Single-Story Masonry Houses, Volume 3: Summary, Conclusions and Recommendations," by R.W. Clough, R.L. Mayes and P. Gülkan - 1979

UCB/EERC-79/26 "Recommendations for a U.S.-Japan Cooperative Research Program Utilizing Large-Scale Testing Facilities," by U.S.-Japan Planning Group - 1979

UCB/EERC-79/27 "Earthquake-Induced Liquefaction Near Lake Amatitlan, Guatemala," by H.B. Seed, I. Arango, C.K. Chan, A. Gomez-Masso and R. Grant de Ascoli - 1979

UCB/EERC-79/28 "Infill Panels: Their Influence on Seismic Response of Buildings," by J.W. Axley and V.V. Bertero - 1979

UCB/EERC-79/29 "3D Truss Bar Element (Type 1) for the ANSR-II Program," by D.P. Mondkar and G.H. Powell - 1979

UCB/EERC-79/30 "2D Beam-Column Element (Type 5 - Parallel Element Theory) for the ANSR-II Program," by D.G. Row, G.H. Powell and D.P. Mondkar

UCB/EERC-79/31 "3D Beam-Column Element (Type 2 - Parallel Element Theory) for the ANSR-II Program," by A. Riahi, G.H. Powell and D.P. Mondkar - 1979

UCB/EERC-79/32 "On Response of Structures to Stationary Excitation," by A. Der Kiureghian - 1979

UCB/EERC-79/33 "Undisturbed Sampling and Cyclic Load Testing of Sands," by S. Singh, H.B. Seed and C.K. Chan - 1979

UCB/EERC-79/34 "Interaction Effects of Simultaneous Torsional and Compressional Cyclic Loading of Sand," by P.M. Griffin and W.N. Houston - 1979

UCB/EERC-80/01 "Earthquake Response of Concrete Gravity Dams Including Hydrodynamic and Foundation Interaction Effects," by A.K. Chopra, P. Chakrabarti and S. Gupta - 1980

UCB/EERC-80/02 "Rocking Response of Rigid Blocks to Earthquakes," by C.S. Yim, A.K. Chopra and J. Penzien - 1980

UCB/EERC-80/03 "Optimum Inelastic Design of Seismic-Resistant Reinforced Concrete Frame Structures," by S.W. Zagajeski and V.V. Bertero - 1980

UCB/EERC-80/04 "Effects of Amount and Arrangement of Wall-Panel Reinforcement on Hysteretic Behavior of Reinforced Concrete Walls," by R. Iliya and V.V. Bertero - 1980

UCB/EERC-80/05 "Shaking Table Research on Concrete Dam Models," by A. Niwa and R.W. Clough - 1980

UCB/EERC-80/06 "Piping With Energy Absorbing Restrainers: Parameter Study on Small Systems," by G.H. Powell, C. Oughourlian and J. Simons - 1980

UCB/EERC-80/07 "Inelastic Torsional Response of Structures Subjected to Earthquake Ground Motions," by Y. Yamazaki - 1980

UCB/EERC-80/08 "Study of X-Braced Steel Frame Structures Under Earthquake Simulation," by Y. Ghanaat - 1980

UCB/EERC-80/09 "Hybrid Modelling of Soil-Structure Interaction," by S. Gupta, T.W. Lin, J. Penzien and C.S. Yeh - 1980

UCB/EERC-80/10 "General Applicability of a Nonlinear Model of a One Story Steel Frame," by B.I. Sveinsson and H. McNiven - 1980

UCB/EERC-80/11 "A Green-Function Method for Wave Interaction with a Submerged Body," by W. Kioka - 1980

UCB/EERC-80/12 "Hydrodynamic Pressure and Added Mass for Axisymmetric Bodies," by F. Nilrat - 1980

UCB/EERC-80/13 "Treatment of Non-Linear Drag Forces Acting on Offshore Platforms," by B.V. Dao and J. Penzien - 1980

UCB/EERC-80/14 "2D Plane/Axisymmetric Solid Element (Type 3 - Elastic or Elastic-Perfectly Plastic) for the ANSR-II Program," by D.P. Mondkar and G.H. Powell - 1980

UCB/EERC-80/15 "A Response Spectrum Method for Random Vibrations," by A. Der Kiureghian - 1980

UCB/EERC-80/16 "Cyclic Inelastic Buckling of Tubular Steel Braces," by V.A. Zayas, E.P. Popov and S.A. Mahin - June 1980

UCB/EERC-80/17 "Dynamic Response of Simple Arch Dams Including Hydrodynamic Interaction," by C.S. Porter and A.K. Chopra - July 1980

UCB/EERC-80/18 "Experimental Testing of a Friction Damped Aseismic Base Isolation System with Fail-Safe Characteristics," by J.M. Kelly, K.E. Beucke and M.S. Skinner - July 1980

UCB/EERC-80/19 "The Design of Steel Energy-Absorbing Restrainers and their Incorporation into Nuclear Power Plants for Enhanced Safety (Vol 1B): Stochastic Seismic Analyses of Nuclear Power Plant Structures and Piping Systems Subjected to Multiple Support Excitations," by M.C. Lee and J. Penzien - 1980

UCB/EERC-80/20 "The Design of Steel Energy-Absorbing Restrainers and their Incorporation into Nuclear Power Plants for Enhanced Safety (Vol 1C): Numerical Method for Dynamic Substructure Analysis," by J.M. Dickens and E.L. Wilson - 1980

UCB/EERC-80/21 "The Design of Steel Energy-Absorbing Restrainers and their Incorporation into Nuclear Power Plants for Enhanced Safety (Vol 2): Development and Testing of Restraints for Nuclear Piping Systems," by J.M. Kelly and M.S. Skinner - 1980

UCB/EERC-80/22 "3D Solid Element (Type 4-Elastic or Elastic-Perfectly-Plastic) for the ANSR-II Program," by D.P. Mondkar and G.H. Powell - 1980

UCB/EERC-80/23 "Gap-Friction Element (Type 5) for the ANSR-II Program," by D.P. Mondkar and G.H. Powell - 1980

UCB/EERC-80/24 "U-Bar Restraint Element (Type 11) for the ANSR-II Program," C. Oughourlian and G.H. Powell - 1980

UCB/EERC-80/25 "Testing of a Natural Rubber Base Isolation System by an Explosively Simulated Earthquake," by J.M. Kelly 1980

UCB/EERC-80/26 "Input Identification from Structural Vibrational Response," by Y. Hu - 1980

UCB/EERC-80/27 "Cyclic Inelastic Behavior of Steel Offshore Structures," by V.A. Zayas, S.A. Mahin and E.P. Popov - 1980

UCB/EERC-80/28 "Shaking Table Testing of a Reinforced Concrete Frame with Biaxial Response," M.G. Oliva and R.W. Clough 1980

UCB/EERC-80/29 "Dynamic Properties of a Twelve-Story Prefabricated Panel Building," by J.G. Bouwkamp, J.P. Kollegger and R.M. Stephen - 1980

UCB/EERC-80/30 "Dynamic Properties of a Eight-Story Prefabricated Panel Building," by J.G. Bouwkamp, J.P. Kollegger and R.M. Stephen - 1980

UCB/EERC-80/31 "Predictive Dynamic Response of Panel Type Structures Under Earthquakes," by J.P. Kollegger and J.G. Bouwkamp 1980