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EFFECT OF BEAM STRENGTH AND STIFFNESS ON DYNAMIC BEHAVIOR OF REINFORCED CONCRETE COUPLED WALLS

Volume 2: Tables and Figures

By

John M. Lybas

and

Mete A. Sozen

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16. Abstracts
This project attempted to develop an understanding of the response of reinforced concrete coupled wall systems to seismic loading. Five test structures (approximately one-twelfth scale) were subjected to one component of the earthquake base motion measured at El Centro, California (1940). The base motions were strong enough to cause yielding of the test structures. A sixth test structure was subjected to slowly applied cyclic lateral loading. An analytical study of the static hysteretic response of the test structures was undertaken. Equivalent viscous damping factors, consistent with the calculated overall structure hysteresis relation, were determined. The variation of damping factor with response mode and response amplitude was studied. The feasibility of simulating the observed dynamic responses with a linear viscously damped analytical model was investigated. Both response-spectrum analyses and response-history analyses were performed. Finally, the experimental results were compared with the results of the analytical studies. This volume contains tables and figures relevant to the text of the report.

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Table 3.1 Observed Maximum Single-Amplitude Horizontal Accelerations

		Acceleration, G.					
		North Wall			South Wall		
Test Run	Specimen Type	Bottom	Middle	Top	Bottom	Middle	Top
D1-1	A	0.14	0.19	0.27	0.13	0.19	0.24
D1-2		0.38	0.38	0.60	0.37	0.42	0.62
D1-3		0.80	0.56	0.91	0.91	0.57	0.93
D1-4		1.58	0.79	1.08	1.84	0.86	1.09
D1-5		2.81	1.26	1.32	3.15	1.53	1.26
D2-1	B	1.33	0.82	0.89	1.47	0.90	1.00
D2-2		2.34	1.03	1.31	2.32	1.23	1.62
D3-1		1.31	0.97	1.02	1.49	0.74	0.97
D3-2		2.53	1.43	1.24	2.58	1.49	1.29
D4-1	C	1.05	0.72	0.94	1.09	0.76	1.01
D4-2		2.27	2.06	1.56	2.41	1.74	1.54
D5-1		1.19	0.72	0.90	1.17	0.74	0.96
D5-2		2.36	1.59	1.38	2.14	1.89	1.49

Table 3.2 Observed Maximum Single-Amplitude Horizontal Displacement

Test Run	Specimen Type	Displacement, in. North Wall Bottom	North Wall Middle	North Wall Top	South Wall Bottom	South Wall Middle	South Wall Top
D1-1	A	0.023	0.041	0.059	0.020	0.038	0.059
D1-2		0.06	0.10	0.15	0.05	0.10	0.15
D1-3		0.12	0.16	0.25	0.11	0.19	0.31
D1-4		0.20	0.33	0.51	0.20	0.31	0.48
D1-5		0.38	0.72	1.07	0.42	0.67	1.05
D2-1	B	0.12	0.30	0.46	0.12	0.29	0.43
D2-2		0.39	0.86	1.35	0.42	0.89	1.36
D3-1		0.10	0.27	0.44	0.11	0.29	0.47
D3-2		0.28	0.64	1.02	0.26	0.59	0.98
D4-1	C	0.12	0.30	0.51	0.12	0.30	0.48
D4-2		0.29	0.71	1.12	0.30	0.71	1.13
D5-1		0.12	0.29	0.48	0.12	0.29	0.48
D5-2		0.30	0.71	1.15	0.32	0.75	1.23

Table 3.3 Observed Maximum Double-Amplitude Horizontal Displacement

		Displacement, in.					
		North Wall			South Wall		
Test Run	Specimen Type	Bottom	Middle	Top	Bottom	Middle	Top
D1-1	A	0.044	0.080	0.115	0.038	0.073	0.110
D1-2		0.10	0.17	0.27	0.10	0.17	0.28
D1-3		0.20	0.31	0.48	0.20	0.32	0.52
D1-4		0.34	0.51	0.79	0.36	0.50	0.81
D1-5		0.62	1.11	1.70	0.74	1.19	1.84
D2-1	B	0.19	0.47	0.75	0.20	0.49	0.77
D2-2		0.68	1.51	2.42	0.73	1.53	2.38
D3-1		0.17	0.42	0.69	0.18	0.45	0.74
D3-2		0.50	1.18	1.93	0.50	1.18	1.94
D4-1	C	0.20	0.46	0.87	0.21	0.46	0.83
D4-2		0.55	1.34	2.2	0.55	1.41	2.1
D5-1		0.20	0.50	0.85	0.19	0.50	0.86
D5-2		0.58	1.36	2.2	0.60	1.40	2.3

Table 3.4 Observed Residual Displacement

		Displacement, in.					
		North Wall			South Wall		
Test Run	Specimen Type	Bottom	Middle	Top	Bottom	Middle	Top
D1-1	A	~0	~0	~0	~0	~0	~0
D1-2		~0	~0	~0	~0	~0	~0
D1-3		~0	0.004	0.01	-0.004	-0.006	-0.01
D1-4		0.01	0.025	0.04	-0.005	-0.005	-0.005
D1-5		0.10	0.17	0.21	0.04	0.07	0.09
D2-1	B	-0.01	-0.03	-0.05	~0	~0	~0
D2-2		~0	0.01	0.02	~0	0.02	0.05
D3-1		~0	~0	~0	~0	~0	~0
D3-2		~0	-0.04	-0.03	~0	0.03	0.04
D4-1	C	~0	-0.01	-0.02	~0	-0.01	-0.02
D4-2		0.01	0.05	0.05	0.01	0.05	0.07
D5-1		-0.01	-0.02	-0.03	-0.01	-0.02	-0.04
D5-2		0.02	0.06	0.08	0.01	0.05	0.08

Table 3.5 Observed Maximum Single-Amplitude Base Functions

Test Run	Specimen Type	Base Acceleration, G. North	Base Acceleration, G. South	Base Shear*, kip North	Base Shear*, kip South	Base Moment,* k-in. North	Base Moment,* k-in. South
D1-1	A	0.12	0.12	0.50	0.46	21	20
D1-2		0.22	0.21	1.18	1.13	48	49
D1-3		0.50	0.49	1.78	1.73	68	69
D1-4		1.05	1.07	2.3	2.3	86	88
D1-5		2.2	2.2	3.5	3.5	105	102
D2-1	B	1.33	1.23	1.54	1.61	58	60
D2-2		4.07	3.1	2.5	2.5	58	60
D3-1		1.14	1.11	1.67	1.63	56	59
D3-2		2.1	2.1	2.3	2.5	65	62
D4-1	C	1.12	1.12	1.35	1.65	54	56
D4-2		2.4	2.4	2.6	2.0	62	58
D5-1		1.06	1.07	1.50	1.47	51	51
D5-2		2.1	2.1	2.5	2.5	63	62

*For a single wall.

Table 3.6 Observed Response Frequencies

		Frequency, Hz. Mode 1		Mode 2	
Test Run	Specimen Type	Pre-Test[a] Frequency	Post-Test[b] Frequency	Pre-Test[a] Frequency	Post-Test[b] Frequency
D1-1	A	12	6.5	--	--
D1-2		6.2	6.1	32	30
D1-3		5.5	4.7	27	27
D1-4		4.9	3.8	27	23
D1-5		4.0	3.3	24	20
D2-1	B	7.8	3.4	39	19
D2-2		3.4	2.2	19	16
D3-1		7.6	3.5	35	19
D3-2		4.7	2.1	22	12
D4-1	C	6.9	3.5	31	21
D4-2		3.8	2.2	25	13
D5-1		8.4	3.4	31	19
D5-2		4.4	2.1	24	13

[a]Free-vibration test. Maximum displacement amplitude less than 0.01 in.

[b]Based on displacement response during the last two sec. of test duration.

Table 3.7 Spectrum Intensities for Observed Base Motions

		Spectrum Intensity, in.									
		North Record					South Record				
Test Run	Spec. Type	β=0.0	β=0.02	β=0.05	β=0.10	β=0.20	β=0.0	β=0.02	β=0.05	β=0.10	β=0.20
D1-1	A	1.72	1.13	0.90	0.72	0.56	1.61	1.05	0.85	0.68	0.53
D1-2		3.4	2.2	1.80	1.46	1.13	3.2	2.1	1.73	1.40	1.09
D1-3		6.4	4.3	3.5	2.9	2.3	6.4	4.3	3.5	2.9	2.3
D1-4		12.6	8.2	6.7	5.7	4.7	12.6	8.3	6.7	5.7	4.7
D1-5		24.4	16.0	13.1	11.0	9.1	25	16.1	13.2	11.1	9.1
D2-1	B	9.3	6.1	5.1	4.3	3.5	9.5	6.2	5.2	4.4	3.5
D2-2		19.3	12.7	10.8	9.2	7.5	19.4	12.8	10.7	9.1	7.4
D3-1		13.4	9.3	7.8	6.4	4.9	12.0	8.1	6.6	5.5	4.4
D3-2		19.8	13.0	10.7	9.0	7.5	20.0	13.0	10.8	9.1	7.4
D4-1	C	9.9	6.5	5.3	4.5	3.7	10.0	6.5	5.3	4.5	3.7
D4-2		20	13.4	11.1	9.3	7.7	20.0	13.2	10.9	9.2	7.6
D5-1		10.1	6.5	5.4	4.5	3.7	10.0	6.5	5.4	4.5	3.7
D5-2		20	13.2	10.9	9.1	7.5	19.9	13.1	10.8	9.0	7.4

Table 4.1 Average Beam Section Properties Computed from Measured Dimensions of Each Test Structure

Parameter	Symbol	Values based on mean dimensions					
		D1	D2	D3	D4	D5	S1
Uncracked Transformed Area, in^2	A_{tr}	2.9	1.69	1.74	1.67	1.66	1.73
Uncracked Transformed Moment of Inertia, in^4	I_{tr}	1.28	0.32	0.32	0.32	0.31	0.33
Cracked Transformed Area, in^2	A_{cr}	1.43	0.59	0.64	0.47	0.48	0.61
Cracked Transformed Moment of Inertia, in^4	I_{cr}	0.61	0.073	0.083	0.054	0.054	0.078
Cracking Moment, k-in.	M_c	0.31	0.171	0.185	0.171	0.20	0.163
Yield Moment, k-in	M_y	2.6	0.49	0.50	0.30	0.30	0.50
Ultimate Moment, k-in.	M_u	3.4	0.78	0.78	0.48	0.46	0.78

Table 4.2 Average Section Stiffnesses for Piers Computed from Measured Dimensions of Each Test Structure

Case	Axial Load, kips	Moment	Area, in^2 D1	D2	D3	D4	D5	S1	Moment of Inertia, in^4 D1	D2	D3	D4	D5	S1
Uncracked	-	-	7.8	7.7	7.7	7.8	7.9	8.1	32	31	31	32	32	33
Cracked	-0.5*	M_{cr}	1.41	1.61	1.89	1.82	1.97	1.71	5.9	5.8	6.9	6.8	7.0	6.3
		$\frac{M_{cr}+M_u}{2}$	1.94	1.91	2.2	2.1	2.2	2.1	6.1	5.9	6.9	6.9	7.0	6.3
		M_u	2.0	2.0	2.2	2.2	2.2	2.1	6.1	5.9	6.9	6.9	7.0	6.3
	0.0	M_{cr}	2.2	2.1	2.4	2.3	2.4	2.3	6.1	5.9	6.9	6.9	7.0	6.3
		$\frac{M_{cr}+M_u}{2}$	2.2	2.1	2.4	2.3	2.4	2.3	6.1	5.9	6.9	6.9	7.0	6.3
		M_u	2.2	2.1	2.4	2.3	2.4	2.3	6.1	5.9	6.9	6.9	7.0	6.3
	0.5	M_{cr}	2.6	2.4	2.7	2.7	2.7	2.6	6.2	5.9	6.9	6.9	7.0	6.3
		$\frac{M_{cr}+M_u}{2}$	2.3	2.3	2.5	2.5	2.5	2.4	6.1	5.9	6.9	6.9	7.0	6.3
		M_u	2.3	2.2	2.5	2.5	2.5	2.4	6.1	5.9	6.9	6.9	7.0	6.3
	1.5	M_{cr}	3.0	2.8	3.1	3.1	3.0	3.0	6.3	5.9	7.0	7.0	7.1	6.4
		$\frac{M_{cr}+M_u}{2}$	2.6	2.5	2.7	2.7	2.8	2.7	6.2	5.9	6.9	6.9	7.0	6.3
		M_u	2.4	2.4	2.6	2.6	2.6	2.5	6.2	5.9	6.9	6.9	7.0	6.3
	3.0	M_{cr}	3.3	3.1	3.4	3.4	3.4	3.4	6.5	6.1	7.2	7.2	7.2	6.6
		$\frac{M_{cr}+M_u}{2}$	2.8	2.7	3.0	2.9	3.0	2.9	6.2	5.9	7.0	6.9	7.1	6.4
		M_u	2.6	2.5	2.8	2.8	2.8	2.7	6.2	5.9	6.9	6.9	7.0	6.3

*Negative Load denotes tension.

Table 4.3 Average Pier Section Strength for Each Test Structure Computed from Measured Dimensions

Parameter	Symbol	Loads (kips)	Average value for each test structure					
			D1	D2	D3	D4	D5	S1
Cracking Moment, k-in.	M_c	-0.5	2.2	3.1	3.4	3.2	3.9	3.0
		0.0	2.8	3.7	4.0	3.7	4.5	3.6
		0.5	3.4	4.3	4.5	4.3	5.1	4.1
		1.5	4.6	5.4	5.7	5.5	6.2	5.3
		3.0	6.3	7.2	7.4	7.2	8.0	7.0
Ultimate Moment, k-in.	M_u	0.5	-	-	-	-	-	13.2
		1.0	-	-	-	-	-	14.7
		1.5	-	-	-	-	-	16.1

Table 4.4 Natural Frequencies for Each Test Structure Computed from Measured Dimensions

Mode	Case	Computed natural frequency for each test structure, Hz.					
		D1	D2	D3	D4	D5	S1
First	Uncracked	16.3	13.8	12.5	12.8	12.5	13.6
	Beams Cracked	15.4	10.5	9.8	9.1	8.9	10.4
	Beams and Lower Piers Cracked	11.3	8.0	7.6	7.0	6.9	8.0
	Uncoupled Piers, Uncracked	6.3	6.1	5.5	5.6	5.5	6.0
	Uncoupled Piers, Lower Piers Cracked	3.7	3.5	3.3	3.4	3.4	3.4
Second	Uncracked	74	57	52	53	52	56
	Beams Cracked	66	47	43	42	42	47
	Beams and Lower Piers Cracked	59	41	38	37	36	40
	Uncoupled Piers, Uncracked	42	40	36	37	37	39
	Uncoupled Piers, Lower Piers Cracked	35	33	31	31	31	33

Table 4.5 Mode Shapes Computed from Measured Dimensions of Test Structures

Case	Level	Mode 1 Structure Types A,B,C	Mode 2 Structure Type A	Mode 2 Structure Types B,C
Uncracked	Top	0.57	-0.42	-0.52
	Middle	0.32	0.74	0.78
	Bottom	0.10	0.68	0.74
Beams Cracked-Piers Uncracked	Top	0.57	-0.47	-0.62
	Middle	0.33	0.76	0.85
	Bottom	0.11	0.71	0.77
Beams and Lower Piers Cracked	Top	0.54	-0.53	-0.71
	Middle	0.33	0.69	0.79
	Bottom	0.13	0.84	0.92
Uncoupled Piers, Uncracked	Top	0.59	-0.56	-0.56
	Middle	0.31	0.86	0.86
	Bottom	0.09	0.71	0.71
Uncoupled Piers, Lower Piers Cracked	Top	0.55	-0.70	-0.70
	Middle	0.33	0.82	0.82
	Bottom	0.13	0.88	0.88

Table 4.6 Stiffness for Each Test Structure Computed from Measured Dimensions

Case	Computed stiffness for each test structure, kip *					
	D1	D2	D3	D4	D5	S1
Uncracked	1980	1570	1290	1340	1290	1530
Beams Cracked	1740	910	790	670	660	890
Beams and Lower Piers Cracked	950	530	480	400	400	530
Uncoupled Piers, Uncracked	290	310	250	250	250	300
Uncoupled Piers, Lower Pier Cracked	102	101	90	94	96	96

*Values given are for one wall (one-half of a test structure).

Note: Stiffness given in terms of base moment per unit deflection at top for the force distribution shown in Fig. 4.4.

Table 4.7 Strength Properties Computed from Measured Dimensions of Each Test Structure

Parameter	Symbol[c]	Computed properties for each test structure (one wall)[a]					
		D1	D2	D3	D4	D5	S1
Base Shear - Mechanism 1	V_b	1.8	1.1	1.1	0.9	0.9	1.1
Base Tension - Mechanism 1	T_b	3.5	0.0	0.0	-0.60[b]	-0.60[b]	0.0
Base Compression - Mechanism 1	C_b	6.5	3.0	3.0	2.4	2.4	3.0
Base Moment due to Couple - Mechanism 1	M_3	55	17	17	10	10	17
Base Moment of Piers - Mechanism 1	M_1+M_2	26	30	30	30	30	30
Total Base Moment - Mechanism 1	M_b	81	47	47	40	40	47
Base Shear - Mechanism 2	V_b	-	1.3	1.3	1.0	1.0	1.3
Base Tension - Mechanism 2	T_b	-	0.84	0.84	-0.06[b]	-0.12[b]	0.84
Base Compression - Mechanism 2	C_b	-	3.8	3.8	2.9	2.9	3.8
Base Moment Due to Couple - Mechanism 2	M_3	-	26	26	16	15	26
Base Moment of Piers - Mechanism 2	M_1+M_2	-	30	30	30	30	30
Total Base Moment - Mechanism 2	M_b	-	56	56	46	45	56

[a]Values given are for one wall (one-half of a test structure).

[b]Negative values for T_b denote compression.

[c]Symbols refer to Fig. 4.12.

Table 5.1 Defining Parameters for Idealization of Moment-Curvature Relations

Description	Symbol*	Beam	Pier
Moment at First Discontinuity, kip-in.	M_{y1}	0.50	14.1
Moment at Second Discontinuity, kip-in.	M_{y2}	0.67	15.9
Moment at Third Discontinuity, kip-in.	M_{y3}	0.78	-
Moment for 20% Strain in Tension Steel, kip-in.	M_{ℓ}	0.78	16.1
Curvature at First Discontinuity, in^{-1}	ϕ_{y1}	0.0022	0.001
Curvature at Second Discontinuity, in^{-1}	ϕ_{y2}	0.0127	0.014
Curvature at Third Discontinuity, in^{-1}	ϕ_{y3}	0.074	-
Curvature for 20% Strain in Tension Steel, in^{-1}	ϕ_{ℓ}	0.20	0.035

*Symbols relate to Fig. 5.2 and 5.3.

Table 5.2 Defining Parameters for Idealization of Moment-Rotation Relations

Parameter[a]		Beam	Pier M_{et}[a] (kip-in.)							
			6	7	8	9	10	11	12	14.1
M_{y1}	(kip-in.)	0.55	20.1	21.1	22.1	23.1	24.1	25.1	26.1	28.2
M_{y2}	(kip-in.)	0.72	21.9	22.9	23.9	24.9	25.9	26.9	27.9	30.0
M_{ℓ}	(kip-in.)	0.80	22.1	23.1	24.1	25.1	26.1	27.1	28.1	30.2
θ_{y1}	(radians)	0.00058	0.0054	0.0056	0.0059	0.0061	0.0064	0.0067	0.0069	0.0075
θ_{y2}	(radians)	0.00188	0.0144	0.0156	0.0171	0.0190	0.021	0.025	0.029	0.056
θ_{ℓ}	(radians)	0.0067	0.0180	0.0195	0.022	0.024	0.027	0.031	0.037	0.070

[a] Symbols relate to Fig. 5.5 and 5.6.

Table 5.3 Member Rotation Parameters Calculated from Hysteresis Shape Study

				Member End Rotations,[b] radians						
				Pier	Beams					
Hysteresis Model	Type of Parameter	Quarter Cycle	Symbol[a]	Lower Level	First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
All	Maximum	First	θ_{m1}	0.0059	0.0059	0.0098	0.0123	0.0130	0.0130	0.0125
	Zero Intercept	Second	θ_{r1}	0	0.0033	0.0062	0.0080	0.0086	0.0086	0.0082
1	Maximum	Third	θ_{m2}	0.0093	0.0093	0.0135	0.0160	0.0169	0.0168	0.0163
	Zero Intercept	Fourth	θ_{r2}	0.0017	0.0058	0.0090	0.0108	0.0115	0.0115	0.0111
	Maximum	Fifth	θ_{m3}	0.0111	0.0111	0.0153	0.0178	0.0187	0.0186	0.0181
2	Maximum	Third	θ_{m2}	0.0076	0.0076	0.0125	0.0158	0.0176	0.0183	0.0184
	Zero Intercept	Fourth	θ_{r2}	0.0005	0.0037	0.0074	0.0100	0.0115	0.0121	0.0121
	Maximum	Fifth	θ_{m3}	0.0094	0.0094	0.0143	0.0176	0.0194	0.0202	0.0202

[a] Symbols refer to Fig. 5.13, 5.17, 5.22 and 5.25.

[b] Rotations are given as absolute values.

Table 5.3 (contd.) Member Rotation Parameters Calculated from Hysteresis Shape Study

Hysteresis Model	Type of Parameter	Quarter Cycle	Symbol	Member End Rotations, radians — Pier: Lower Level	Beams: First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
3	Maximum	Third	θ_{m2}	0.0093	0.0093	0.0135	0.0160	0.0169	0.0168	0.0163
	Zero Intercept	Fourth	θ_{r2}	0.0016	0.0059	0.0090	0.0108	0.0115	0.0114	0.0111
	Maximum	Fifth	θ_{m3}	0.0110	0.0110	0.0153	0.0178	0.0187	0.0186	0.0182
4-5	Maximum	Third	θ_{m2}	0.0093	0.0093	0.0135	0.0160	0.0169	0.0168	0.0163
	Zero Intercept	Fourth	θ_{r2}	0.0016	0.0058	0.0089	0.0108	0.0114	0.0114	0.0110
	Maximum	Fifth	θ_{m_3}	0.0109	0.0109	0.0153	0.0178	0.0187	0.0187	0.0183
5	Maximum	Fifth	θ_{m_3}	0.0110	0.0110	0.0153	0.0178	0.0187	0.0186	0.0181

Table 5.4 Member Rotation Parameters Calculated from Study of Equivalent Damping and Response Amplitude

					Member End Rotations,[b] radians						
					Pier	Beams					
Mode	Ampl. Level	Type of Parameter	Quarter Cycle	Symbol[a]	Lower Level	First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
1	Both	Maximum	First	θ_{m1}	0.0054	0.0054	0.0090	0.0111	0.0118	0.0117	0.0113
		Zero Intercept	Second	θ_{r1}	0	0.0030	0.0056	0.0072	0.0077	0.0076	0.0073
		Maximum	Third	θ_{m2}	0.0057	0.0057	0.0091	0.0111	0.0117	0.0116	0.0111
		Zero Intercept	Fourth	θ_{r2}	0	0.0045	0.0057	0.0071	0.0076	0.0075	0.0072
		Maximum	Fifth	θ_{m3}	0.0054	0.0054	0.0090	0.0111	0.0118	0.0117	0.0113
		Zero Intercept	Sixth	θ_{r3}	0	0.0030	0.0056	0.0072	0.0077	0.0076	0.0073
	High	Maximum	Seventh	θ_{m4}	0.0057	0.0057	0.0091	0.0111	0.0117	0.0116	0.0111
	Low	Maximum	Seventh	θ_{m4}	0.0016	0.0016	0.0027	0.0033	0.0036	0.0036	0.0035
		Zero Intercept	Eighth	θ_{r4}	0	0.0012	0.0022	0.0028	0.0030	0.0030	0.0029
		Maximum	Ninth	θ_{m5}	0.0015	0.0015	0.0026	0.0033	0.0036	0.0037	0.0036
		Zero Intercept	Tenth	θ_{r5}	0	0.0013	0.0023	0.0029	0.0031	0.0032	0.0031
		Maximum	Eleventh	θ_{m6}	0.0015	0.0015	0.0026	0.0033	0.0036	0.0036	0.0036

[a] Symbols refer to Fig. 5.33

[b] For Mode 1, rotations are given as absolute values.
For Mode 2, rotations are positive clockwise.

Table 5.4 (contd.) Member Rotation Parameters Calculated from Study of Equivalent Damping and Response Amplitude

					Member End Rotations, radians						
					Pier	Beams					
Mode	Ampl. Level	Type of Parameter	Quarter Cycle	Symbol	Lower Level	First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
2	Both	Maximum	First	θ_{m1}	0.0020	0.0020	0.0020	0.0009	-0.0002	-0.0011	-0.0011
		Zero Intercept	Second	θ_{r1}	0	0.0006	0.0006	0.0001	0	-0.0002	-0.0002
		Maximum	Third	θ_{m2}	-0.0021	-0.0021	-0.0021	-0.0011	-0.0002	0.0013	0.0015
		Zero Intercept	Fourth	θ_{r2}	0	-0.0013	-0.0014	-0.0005	0	0.0007	0.0008
		Maximum	Fifth	θ_{m3}	0.0021	0.0021	0.0021	0.0011	-0.0002	-0.0013	-0.0015
		Zero Intercept	Sixth	θ_{r3}	0	0.0013	0.0014	0.0005	0	-0.0007	-0.0008
		Maximum	Seventh	θ_{m4}	-0.0021	-0.0021	-0.0021	-0.0011	0.0002	0.0013	0.0015

Table 5.5 Equivalent Damping Results

Mode of Loading	Amplitude Level	Loading Segments Enclosing Area for Energy Dissipation Calculation (Quarter Cycles)	Damping as a fraction of Critical Damping
First	High	Fourth through Seventh	0.065
First	Low	Eighth through Eleventh	0.146
Second	-	Fourth through Seventh	0.043

Table 6.1 Fourier Analysis. Maximum Computed Accelerations and Displacements

Parameter	Test Run	Lower Level			Middle Level			Top Level		
		First Mode	Higher Modes	Total	First Mode	Higher Modes	Total	First Mode	Higher Modes	Total
Acceleration, g[a]	D1-4	0.78	1.23	1.58	0.58	0.61	0.79	0.96	0.58	1.08
	D2-1	0.31	1.35	1.33	0.39	0.66	0.82	0.64	0.73	0.89
	D3-1	0.33	1.34	1.31	0.38	0.74	0.97	0.70	0.87	1.02
	D4-1	0.30	1.03	1.05	0.38	0.76	0.72	0.67	0.73	0.94
	D5-1	0.30	1.18	1.19	0.37	0.63	0.72	0.66	0.74	0.90
Displacement, in.[b]	D1-4	0.18	0.08	0.18	0.25	0.04	0.26	0.39	0.07	0.40

[a]Values provided are single amplitude maxima.

[b]Values provided are one-half of double amplitude maxima.

Table 6.2 Fourier Analysis. Maximum Computed Base Shear and Base Moment

Test Run	Base Shear, kips			Base Moment, kip-in.		
	First Mode	Higher Modes	Total	First Mode	Higher Modes	Total
D1-4	2.02	0.87	2.25	78	26	86
D2-1	1.13	1.13	1.54	49	19	58
D3-1	1.16	1.14	1.67	51	17	56
D4-1	1.14	0.92	1.35	50	10	54
D5-1	1.11	1.00	1.50	49	13	51

Table 6.3 Fourier Analysis. Frequencies for Computed Response Histories

		Frequency, Hz.			
		First Mode		Higher Modes	
Parameter	Run	Early[a]	Late[b]	Early[a]	Late[b]
Lower Level Acceleration[c]	D1-4	(7.3)	(5.5)	15	16
	D2-1	(7.3)	(7.5)	24	20
	D3-1	(7.3)	(8.5)	20	19
	D4-1	(7.3)	(8.0)	19	19
	D5-1	(7.3)	(8.0)	20	19
Middle Level Acceleration	D1-4	4.3	4.3	25	21
	D2-1	4.5	3.3	26	25
	D3-1	4.5	4.3	21	19
	D4-1	4.3	3.0	23	22
	D5-1	4.5	3.0	21	19
Top Level Acceleration	D1-4	4.7	4.5	27	21
	D2-1	4.5	4.3	23	22
	D3-1	4.5	5.0	20	19
	D4-1	4.5	3.0	20	18
	D5-1	5.2	4.0	19	19
Lower Level Displacement	D1-4	(6.0)	4.9	11	11
Middle Level Displacement	D1-4	5.7	4.5	11[d]	--
Top Level Displacement	D1-4	5.7	4.5	11[d]	--

[a]Measured over first 1.5 sec. of response.

[b]Measured over final 2.0 sec. of response.

[c]Influenced strongly by frequency content of base motion.

[d]Measured over first 1.0 sec. of response.

Table 7.1 Reference Section Stiffnesses for Study of Dynamic Response

Specimen Type	Test Structure	Bending Stiffness of Pier Section, $kip\text{-}in^2$		Axial Stiffness of Pier Section, kips		Bending Stiffness of Beam Section, $kip\text{-}in^2$	
		Uncracked	Reference	Uncracked	Reference	Uncracked	Reference
A	D1	104,300	57,200	25,500	14,000	3,660	2,010
B	D2	106,800	31,500	26,200	7,730	1,074	317
B	D3	87,300	31,400	21,400	7,700	890	320
C	D4	91,600	31,400	22,500	7,720	913	313
C	D5	88,600	31,900	21,700	7,810	858	309
	Average for types B and C	--	31,600	--	7,740	--	315

Table 7.2 Study of Response History. First-Mode Frequencies for Substitute Structures

Specimen Type	Test Run	First Mode Frequency, Hz. Early Frequency	Late Frequency
A	D1-4	4.7	3.8
B	D2-1	4.5	3.4
B	D3-1	4.1	3.5
C	D4-1	4.3	3.5
C	D5-1	4.3	3.4

Table 7.3 Study of Response History. Test Runs Analyzed for Each Combination of First- and Second-Mode Viscous Damping Factors

First-Mode Viscous Damping as a Fraction of Critical Damping	Second-Mode Viscous Damping as a Fraction of Critical Damping			
	0.02	0.05	0.10	0.15
0.02	D1-4 D2-1 D3-1 D4-1 D5-1			
0.05				
0.10	D4-1	D4-1	D1-4 D2-1 D3-1 D4-1 D5-1	
0.15				D4-1

Note: All above cases analyzed for both early frequency and late frequency.

Table 7.4 Parameters for Study of Response History

Analysis Number	Base Motion	Structure Type	Damage Ratio		Frequency, Hz.		Frequency Description	Damping Factor PerCent		Shape of First Mode			Shape of Second Mode		
			First Story Pier	Beams	First Mode	Second Mode		First Mode	Second Mode	Bottom Level	Middle Level	Top Level	Bottom Level	Middle Level	Top Level
1	D1-4	A	11.3	11.3	4.7	30	Early	2.0	2.0	0.14	0.33	0.52	0.89	0.72	-0.62
2	D1-4	A	11.3	11.3	4.7	30	Early	10.0	10.0	0.14	0.33	0.52	0.89	0.72	-0.62
3	D1-4	A	17.6	17.6	3.8	27	**Late**	2.0	2.0	0.14	0.33	0.52	0.89	0.70	-0.59
4	D1-4	A	17.6	17.6	3.8	27	Late	10.0	10.0	0.14	0.33	0.52	0.89	0.70	-0.59
5	D4-1	C	1.0	17.1	4.3	23	Early	2.0	2.0	0.10	0.32	0.58	0.74	0.86	-0.60
6	D4-1	C	1.0	17.1	4.3	23	Early	10.0	10.0	0.10	0.32	0.58	0.74	0.86	-0.60
7	D4-1	C	1.0	114	3.5	22	Late	2.0	2.0	0.10	0.32	0.59	0.72	0.86	-0.57
8	D4-1	C	1.0	114	3.5	22	Late	10.0	10.0	0.10	0.32	0.59	0.72	0.86	-0.57
9	D4-1	C	1.0	17.1	4.3	23	Early	15.0	15.0	0.10	0.32	0.58	0.74	0.86	-0.60
10	D4-1	C	1.0	114	3.5	22	Late	15.0	15.0	0.09	0.32	0.59	0.72	0.86	-0.57
11	D4-1	C	1.0	17.1	4.3	23	Early	10.0	2.0	0.10	0.32	0.58	0.74	0.86	-0.60
12	D4-1	C	1.0	17.1	4.3	23	Early	10.0	5.0	0.10	0.32	0.58	0.74	0.86	-0.60
13	D4-1	C	1.0	114	3.5	22	Late	10.0	2.0	0.09	0.32	0.59	0.72	0.86	-0.57
14	D4-1	C	1.0	114	3.5	22	Late	10.0	5.0	0.09	0.32	0.59	0.72	0.86	-0.57
15	D2-1	B	1.0	13.4	4.5	23	Early	2.0	2.0	0.10	0.32	0.58	0.74	0.86	-0.61
16	D2-1	B	1.0	13.4	4.5	23	Early	10.0	10.0	0.10	0.32	0.58	0.74	0.86	-0.61
17	D2-1	B	1.0	225	3.4	22	Late	2.0	2.0	0.09	0.32	0.59	0.71	0.85	-0.57
18	D2-1	B	1.0	225	3.4	22	Late	10.0	10.0	0.09	0.32	0.59	0.71	0.85	-0.57
19	D3-1	B	1.0	23	4.1	23	Early	2.0	2.0	0.10	0.32	0.58	0.73	0.86	-0.60
20	D3-1	B	1.0	23	4.1	23	Early	10.0	10.0	0.10	0.32	0.58	0.73	0.86	-0.60
21	D3-1	B	1.0	114	3.5	22	Late	2.0	2.0	0.09	0.32	0.59	0.72	0.86	-0.57
22	D3-1	B	1.0	114	3.5	22	Late	10.0	10.0	0.09	0.32	0.59	0.72	0.86	-0.57
23	D5-1	C	1.0	17.1	4.3	23	Early	2.0	2.0	0.10	0.32	0.58	0.74	0.86	-0.60
24	D5-1	C	1.0	17.1	4.3	23	Early	10.0	10.0	0.10	0.32	0.58	0.74	0.86	-0.60
25	D5-1	C	1.0	225	3.4	22	Late	2.0	2.0	0.09	0.32	0.59	0.71	0.85	-0.57
26	D5-1	C	1.0	225	3.4	22	Late	10.0	10.0	0.09	0.32	0.59	0.71	0.85	-0.57

Table 7.5 Maximum Calculated Responses from Study of Response History

Analysis Number	Top Level Deflection, in.			Base Shear, kips			Base Moment, kip-in.		
	First Mode	Second Mode	Sum of First and Second Modes	First Mode	Second Mode	Sum of First and Second Modes	First Mode	Second Mode	Sum of First and Second Modes
1	0.78	0.005	0.78	3.3	0.70	3.4	143	6.2	142
2	0.49	0.004	0.49	2.1	0.67	2.1	90	5.9	87
3	0.62	0.006	0.62	1.77	0.82	1.83	76	7.7	75
4	0.49	0.005	0.49	1.38	0.67	1.41	59	6.2	58
5	0.57	0.014	0.57	1.85	1.31	2.4	82	15.5	82
6	0.34	0.013	0.34	1.10	1.14	1.30	49	13.5	47
7	0.48	0.019	0.49	1.02	1.67	1.82	46	21	47
8	0.37	0.015	0.37	0.78	1.26	1.19	35	16.2	35
9	0.29	0.012	0.29	0.96	1.05	1.07	43	12.4	41
10	0.34	0.013	0.34	0.72	1.15	1.05	32	14.7	31
11	0.34	0.014	0.35	1.10	1.31	1.86	49	15.5	54
12	0.34	0.012	0.35	1.10	1.12	1.60	49	13.3	50
13	0.37	0.019	0.37	0.78	1.67	1.72	35	21	40
14	0.37	0.015	0.37	0.78	1.30	1.44	35	16.6	36
15	0.48	0.028	0.49	1.73	2.5	3.5	77	29	84
16	0.34	0.019	0.34	1.21	1.75	2.3	54	20	55
17	0.47	0.032	0.48	0.94	2.8	3.2	42	36	53
18	0.36	0.019	0.36	0.71	1.60	1.72	32	21	37
19	0.65	0.017	0.66	1.92	1.49	3.2	86	18.0	98
20	0.43	0.016	0.44	1.26	1.39	2.3	57	16.8	62
21	0.82	0.022	0.81	1.74	1.93	3.2	78	25	94
22	0.67	0.018	0.66	1.42	1.54	2.1	64	19.8	72
23	0.57	0.016	0.57	1.86	1.42	2.4	83	16.8	83
24	0.33	0.013	0.34	1.08	1.22	1.26	48	14.5	46
25	0.52	0.020	0.53	1.05	1.75	2.1	47	23	50
26	0.40	0.016	0.40	0.80	1.41	1.33	36	18.2	36

Table 7.6 Study of Response History. Per Cent Change in Maximum Response as First-Mode Frequency Changes from Early Frequency to Late Frequency

Test Run	Top Level Deflection		Base Shear				Base Moment			
	First-Mode Response		First-Mode Response		Second-Mode Response		First-Mode Response		Second-Mode Response	
	β_1=0.02	β_1=0.10	β_1=0.02	β_1=0.10	β_2=0.02	β_2=0.10	β_1=0.02	β_1=0.10	β_2=0.02	β_2=0.10
D1-4	-21	0	-46	-34	+17	0	-47	-34	+24	+5
D2-1	- 2	+6	-46	-41	+12	-9	-45	-41	+24	+5
D3-1	+26	+56	- 9	+13	+30	+11	- 9	+12	+39	+18
D4-1	-16	+ 9	-45	-29	+27	+11	-44	-29	+35	+20
D5-1	- 9	+21	-44	-26	+23	+16	-43	-25	+37	+26

β_1 = Viscous damping factor for first mode, expressed as a fraction of critical damping.

β_2 = Viscous damping factor for second mode, expressed as a fraction of critical damping.

Results given represent $\frac{w_L - w_E}{w_E} \times 100\%$

where, w_E = maximum response when the first-mode frequency is equal to the early frequency.

w_L = maximum response when the first-mode frequency is equal to the late frequency.

Table 8.1 Comparison of Initial Stiffnesses

Origin	Description	Test Structure	Stiffness,* kips	First-Mode Frequency, Hz.
Calculated	Beams and Piers Uncracked	D2	1570	13.8
		D3	1290	12.5
		S1	1530	13.6
Calculated	Beams Cracked, Piers Uncracked	D2	910	10.5
		D3	790	9.8
		S1	890	10.4
Calculated	Beams Cracked, Lower Piers Cracked	D2	530	8.0
		D3	480	7.6
		S1	530	8.0
Observed	Low-Amplitude Free-Vibration Test	D2	500	7.8
		D3	480	7.6
Observed	Measured by Dial Gages (Corrected for Base Movement)	S1	520	7.9
Observed	Measured by Dial Gages (Uncorrected for Base Movement)	S1	470	7.5
Observed	Measured by Differential Transformers	S1	420	7.1

*Base moment per in. of top-story displacement for one wall (first-mode force distribution).

Table 8.2 Ratios of Initial Stiffnesses of Structure, Obtained in Various Manners, to the Stiffness of the Structure in the Uncracked State

Parameter	Test Structure		
	D2	D3	S1
(Measured Initial Stiffness of Structure)[a]/(Calculated Stiffness of Uncracked Structure)[b]	0.32	0.37	0.34
(Cracked Section Stiffness for Beams)/(Uncracked Section Stiffness for Beams)	0.23	0.26	0.24
(Cracked Section Stiffness for Pier)/(Uncracked Section Stiffness for Pier)	0.19	0.22	0.19
(Calculated Stiffness of Structure with Beams Cracked and Pier Uncracked)[b]/(Calculated Stiffness of Uncracked Structure)[b]	0.58	0.61	0.58
(Calculated Stiffness of Structure with Beams Cracked and First-Story Pier Cracked)[b]/(Calculated Stiffness of Uncracked Structure)[b]	0.34	0.37	0.35

[a]From a low-amplitude free-vibration test or a dial-gage reading corrected for base movement.

[b]Expressed in terms of base moment per inch of top-level deflection for one wall.

Table 8.3 Observed Maximum Responses and Strengths for Test Structures

Parameter	Symbol	Structure Identification and Type					
		Type A D1	Type B D2	Type B D3	Type C D4	Type C D5	Type B S1
Calculated Base Moment at Failure, Mechanism 1, kip-in.[a]	M_{mch1}	81	47	47	40	40	47
Calculated Base Shear at Failure, Mechanism 1, kips[a]	V_{mch1}	1.8	1.1	1.1	0.9	0.9	1.1
Calculated Base Moment at Failure, Mechanism 2, kip-in.[a]	M_{mch2}	-	56	56	46	45	56
Calculated Base Shear at Failure, Mechanism 2, kips[a]	V_{mch2}	-	1.3	1.3	1.0	1.0	1.3
Maximum Base Moment for First-Mode Response, 1.0g Test Run, kip-in.[b]	M_{md1}	78	49	51	50	49	-
Maximum Base Moment for Total Observed Response, 1.0g Test Run, kip-in.[b]	M_{crn}	86	58	56	54	51	-
Maximum Observed Base Moment, Final Test Run, kip-in.[c]	M_{frn}	105	58	65	62	63	-

[a]Failure mechanisms 1 and 2 are defined in section 4.4(c).

[b]Maxima are results of Fourier analysis (chapter 6), for test runs D1-4, D2-1, D3-1, D4-1 and D5-1.

[c]Maxima as reported in chapter 3, for test runs D1-5, D2-2, D3-2, D4-2 and D5-2, north wall.

[d]Negative and positive loading directions defined in chapters 3 and 5.

Table 8.3 (contd.) Observed Maximum Responses and Strengths for Test Structures

Parameter	Symbol	Structure Identification and Type					
		Type A D1	Type B D2	Type B D3	Type C D4	Type C D5	Type B S1
Maximum Base Shear for First Mode Response, 1.0g Test Run, kips[b]	V_{md1}	2.0	1.1	1.2	1.1	1.1	-
Maximum Base Shear for Total Observed Response, 1.0g Test Run, kips[b]	V_{crn}	2.3	1.5	1.7	1.4	1.5	-
Maximum Observed Base Shear, Final Test Run, kips[c]	V_{frn}	3.5	2.5	2.3	2.6	2.5	-
Maximum Observed Positive Base Moment, Static Test, kip-in.[d]	M_{spos}	-	-	-	-	-	57
Maximum Observed Negative Base Moment, Static Test, kip-in.	M_{sneg}	-	-	-	-	-	58
Maximum Observed Positive Base Shear, Static Test, kips	V_{spos}	-	-	-	-	-	1.3
Maximum Observed Negative Base Shear, Static Test, kips[d]	V_{sneg}	-	-	-	-	-	1.3

Table 8.4 Stiffnesses for the Test Structures for Several Cases

Case	Stiffness for Each Test Structure,* kip					
	Type A D1	Type B D2	Type B D3	Type C D4	Type C D5	Type B S1
Uncracked	1980	1570	1290	1340	1290	1530
Beams Cracked	1740	910	790	670	660	890
Beams and Lower Piers Cracked	950	530	480	400	400	530
Uncoupled Piers, Uncracked	290	310	250	250	250	300
Uncoupled Piers, Lower Piers Cracked	102	101	90	94	96	96
Maximum First Quarter Cycle Deflection - Static Test	-	-	-	-	-	105
Maximum First Quarter Cycle Deflection-Hysteretic Analysis, Model 5	-	-	-	-	-	103
Pre-Test Free-Vibration Test	851	500	480	390	590	-
Early Frequency	166	166	139	151	153	-
Late Frequency	108	95	101	100	96	-
Ratio of Base Moment to Top Level Deflection, t = 0.4 sec.	-	165	160	150	161	-
Ratio of Base Moment to Top Level Deflection, t = 0.6 sec.	-	142	137	131	128	-
Ratio of Base Moment to Top Level Deflection, t = 0.7 sec.	153	130	146	117	115	-
Ratio of Base Moment to Top Level Deflection, t = 1.2 sec.	-	109	114	100	102	-

*Base moment per in. of top story displacement for one wall.

Table 8.5 First-Mode Frequencies for the Test Structures for Several Cases

Case	First-Mode Frequency for Each Test Structure, Hz.					
	Type A D1	Type B D2	Type B D3	Type C D4	Type C D5	Type B S1
Uncracked	16.3	13.8	12.5	12.8	12.5	13.6
Beams Cracked	15.4	10.5	9.8	9.1	8.9	10.4
Beams and Lower Piers Cracked	11.3	8.0	7.6	7.0	6.9	8.0
Uncoupled Piers, Uncracked	6.3	6.1	5.5	5.6	5.5	6.0
Uncoupled Piers, Lower Piers Cracked	3.7	3.5	3.3	3.4	3.4	3.4
Maximum First Quarter Cycle Deflection - Static Test	-	-	-	-	-	3.6
Maximum First Quarter Cycle Deflection - Hysteretic Analysis, Model 5	-	-	-	-	-	3.5
Pre-Test Free-Vibration Test	12	7.8	7.6	6.9	8.4	-
Early Frequency	4.7	4.5	4.1	4.3	4.3	-
Late Frequency	3.8	3.4	3.5	3.5	3.4	-
Ratio of Base Moment to Top Level Deflection, t = 0.4 sec.	-	4.5	4.4	4.3	4.4	-
Ratio of Base Moment to Top Level Deflection, t = 0.6 sec.	-	4.2	4.1	4.0	3.9	-
Ratio of Base Moment to Top Level Deflection, t = 0.7 sec.	4.5	4.0	4.2	3.8	3.7	-
Ratio of Base Moment to Top Level Deflection, t = 1.2 sec.	-	3.6	3.7	3.5	3.5	-

Table 8.6 Section Stiffnesses Used as References in Study of Member Damage Ratios

Case	Test Structure Identification and Type					
	Type A D1	Type B D2	Type B D3	Type C D4	Type C D5	Type B S1
Reference Section Stiffness for the Pier, kip-in.^{2} [a]	57,200	31,600	31,600	31,600	31,600	14,100
Cracked Section Stiffness for the Pier, kip-in.^{2} [b]	20,300	20,100	19,180	19,800	19,300	19,900
Reference Section Stiffness for the Beams, kip-in.^{2} [a]	2,010	315	315	315	315	234
Cracked Section Stiffness for the Beams, kip-in.^{2} [b]	2,000	248	231	155	149	246

[a]For tests D1 through D5, these are the reference, or initial, uniform section stiffnesses from the study of linear dynamic response (chapter 7). For test S1, the value listed is the stiffness consistent with the initial slope of idealized hysteresis relation for the member (chapter 5).

[b]Calculated from moments of inertia listed in Table 4.1 and secant moduli listed in Table A.1.

Table 8.7 Member Damage Ratios for Several Cases. Based on Reference Stiffnesses for Study of Linear Dynamic Response

Case	Damage Distribution	Type A D1		Type B D2		Type B D3		Type C D4		Type C D5	
		μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}
Early Frequency	$\mu_{pr} = 1$	1.0	a	1.0	13.2	1.0	23	1.0	16.8	1.0	16.8
	$\mu_{bm} = 2\mu_{pr}$	9.0	18.0	1.90	3.8	2.4	4.8	2.2	4.3	2.2	4.3
	$\mu_{bm} = \mu_{pr}$	11.2	11.2	2.7	2.7	3.4	3.4	3.0	3.0	3.0	3.0
Ratio of Base Moment to Top Level Deflection, t = 0.4 sec.	$\mu_{pr} = 1$	-	-	1.0	13.2	1.0	15	1.0	17	1.0	15
	$\mu_{bm} = 2\mu_{pr}$	-	-	1.9	3.8	2.0	4.0	2.1	4.2	2.0	4.0
	$\mu_{bm} = \mu_{pr}$	-	-	2.7	2.7	2.8	2.8	3.0	3.0	2.8	2.8
Ratio of Base Moment to Top Level Deflection, t = 0.6 sec.	$\mu_{pr} = 1$	-	-	1.0	19	1.0	23	1.0	28	1.0	35
	$\mu_{bm} = 2\mu_{pr}$	-	-	2.3	4.5	2.4	4.7	2.5	5.0	2.7	5.3
	$\mu_{bm} = \mu_{pr}$	-	-	3.2	3.2	3.4	3.4	3.1	3.1	3.8	3.8

[a] The ductility requirement was extremely high, beyond the range of Fig. 7.6.

Table 8.7 (contd.) Member Damage Ratios for Several Cases. Based on Reference Stiffnesses for Study of Linear Dynamic Response

Case	Damage Distribution	Type A D1		Type B D2		Type B D3		Type C D4		Type C D5	
		μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}	μ_{pr}	μ_{bm}
Ratio of Base Moment to Top Level Deflection, t = 0.7 sec.	$\mu_{pr} = 1$	1.0	a	1.0	28	1.0	19	1.0	a	1.0	a
	$\mu_{bm} = 2\mu_{pr}$	10	20	2.5	5.0	2.3	4.5	2.8	5.6	3.0	6.0
	$\mu_{bm} = \mu_{pr}$	12.2	12.2	3.6	3.6	3.2	3.2	4.0	4.0	4.3	4.3
Ratio of Base Moment to Top Level Deflection, t = 1.2 sec.	$\mu_{pr} = 1$	-	-	1.0	a	1.0	a	1.0	a	1.0	a
	$\mu_{bm} = 2\mu_{pr}$	-	-	3.2	6.3	3.0	6.0	3.4	6.7	3.4	6.7
	$\mu_{bm} = \mu_{pr}$	-	-	4.6	4.6	4.3	4.3	4.8	4.8	4.8	4.8

[a]The ductility requirement was extremely high, beyond the range of Fig. 7.6.

Table 8.8 Member Damage Ratios for Several Cases. Based on Cracked Section Stiffness for Beams and Piers

Case	Damage Distribution	Member Damage Ratios											
		D1		D2		D3		D4		D5		S1	
		Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams
Early Frequency	$\mu_{pr} = 1$	0.36	a	0.64	10.4	0.61	16.9	0.63	8.3	0.61	7.9	-	-
	$\mu_{bm} = 2\mu_{pr}$	3.2	17.9	1.21	3.0	1.46	3.5	1.38	2.1	1.34	2.0	-	-
	$\mu_{bm} = \mu_{pr}$	4.0	11.1	1.72	2.1	2.1	2.5	1.88	1.48	1.83	1.42	-	-
Ratio of Base Moment to Top Level Deflection, t = 0.4 sec.	$\mu_{pr} = 1$	-	-	0.64	10.4	0.61	11.0	0.63	8.4	0.61	7.1	-	-
	$\mu_{bm} = 2\mu_{pr}$	-	-	1.21	3.0	1.21	2.9	1.32	2.1	1.22	1.89	-	-
	$\mu_{bm} = \mu_{pr}$	-	-	1.72	2.1	1.70	2.1	1.88	1.48	1.71	1.32	-	-
Ratio of Base Moment to Top Level Deflection, t = 0.6 sec.	$\mu_{pr} = 1$	-	-	0.64	15.0	0.61	16.9	0.63	13.8	0.61	16.6	-	-
	$\mu_{bm} = 2\mu_{pr}$	-	-	1.46	3.5	1.46	3.4	1.57	2.5	1.65	2.5	-	-
	$\mu_{bm} = \mu_{pr}$	-	-	2.0	2.5	2.1	2.5	1.94	1.53	2.3	1.80	-	-

[a] Damage ratio greater than 30.

Table 8.8 (contd.) Member Damage Ratios for Several Cases. Based on Cracked Section Stiffness for Beams and Piers

Case	Damage Distribution	Member Damage Ratios											
		D1		D2		D3		D4		D5		S1	
		Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams	Pier	Beams
Ratio of Base Moment to Top Level Deflection, t = 0.7 sec.	$\mu_{pr} = 1$	0.36	a	0.64	22	0.61	13.9	0.63	a	0.61	a	-	-
	$\mu_{bm} = 2\mu_{pr}$	3.6	19.9	1.59	3.9	1.40	3.3	1.76	2.8	1.83	2.8	-	-
	$\mu_{bm} = \mu_{pr}$	4.3	12.1	2.3	2.8	1.94	2.3	2.5	1.97	2.6	2.0	-	-
Ratio of Base Moment to Top Level Deflection, t = 1.2 sec.	$\mu_{pr} = 1$	-	-	0.64	a	0.61	a	0.63	a	0.61	a	-	-
	$\mu_{bm} = 2\mu_{pr}$	-	-	2.0	5.0	1.82	4.4	2.1	3.3	2.1	3.2	-	-
	$\mu_{bm} = \mu_{pr}$	-	-	2.9	3.6	2.6	3.2	3.0	2.4	2.9	2.3	-	-

[a] Damage ratio greater than 30.

Table 8.9 Damage Ratios Computed in Hysteresis Shape Study Using Static Hysteretic Model

Case	Lower Pier Damage Ratio	Beam Damage Ratios					
		First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
Damage Ratios Referenced to Slope, s_1 [a]	1.00	7.1	10.9	13.1	13.5	13.5	13.2
Damage Ratios Referenced to Cracked Section Stiffnesses (Tables 4.1 and 4.2)	1.41	7.5	11.5	13.8	14.2	14.2	13.9

[a]Stiffness, s_1, defined in section 5.3.

Table 9.1 Effect of Inelastic Structural Response on Top-Level Deflection

Case	Test Structure				
	D1	D2	D3	D4	D5
Top Level Deflection Consistent with Uncracked State*, in.	0.11	0.13	0.17	0.15	0.16
Top Level Deflection Consistent with the Stiffness Corresponding to the Free-Vibration Test, in.	0.19	0.25	0.29	0.29	0.29
Maximum Top Level Deflection for the Test with A_{max} = 1.0g., in.	0.50	0.45	0.46	0.50	0.48
Ratio of Observed Maximum Deflection (A_{max} = 1.0g) to that Calculated for Uncracked Structure	4.6	3.5	2.7	3.3	3.0

*Calculated using response spectra from observed base motions.

Table A.1 Measured Compressive Properties of Concrete

Parameter	Test Spec.	Age, Days	Size of Sample	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Compressive Strength, psi	D1	32	9	4550	4980	4180	280	0.062	4830	4270
	D2	53	11	5710	5980	5260	230	0.041	5940	5480
	D3	43	9	4610	5260	3390	610	0.133	5220	4000
	D4	30	9	4960	5100	4740	140	0.027	5100	4820
	D5	20	9	4180	4500	3830	230	0.055	4410	3950
	S1	50	7	5220	5380	4900	160	0.031	5380	5060
Strain at Maximum Stress	D1	32	3	0.0034	0.0036	0.0032	0.0002	0.06	0.0036	0.0032
	D2	53	9	0.0034	0.0040	0.0019	0.0006	0.18	0.0040	0.0028
	D3	43	9	0.0034	0.0041	0.0029	0.0004	0.13	0.0038	0.0030
	D4	30	9	0.0040	0.0045	0.0036	0.0003	0.08	0.0043	0.0037
	D5	20	9	0.0038	0.0049	0.0031	0.0007	0.18	0.0045	0.0031
	S1	50	7	0.0041	0.0050	0.0034	0.0005	0.12	0.0046	0.0036
Secant Modulus from Zero to 1000 psi, ksi	D1	32	9	3280	4350	2700	560	0.171	3840	2720
	D2	53	11	3400	5000	2860	610	0.179	4010	2790
	D3	43	9	2780	3230	2320	310	0.112	3090	2470
	D4	30	9	2870	3230	2500	260	0.089	3130	2610
	D5	20	9	2760	3130	2500	250	0.089	3010	2510
	S1	50	7	3160	3700	2780	350	0.110	3510	2810

Compressive strength based on tests of 4 by 8-in. cylinders

Table A.2 Measured Tensile Properties of Concrete

Parameter	Test Spec.	Age, Days	Size of Sample	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Splitting Stress, psi	D1	32	3	310	330	300	20	0.06	--	--
	D2	53	1	410	--	--	--	--	--	--
	D3	43	3	440	510	380	70	0.15	--	--
	D4	30	3	410	520	350	90	0.20	--	--
	D5	20	3	490	520	460	30	0.06	--	--
	S1	50	3	380	430	350	40	0.11	--	--
Modulus of Rupture, psi	D1	32	6	850	980	730	110	0.13	960	740
	D2	53	6	1030	1100	900	90	0.09	1020	940
	D3	43	6	840	920	750	60	0.08	900	780
	D4	30	6	780	910	590	110	0.15	890	670
	D5	20	6	750	860	680	60	0.08	810	690
	S1	50	6	990	1150	930	80	0.08	1070	910

Splitting stress based on tests of 4 by 8-in. cylinders
Modulus of rupture based on tests of 1 by 1-in. beams loaded at the center of a six-in. span

Table A.3 Measured Diameter of Reinforcement

Wire Gauge	Size of Sample	Diameters, in.						
		Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
No. 8	80	0.161	0.161	0.160	0	0	0.161	0.161
No. 11	80	0.121	0.123	0.119	0.001	0.01	0.122	0.120
No. 13	64	0.091	0.091	0.090	0	0	0.091	0.091

Table A.4 Measured Stress-Strain Properties of Reinforcement

Wire Gauge	Parameter	Size of Sample	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
No. 8	Yield Stress, ksi	8	42.6	43.0	41.8	0.4	0.009	43.0	42.2
	Ultimate Stress, ksi	8	51.9	52.9	49.3	1.2	0.023	53.1	50.7
	Ult. Stress/Yield Stress	8	1.218	1.239	1.155	0.027	0.022	1.245	1.191
	Strain at Strain-Hardening	8	0.016	0.024	0.011	0.004	0.3	0.020	0.012
	Strain at Ultimate	8	0.074	0.090	0.050	0.010	0.14	0.084	0.064
	Strain at Fracture	8	0.17	0.20	0.15	0.02	0.10	0.19	0.15
	Young's Modulus, ksi	8	27500	31900	23000	3400	0.12	30900	24100
No. 11	Yield Stress, ksi	33	43.7	50.4	36.8	3.1	0.070	46.8	40.6
	Ultimate Stress, ksi	33	53.1	59.6	47.8	2.6	0.049	55.7	50.5
	Ult. Stress/Yield Stress	33	1.218	1.319	1.139	0.043	0.035	1.261	1.175
	Strain at Strain-Hardening	33	0.025	0.045	0.010	0.009	0.4	0.034	0.016
	Strain at Ultimate	33	0.066	0.100	0.035	0.019	0.3	0.085	0.047
	Strain at Fracture	9	0.21	0.36	0.12	0.10	0.5	0.31	0.11
	Young's Modulus, ksi	33	31300	45300	17500	7600	0.24	38900	23700
No. 13	Yield Stress, ksi	9	39.0	41.9	37.3	1.4	0.035	40.4	37.6
	Ultimate Stress, ksi	9	46.5	49.0	38.1	3.4	0.073	49.9	43.1
	Ult. Stress/Yield Stress	9	1.193	1.261	1.019	0.086	0.072	1.279	1.107
	Strain at Strain-Hardening	9	0.035	0.040	0.021	0.007	0.2	0.042	0.028
	Strain at Ultimate	9	0.081	0.090	0.030	0.020	0.2	0.101	0.061
	Strain at Fracture	9	0.20	0.30	0.16	0.04	0.2	0.24	0.16
	Young's Modulus, ksi	9	25300	30700	21300	2400	0.095	27700	22900

Table A.5 Yield Stress for Wire Used in Specimens

Wire Gauge	Test Spec.	Size of Sample	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
No. 8	D1	3	42.8	43.0	42.7	0.2	0.004	--	--
No. 11	D1	56	42.2	50.9	37.7	3.0	0.070	45.2	39.2
	D2	49	43.8	50.9	40.4	2.2	0.051	46.0	41.6
	D3	61	45.3	51.8	41.2	2.4	0.053	47.7	42.9
	D4	47	44.5	50.0	41.2	2.1	0.046	46.6	42.4
	D5	48	44.6	50.9	41.7	2.2	0.049	46.8	42.4
	S1	48	44.2	48.3	40.4	1.7	0.038	45.9	42.5
No. 13	D4	4	41.8	42.0	41.2	0.4	0.01	42.2	41.4
	D5	3	41.7	42.0	41.2	0.4	0.01	42.1	41.3

Table A.6 Measured Dimensions of Test Structure - Test D1

Parameter	Symbol (Fig. A.25)	Size of Sample	Dimensions, in. Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	7.01	7.08	6.92	0.04	0.005	7.05	6.97
Opening Width	B	48	4.00	4.02	4.09	3.97	0.02	0.006	4.04	4.00
Pier Thickness	T	96	1.00	1.03	1.08	0.99	0.02	0.02	1.05	1.01
Opening Height	D	48	6.75	6.75	7.03	6.67	0.09	0.01	6.84	6.66
Pier Width at Base	A1	16	7.00	7.01	7.05	6.95	0.03	0.004	7.04	6.98
Opening Width at Base	B1	8	4.00	4.04	4.09	4.00	0.03	0.007	4.07	4.01
Pier Thickness at Base	T1	8	1.00	1.02	1.03	0.99	0.01	0.01	1.03	1.01
Pier Reinforcement	F1	4	0.53	0.61	0.71	0.55	0.08	0.12	0.69	0.53
Geometry at Base	F2	4	1.19	1.20	1.24	1.17	0.03	0.03	1.23	1.17
	F3	4	1.19	1.18	1.22	1.13	0.04	0.03	1.22	1.14
	F4	4	1.19	1.18	1.20	1.16	0.02	0.01	1.20	1.16
	F5	4	1.19	1.19	1.22	1.16	0.03	0.02	1.22	1.16
	F6	4	1.19	1.19	1.24	1.14	0.04	0.03	1.23	1.15
	F7	4	0.53	0.50	0.57	0.38	0.09	0.18	0.59	0.41
Beam Depth	E	48	2.25	2.26	2.35	2.18	0.04	0.02	2.30	2.22
Beam Thickness	G	72	1.00	0.99	1.03	0.96	0.02	0.02	1.01	0.97
Top Steel Cover	HT	24	0.29	0.33	0.40	0.26	0.04	0.11	0.37	0.29
Bottom Steel Cover	HB	24	0.29	0.34	0.41	0.30	0.03	0.09	0.37	0.31

Table A.7 Measured Dimensions of Test Structure - Test D2

Parameter	Symbol (Fig. A.25)	Size of Sample	Dimensions, in.							
			Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	6.99	7.04	6.93	0.02	0.003	7.01	6.97
Opening Width	B	48	4.00	4.12	4.18	4.03	0.04	0.009	4.16	5.08
Pier Thickness	T	96	1.00	1.03	1.08	1.00	0.02	0.01	1.05	1.01
Opening Height	D	48	7.50	7.49	7.61	7.38	0.05	0.006	7.54	7.45
Pier Width at Base	A1	16	7.00	6.99	7.04	6.95	0.02	0.003	7.01	6.97
Opening Width at Base	B1	8	4.00	4.09	4.13	4.03	0.03	0.008	4.12	4.06
Pier Thickness at Base	T1	8	1.00	1.02	1.05	1.01	0.01	0.01	1.03	1.01
Pier Reinforcement	F1	4	0.53	0.60	0.64	0.53	0.05	0.08	0.65	0.55
Geometry at Base	F2	4	1.19	1.18	1.20	1.15	0.03	0.02	1.21	1.15
	F3	4	1.19	1.17	1.18	1.16	0.01	0.008	1.18	1.16
	F4	4	1.19	1.19	1.20	1.18	0.01	0.008	1.20	1.18
	F5	4	1.19	1.18	1.18	1.17	0.01	0.004	1.19	1.17
	F6	4	1.19	1.17	1.20	1.15	0.02	0.02	1.19	1.15
	F7	4	0.53	0.49	0.58	0.42	0.07	0.15	0.56	0.42
Beam Depth	E	48	1.50	1.52	1.57	1.43	0.03	0.02	1.55	1.49
Beam Thickness	G	72	1.00	1.00	1.05	0.97	0.02	0.02	1.02	0.98
Top Steel Cover	HT	24	0.31	0.33	0.41	0.22	0.05	0.14	0.38	0.28
Bottom Steel Cover	HB	24	0.31	0.33	0.41	0.28	0.04	0.12	0.37	0.29

Table A.8 Measured Dimensions of Test Structure - Test D3

Parameter	Symbol (Fig. A.25)		Dimensions, in. Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	6.99	7.11	6.92	0.03	0.005	7.02	6.96
Opening Width	B	48	4.00	4.16	4.22	4.10	0.03	0.007	4.19	4.13
Pier Thickness	T	96	1.00	1.01	1.04	0.99	0.01	0.01	1.02	1.00
Opening Height	D	48	7.50	7.50	7.60	7.38	0.06	0.007	7.56	7.44
Pier Width at Base	A1	16	7.00	7.01	7.11	6.97	0.04	0.006	7.05	6.97
Opening Width at Base	B1	8	4.00	4.13	4.17	4.11	0.02	0.005	4.15	4.11
Pier Thickness at Base	T1	8	1.00	1.02	1.03	1.00	0.01	0.01	1.03	1.01
Pier Reinforcement	F1	4	0.53	0.57	0.71	0.44	0.12	0.21	0.69	0.45
Geometry at Base	F2	4	1.19	1.24	1.26	1.22	0.02	0.01	1.26	1.22
	F3	4	1.19	1.15	1.17	1.13	0.02	0.01	1.17	1.13
	F4	4	1.19	1.17	1.19	1.15	0.02	0.01	1.19	1.15
	F5	4	1.19	1.15	1.18	1.14	0.02	0.02	1.17	1.13
	F6	4	1.19	1.20	1.22	1.18	0.02	0.01	1.22	1.18
	F7	4	0.53	0.54	0.64	0.44	0.09	0.16	0.63	0.45
Beam Depth	E	48	1.50	1.52	1.60	1.46	0.03	0.02	1.55	1.49
Beam Thickness	G	72	1.00	1.00	1.02	0.96	0.01	0.01	1.01	0.99
Top Steel Cover	HT	24	0.31	0.30	0.39	0.22	0.04	0.13	0.34	0.26
Bottom Steel Cover	HB	24	0.31	0.40	0.50	0.32	0.05	0.12	0.45	0.35

Table A.9 Measured Dimensions of Test Structure - Test D4

Parameter	Symbol (Fig. A.25)	Size of Sample	Dimensions, in. Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	6.99	7.11	6.87	0.06	0.008	7.05	6.93
Opening Width	B	48	4.00	4.13	4.21	4.03	0.04	0.01	4.17	4.09
Pier Thickness	T	96	1.00	1.03	1.08	0.99	0.01	0.01	1.04	1.02
Opening Height	D	48	7.50	7.50	7.70	7.31	0.08	0.01	7.58	7.42
Pier Width at Base	A1	16	7.00	7.01	7.11	6.92	0.07	0.009	7.08	6.94
Opening Width at Base	B1	8	4.00	4.13	4.20	4.08	0.04	0.01	4.17	4.09
Pier Thickness at Base	T1	8	1.00	1.02	1.02	1.01	0.01	0.007	1.03	1.01
Pier Reinforcement	F1	4	0.53	0.63	0.77	0.47	0.13	0.20	0.76	0.50
Geometry at Base	F2	4	1.19	1.19	1.20	1.17	0.01	0.01	1.20	1.18
	F3	4	1.19	1.19	1.22	1.15	0.04	0.03	1.23	1.15
	F4	4	1.19	1.18	1.18	1.17	0.01	0.01	1.19	1.17
	F5	4	1.19	1.19	1.20	1.18	0.01	0.01	1.20	1.18
	F6	4	1.19	1.18	1.20	1.15	0.02	0.02	1.20	1.16
	F7	4	0.53	0.51	0.62	0.35	0.12	0.23	0.63	0.39
Beam Depth	E	48	1.50	1.53	1.59	1.45	0.04	0.02	1.57	1.49
Beam Thickness	G	72	1.00	1.01	1.06	0.98	0.02	0.02	1.03	0.99
Top Steel Cover	HT	24	0.33	0.25	0.34	0.18	0.04	0.17	0.29	0.21
Bottom Steel Cover	HB	24	0.33	0.48	0.59	0.40	0.06	0.12	0.54	0.42

Table A.10 Measured Dimensions of Test Structure - Test D5

Parameter	Symbol (Fig. A.25)	Size of Sample	Dimensions, in. Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	7.00	7.07	6.94	0.03	0.004	7.03	6.97
Opening Width	B	48	4.00	4.12	4.19	4.02	0.04	0.01	4.16	4.08
Pier Thickness	T	96	1.00	1.03	1.07	1.01	0.02	0.02	1.05	1.01
Opening Height	D	48	7.50	7.49	7.65	7.30	0.09	0.01	7.58	7.40
Pier Width at Basd	A1	16	7.00	7.01	7.05	6.96	0.02	0.003	7.03	6.99
Opening Width at Base	B1	8	4.00	4.17	4.19	4.13	0.02	0.006	4.19	4.15
Pier Thickness at Base	T1	8	1.00	1.02	1.03	1.01	0.008	0.008	1.03	1.01
Pier Reinforcement	F1	4	0.53	0.54	0.63	0.36	0.13	0.23	0.67	0.41
Geometry at Base	F2	4	1.19	1.22	1.26	1.20	0.03	0.02	1.25	1.19
	F3	4	1.19	1.15	1.18	1.13	0.02	0.02	1.17	1.13
	F4	4	1.19	1.17	1.22	1.13	0.04	0.03	1.21	1.13
	F5	4	1.19	1.19	1.25	1.14	0.06	0.05	1.25	1.13
	F6	4	1.19	1.21	1.24	1.19	0.02	0.02	1.23	1.19
	F7	4	0.53	0.55	0.69	0.44	0.11	0.19	0.66	0.44
Beam Depth	E	48	1.50	1.52	1.59	1.47	0.03	0.02	1.55	1.49
Beam Thickness	G	72	1.00	1.01	1.04	0.98	0.01	0.01	1.02	1.00
Top Steel Cover	HT	24	0.33	0.28	0.39	0.15	0.07	0.23	0.35	0.21
Bottom Steel Cover	HB	24	0.33	0.46	0.56	0.32	0.07	0.15	0.53	0.39

Table A.11 Measured Dimensions of Test Structure - Test S1

Parameter	Symbol (Fig. A.25)	Size of Sample	Dimensions, in.							
			Nominal	Mean	Maximum	Minimum	Standard Deviation	Coefficient of Variation	Mean Plus Std. Dev.	Mean Minus Std. Dev.
Pier Width	A	96	7.00	6.97	7.02	6.90	0.03	0.004	7.00	6.94
Opening Width	B	48	4.00	4.09	4.20	4.01	0.05	0.01	4.14	4.04
Pier Thickness	T	96	1.00	1.08	1.14	1.00	0.03	0.03	1.11	1.05
Opening Height	D	48	7.50	7.48	7.58	7.38	0.05	0.006	7.53	7.43
Pier Width at Base	A1	16	7.00	7.00	7.06	6.95	0.03	0.004	7.03	6.97
Opening Width at Base	B1	8	4.00	4.05	4.11	4.01	0.04	0.01	4.09	4.01
Pier Thickness at Base	T1	8	1.00	1.08	1.13	1.02	0.04	0.04	1.12	1.04
Pier Reinforcement	F1	4	0.53	0.62	0.70	0.52	0.08	0.12	0.70	0.54
Geometry at Base	F2	4	1.19	1.18	1.22	1.13	0.04	0.03	1.22	1.14
	F3	4	1.19	1.18	1.20	1.17	0.01	0.01	1.19	1.17
	F4	4	1.19	1.16	1.17	1.14	0.02	0.01	1.18	1.14
	F5	4	1.19	1.16	1.18	1.12	0.03	0.02	1.19	1.13
	F6	4	1.19	1.18	1.23	1.12	0.05	0.04	1.23	1.13
	F7	4	0.53	0.55	0.65	0.43	0.10	0.18	0.65	0.45
Beam Depth	E	48	1.50	1.53	1.58	1.47	0.03	0.02	1.56	1.50
Beam Thickness	G	72	1.00	1.01	1.05	0.97	0.02	0.02	1.03	0.99
Top Steel Cover	HT	24	0.31	0.27	0.38	0.17	0.06	0.24	0.33	0.21
Bottom Steel Cover	HB	24	0.31	0.42	0.53	0.34	0.06	0.13	0.48	0.36

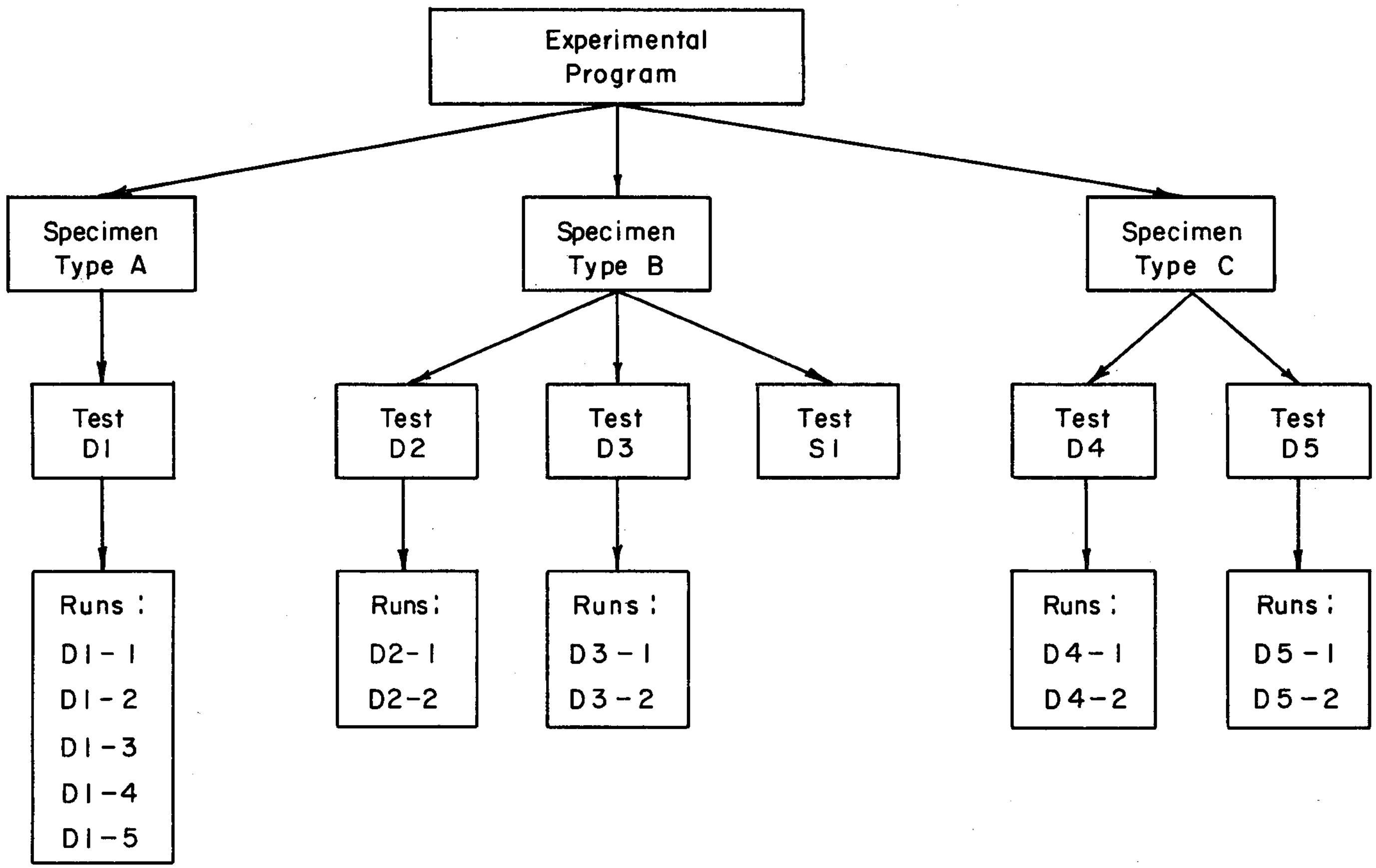


Figure 2.1 Outline of Experimental Program

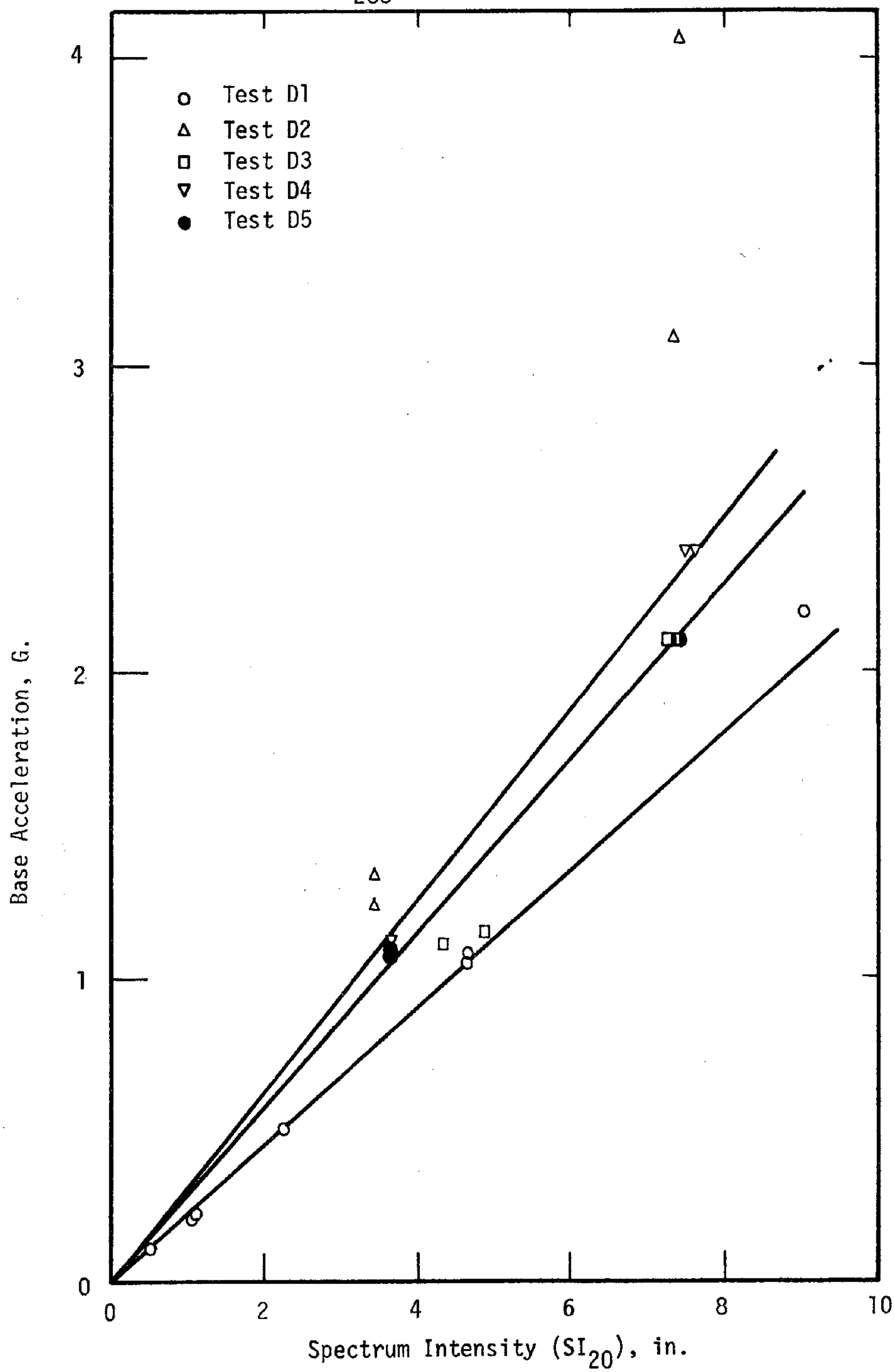
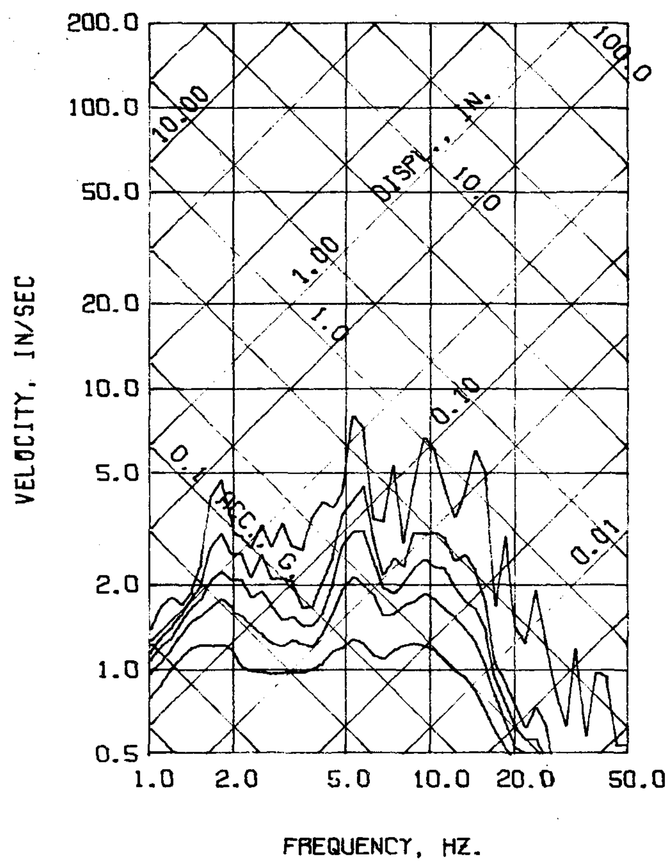
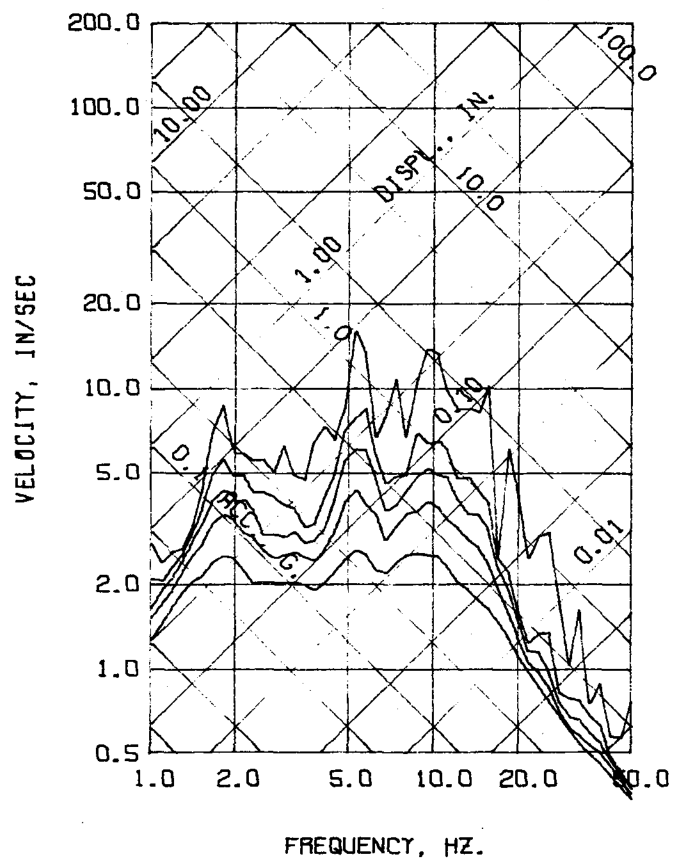


Figure 3.1 Variation of Spectrum Intensity with Base Acceleration

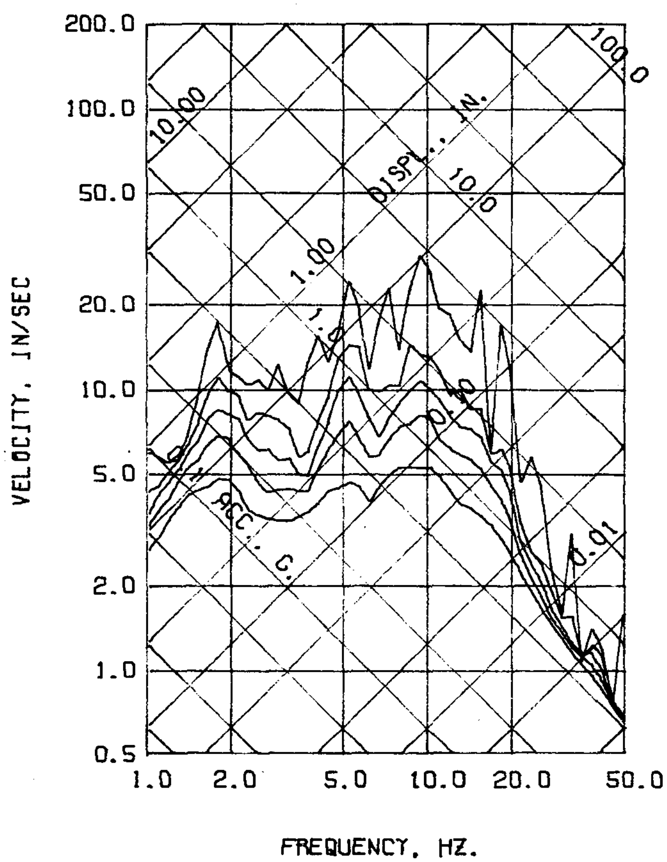


(a) Test Run D1-1

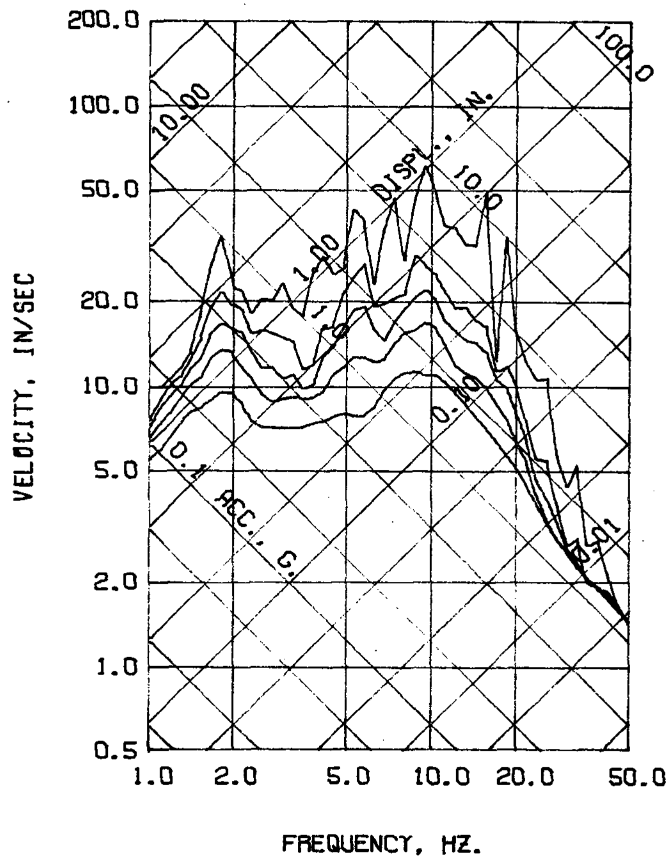


(b) Test Run D1-2

Figure 3.2 Test Structure D1. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)

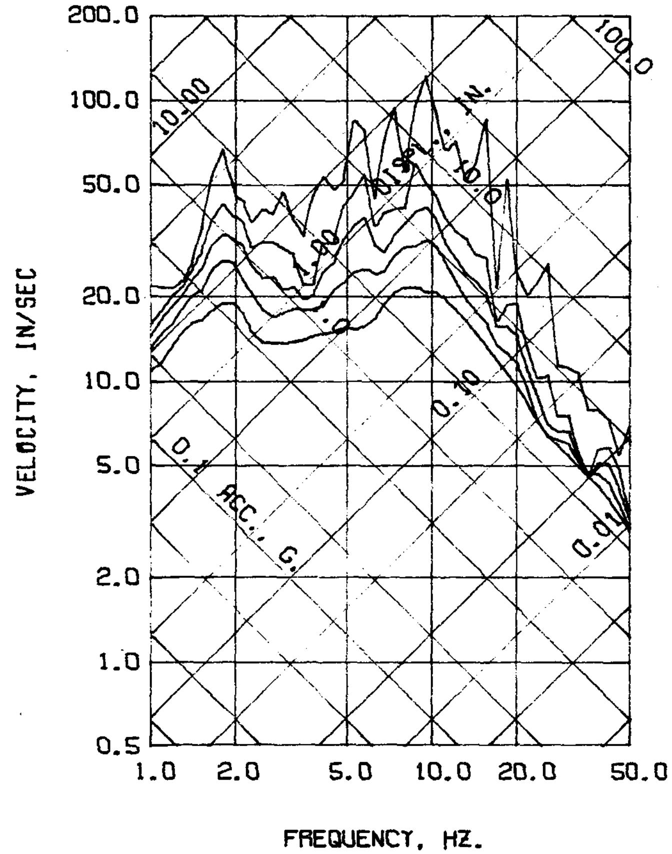


(c) Test Run D1-3



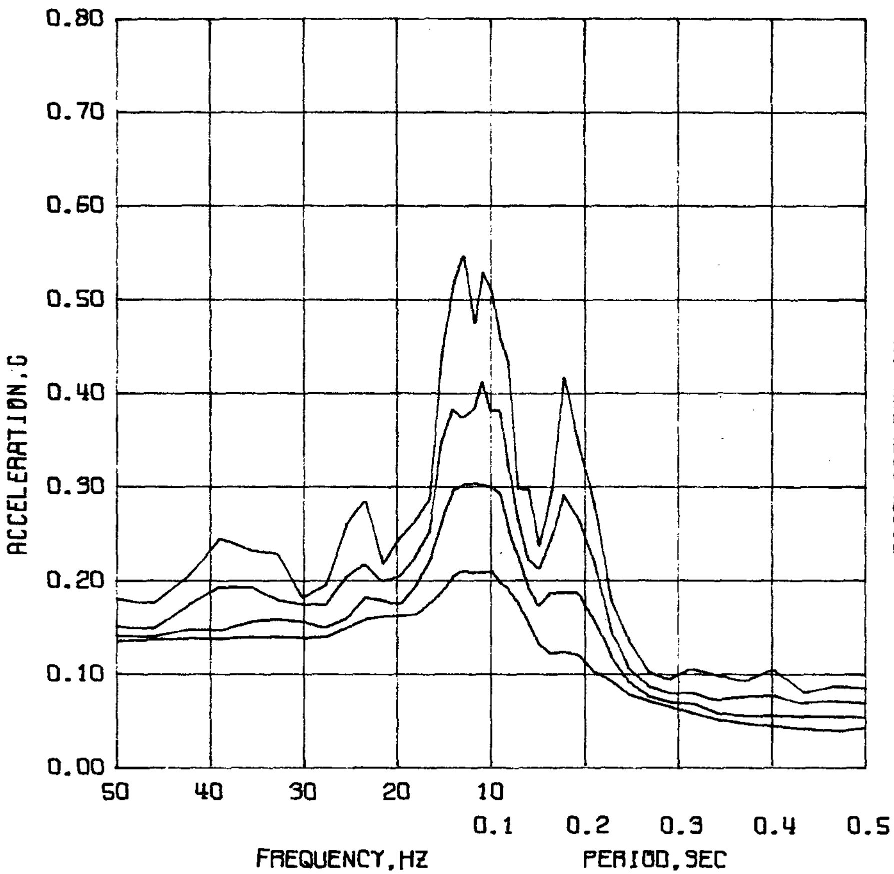
(d) Test Run D1-4

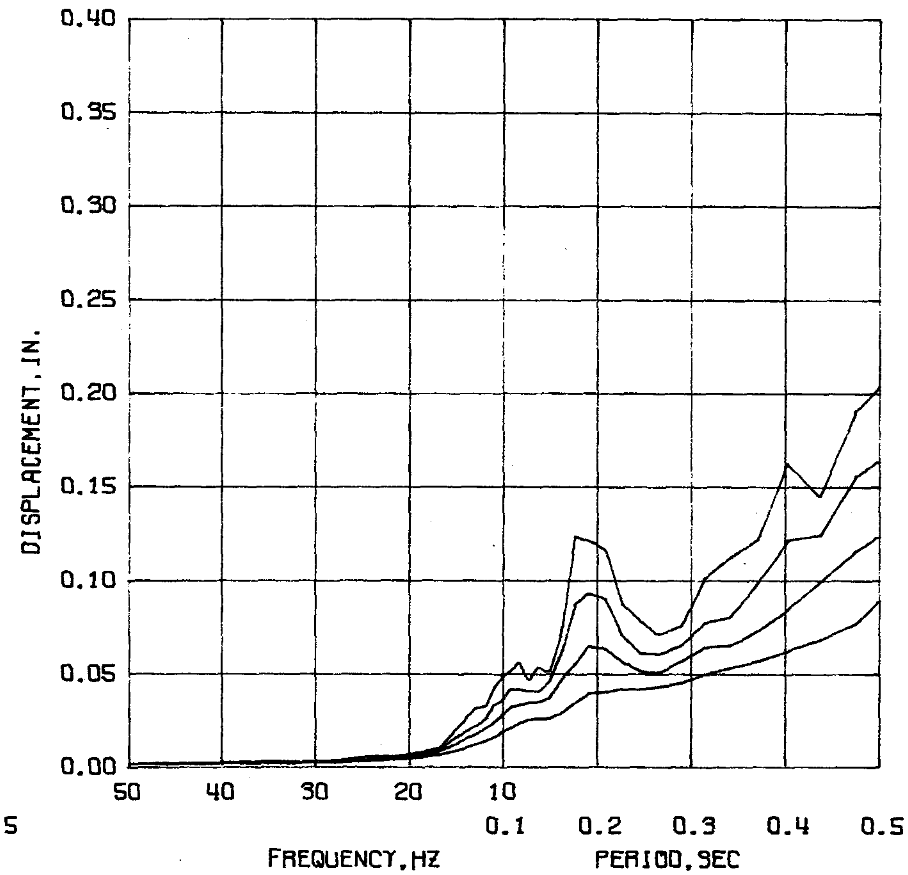
Figure 3.2 (contd.) Test Structure D1. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)



(e) Test Run D1-5

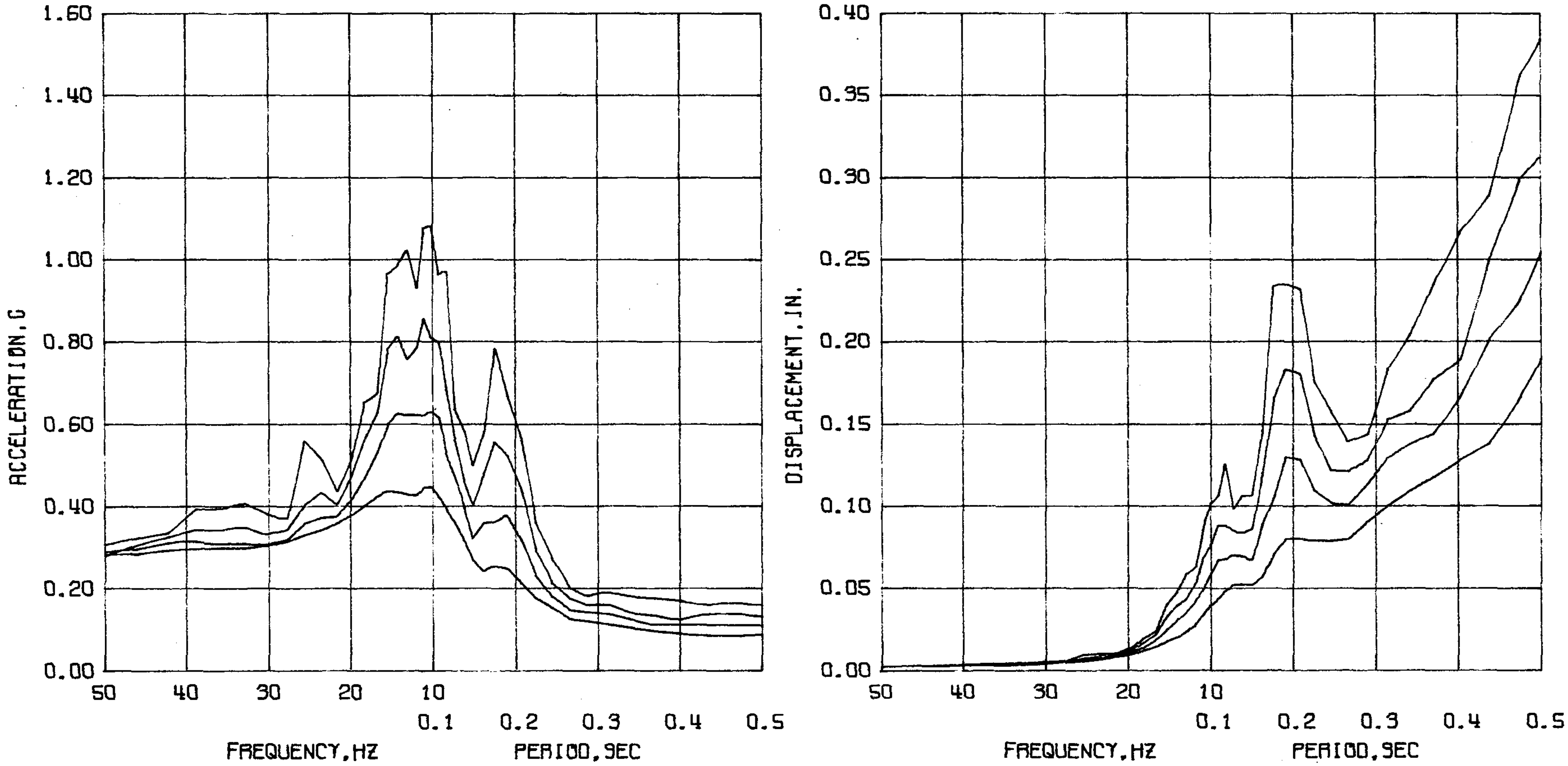
Figure 3.2 (contd.) Test Structure D1. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)





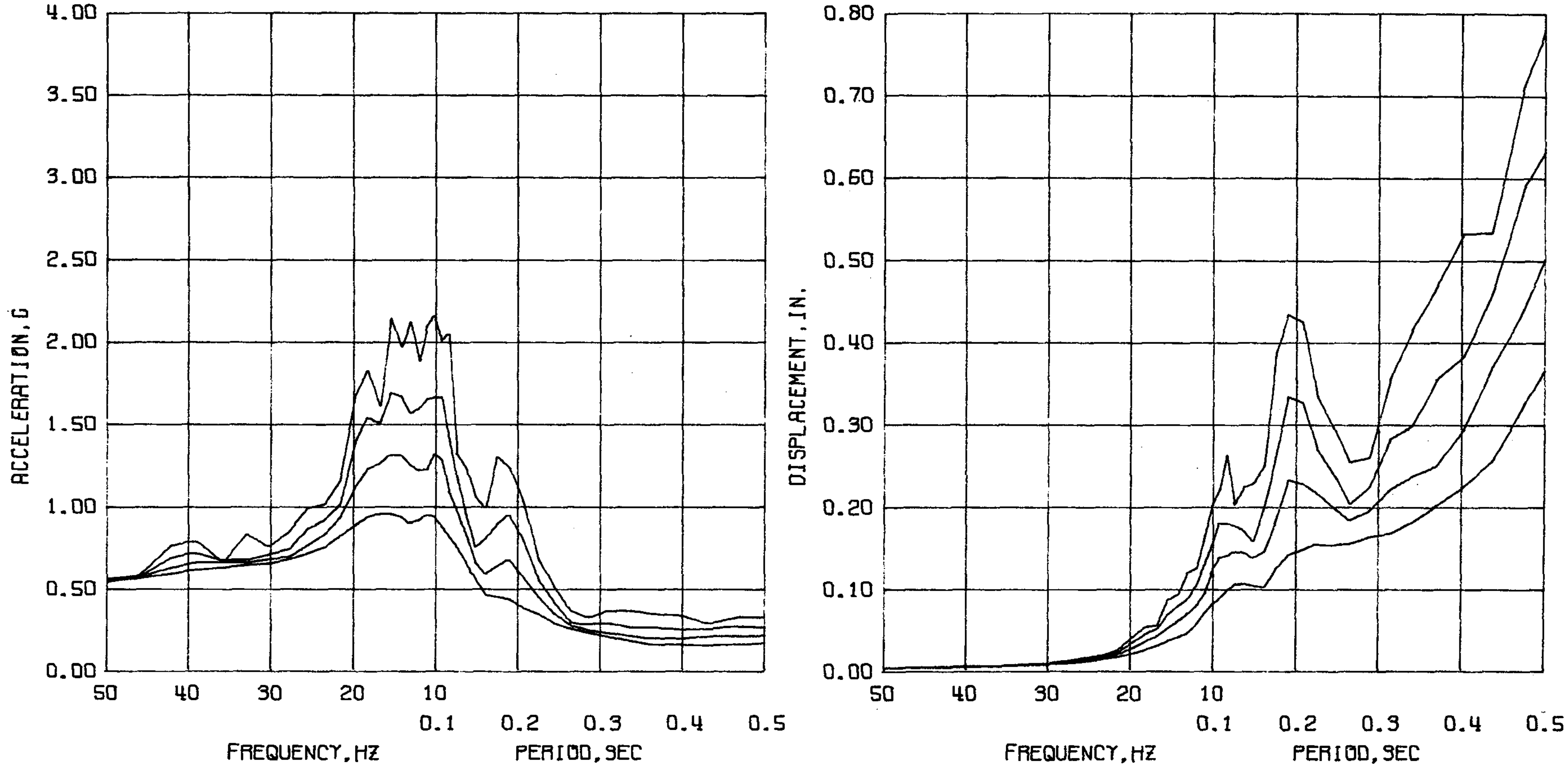
(a) Test Run D1-1. North Wall.

Figure 3.3 Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



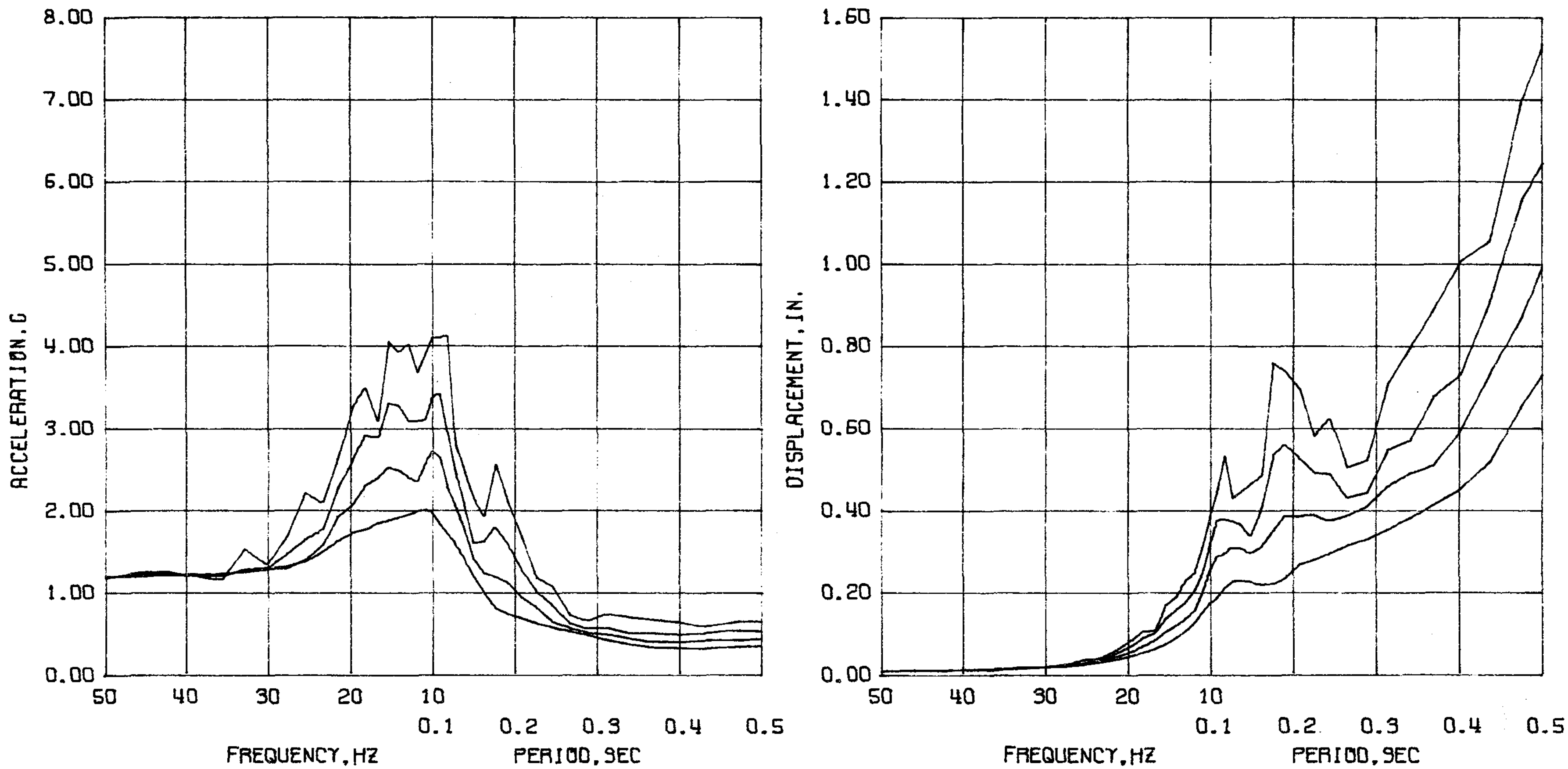
(b) Test Run D1-2. North Wall.

Figure 3.3 (contd.) Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



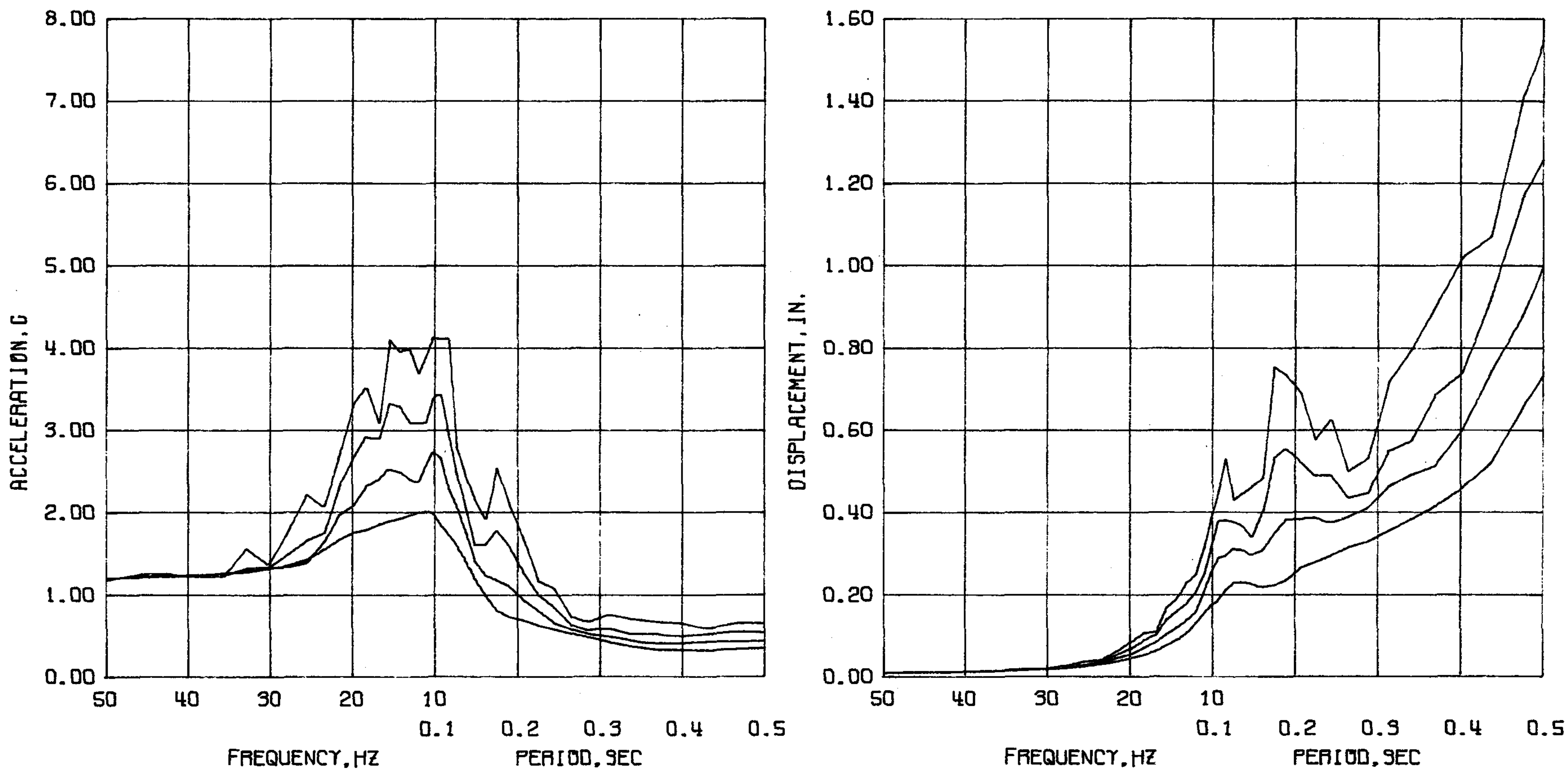
(c) Test Run D1-3. North Wall.

Figure 3.3 (contd.) Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



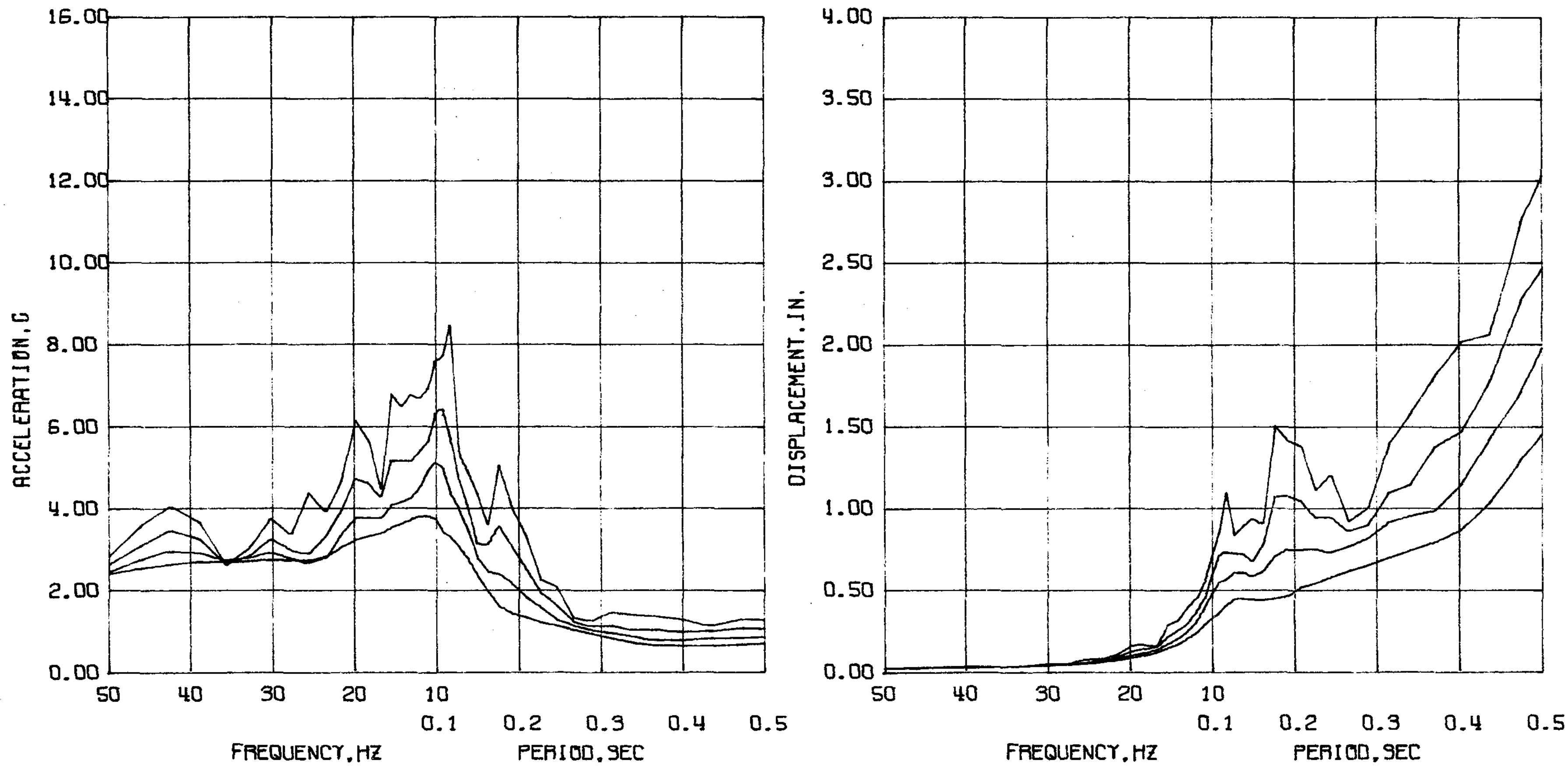
(d) Test Run D1-4. North Wall.

Figure 3.3 (contd.) Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



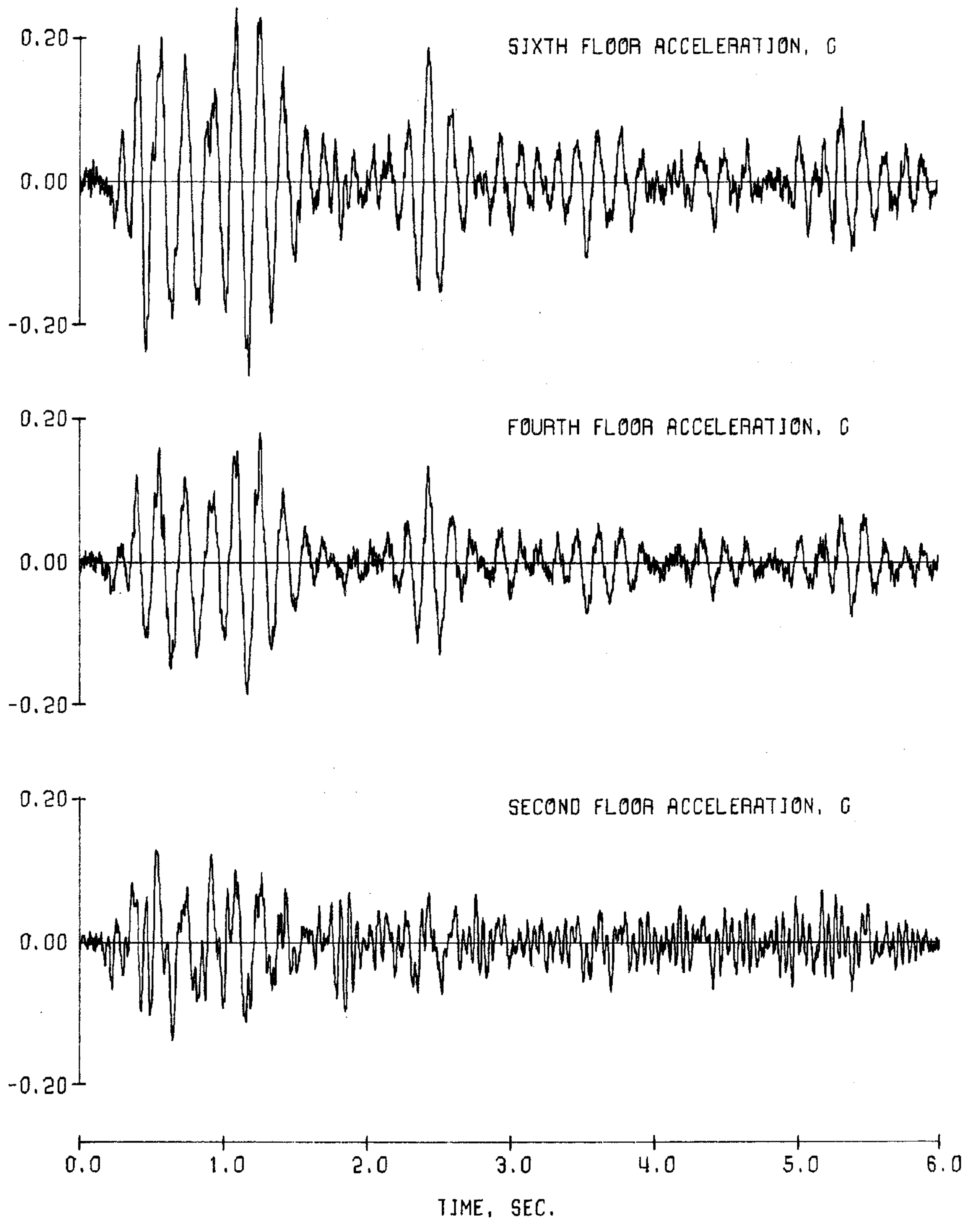
(e) Test Run D1-4. South Wall.

Figure 3.3 (contd.) Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



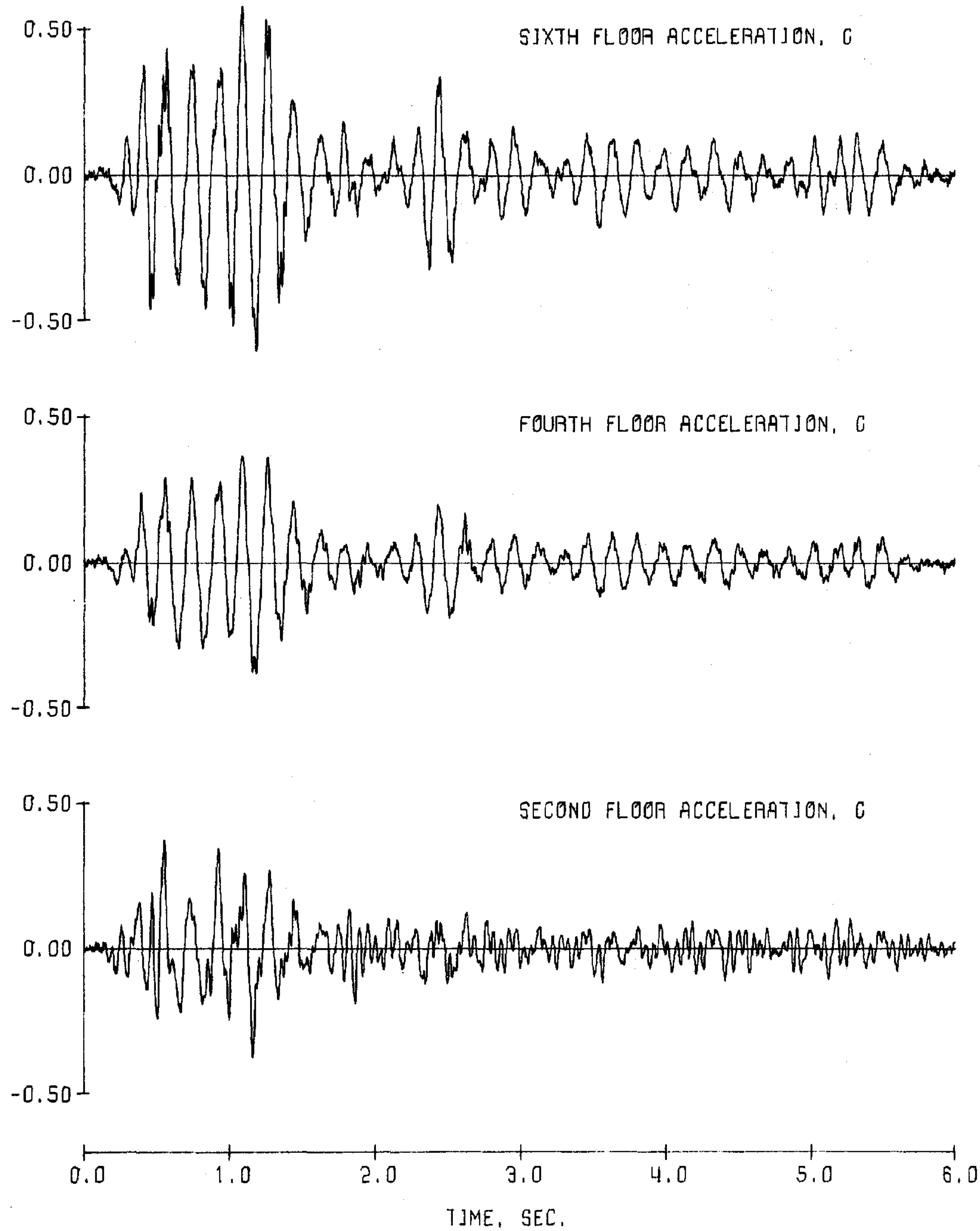
(f) Test Run D1-5. North Wall

Figure 3.3 (contd.) Test Structure D1. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



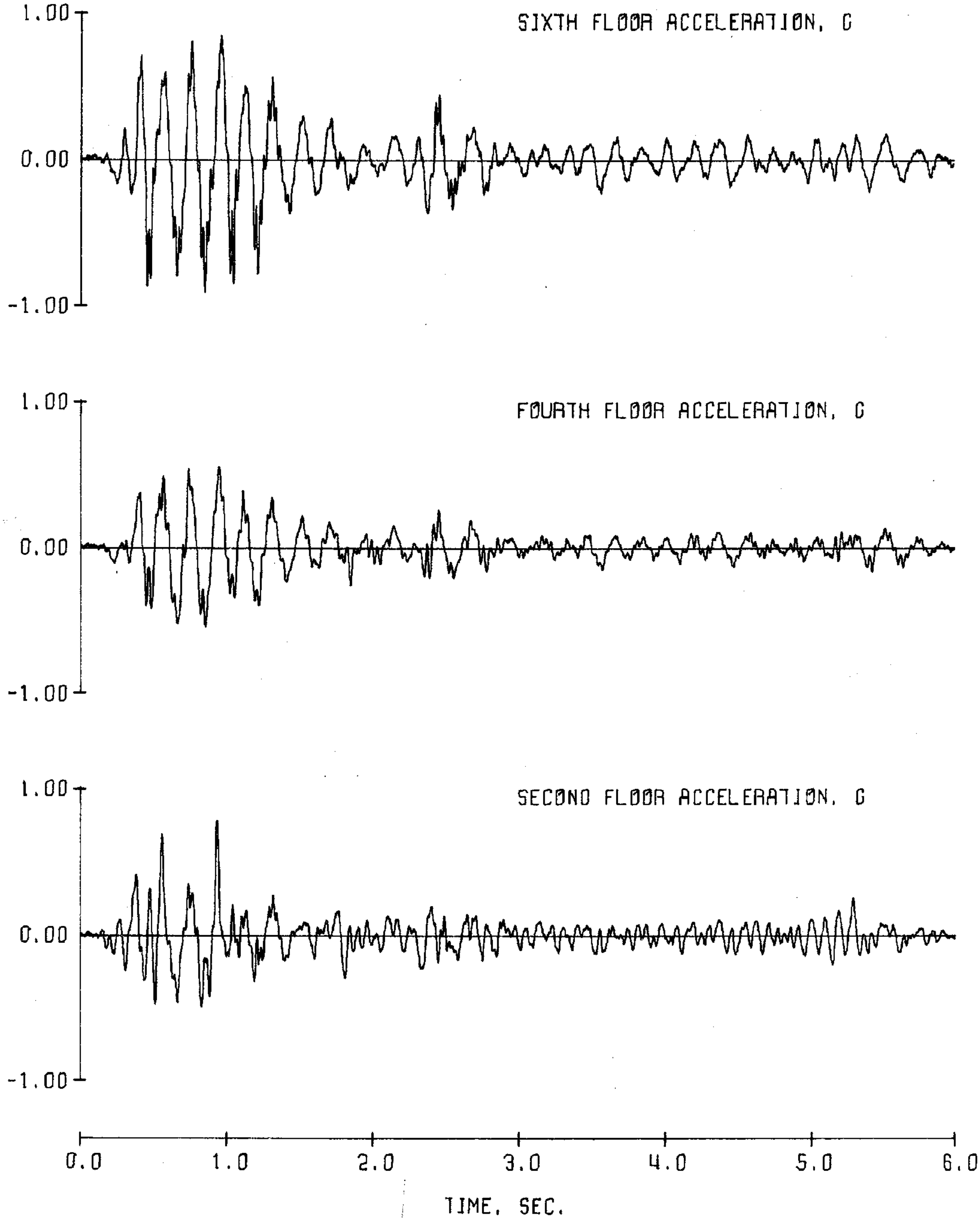
(a) Test Run D1-1. North Wall.

Figure 3.4 Test Structure D1. Observed Horizontal Accelerations



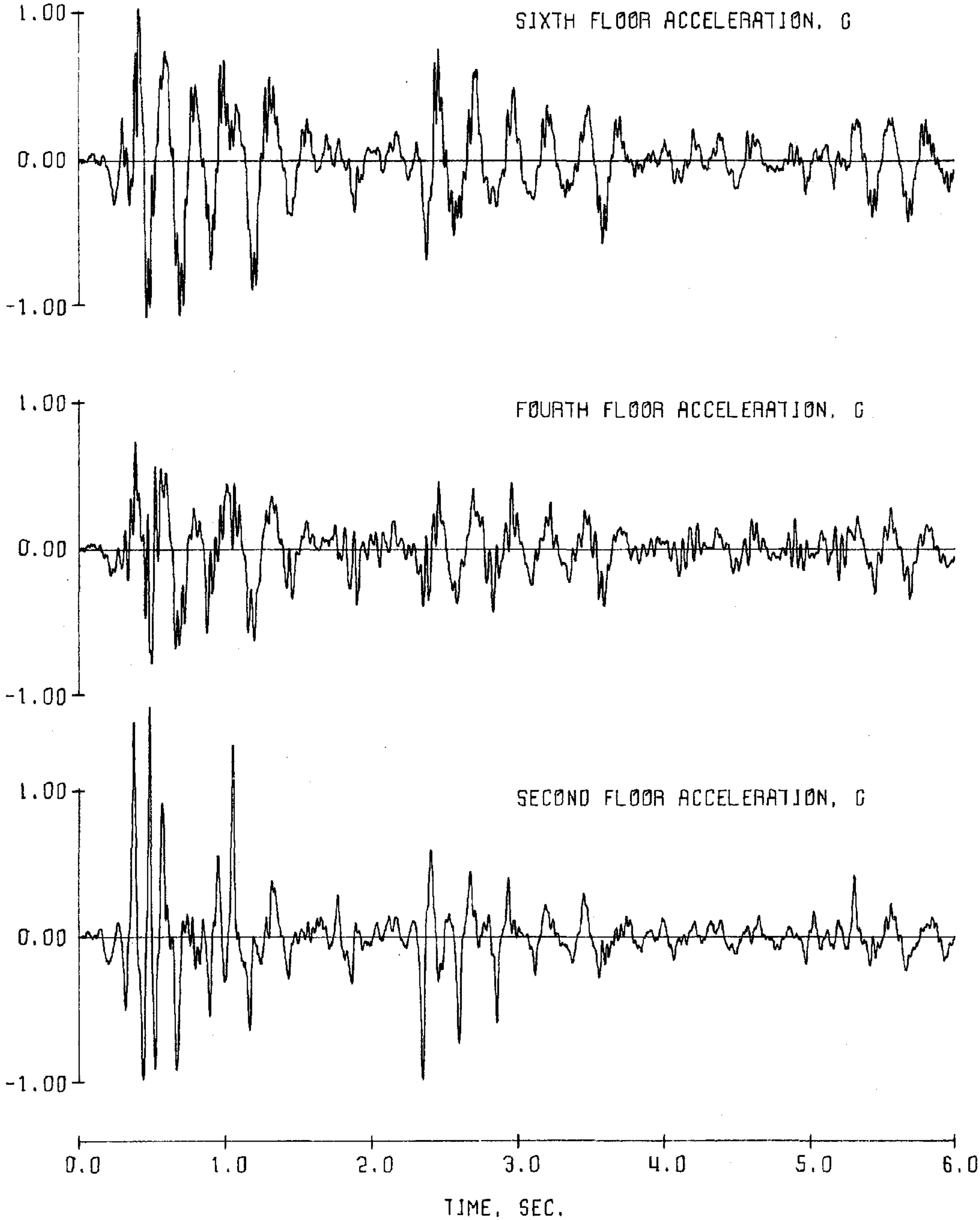
(b) Test Run D1-2. North Wall

Figure 3.4 (contd.) Test Structure D1. Observed Horizontal Accelerations



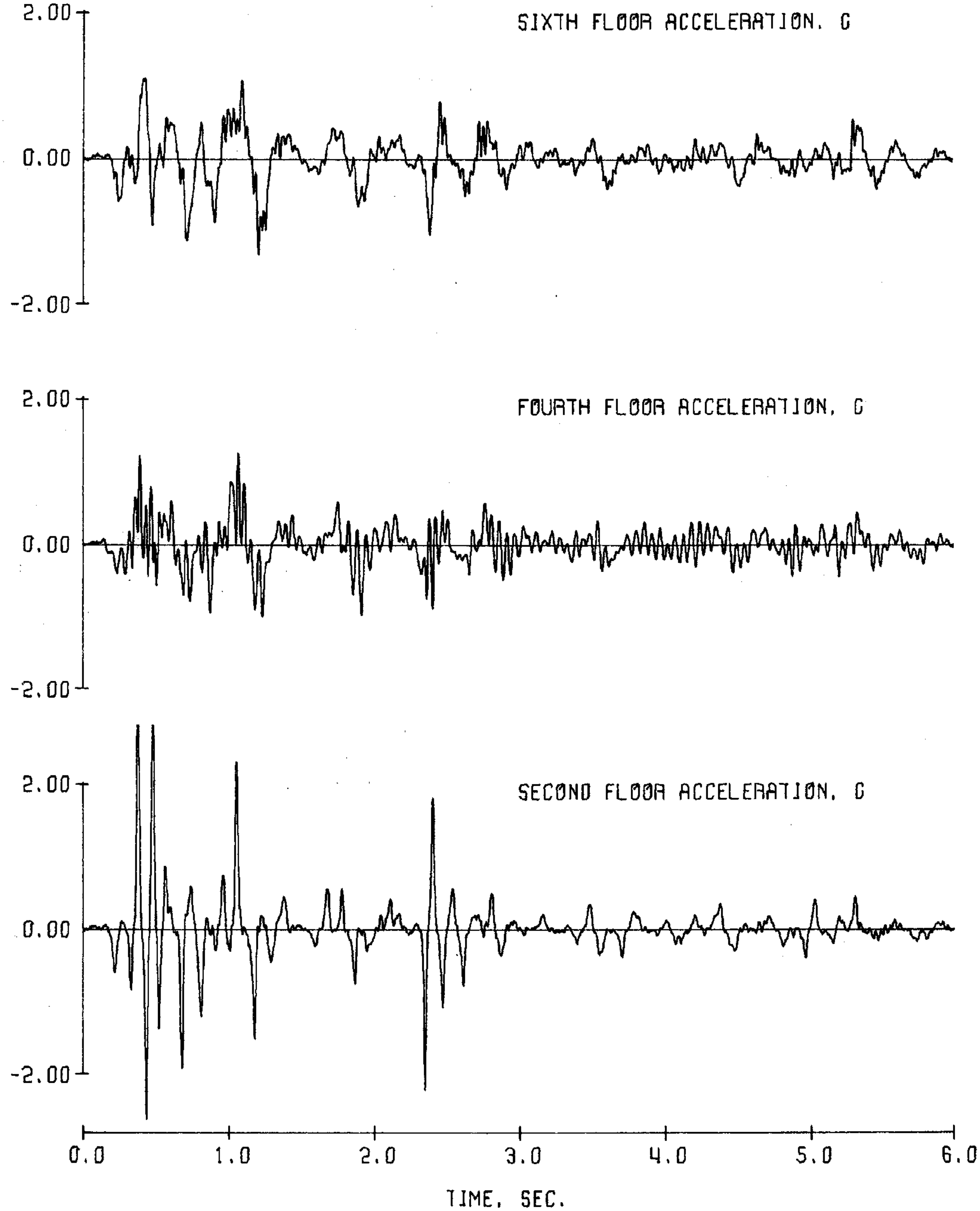
(c) Test Run D1-3. North Wall.

Figure 3.4 (contd.) Test Structure D1. Observed Horizontal Accelerations



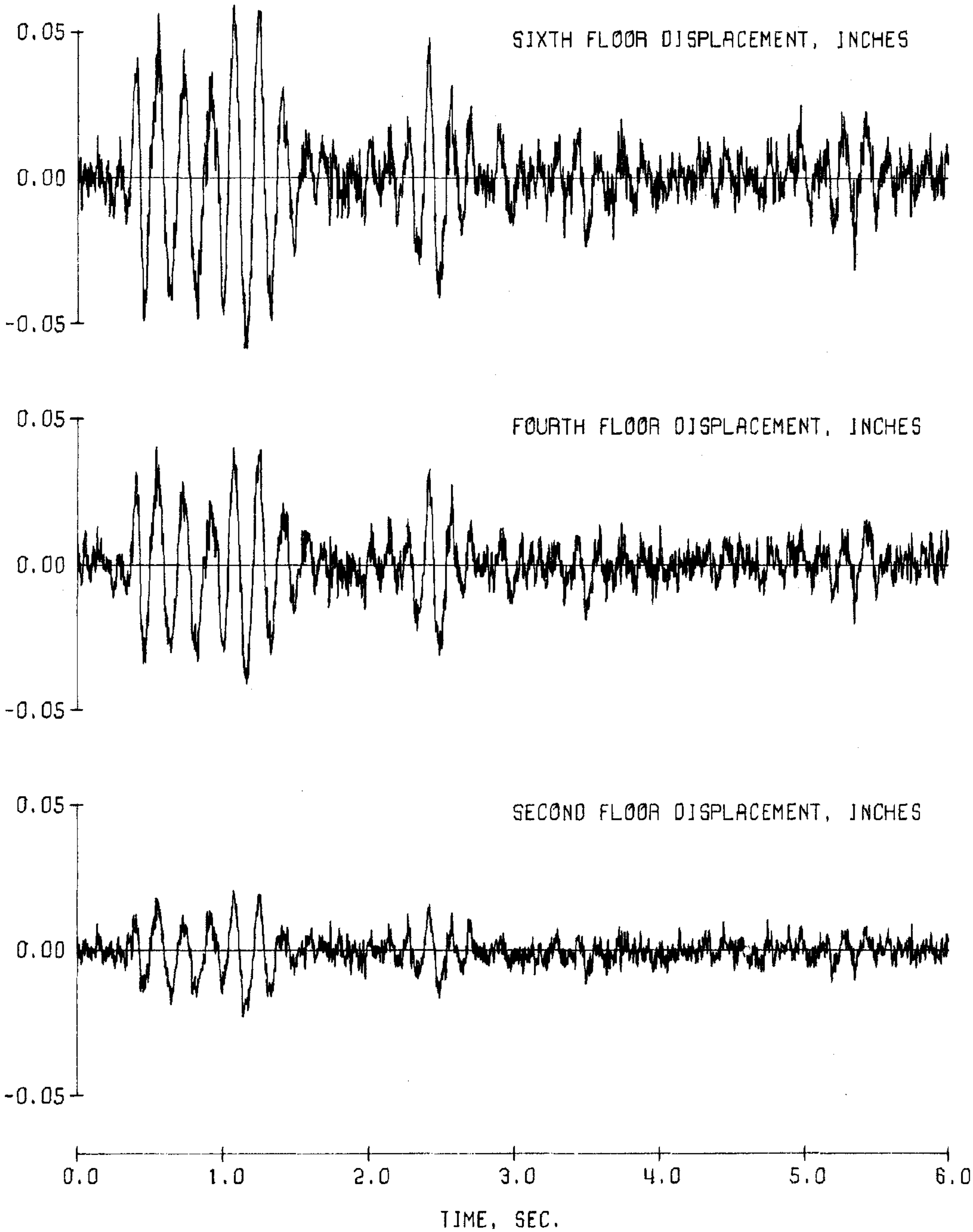
(d) Test Run D1-4. North Wall

Figure 3.4 (contd.) Test Structure D1. Observed Horizontal Accelerations



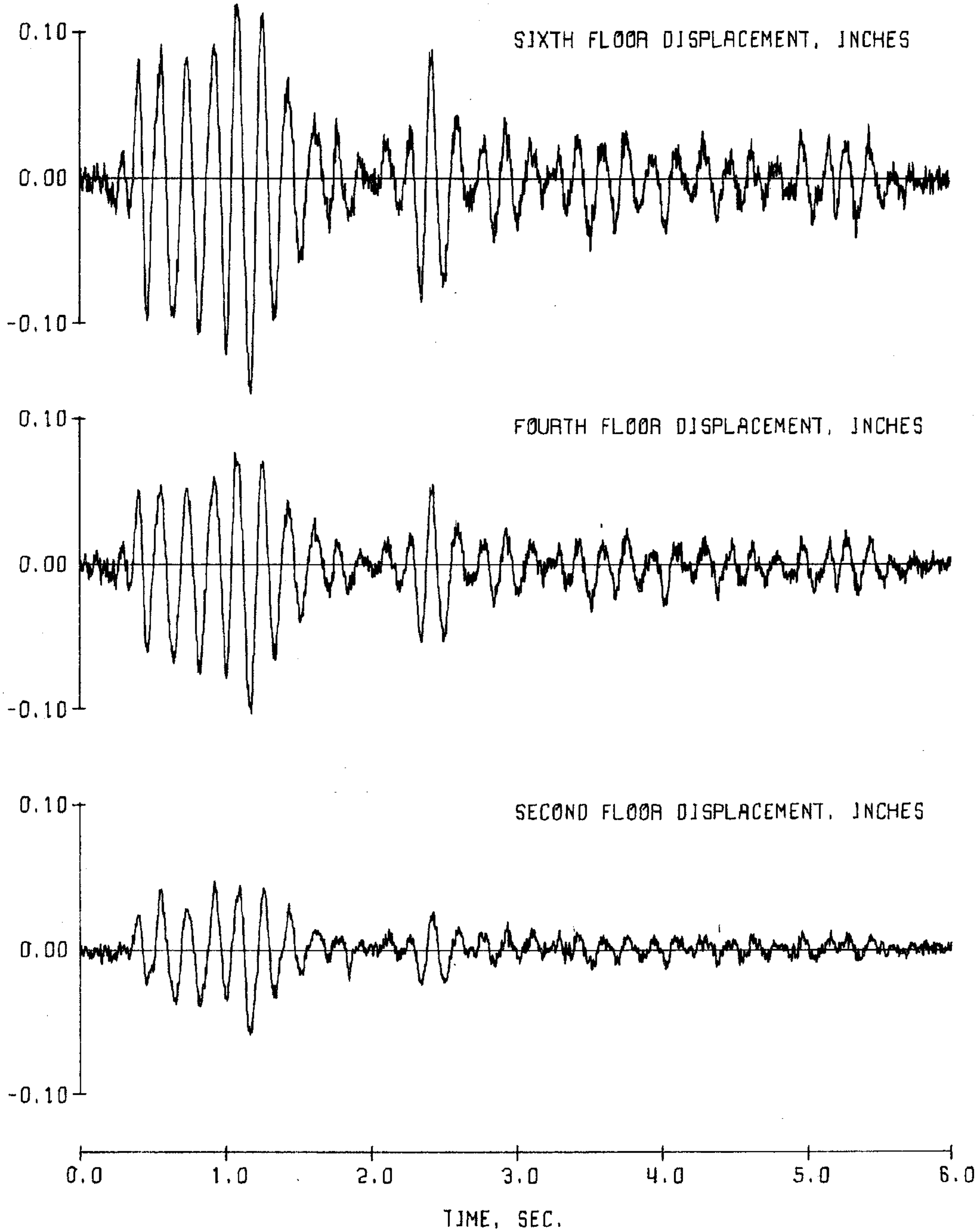
(e) Test Run D1-5. North Wall.

Figure 3.4 (contd.) Test Structure D1. Observed Horizontal Accelerations



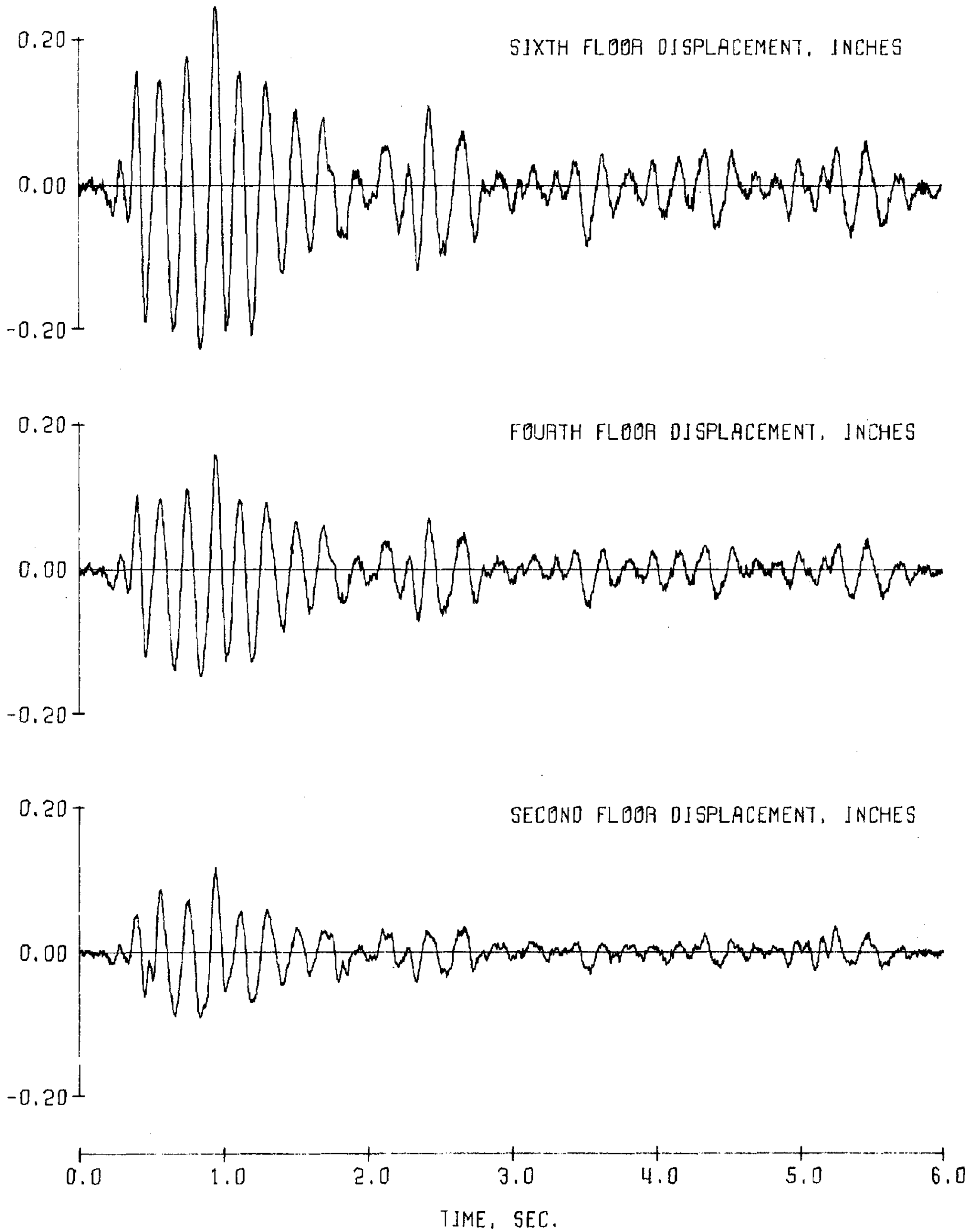
(a) Test Run D1-1. North Wall.

Figure 3.5 Test Structure D1. Observed Horizontal Displacements



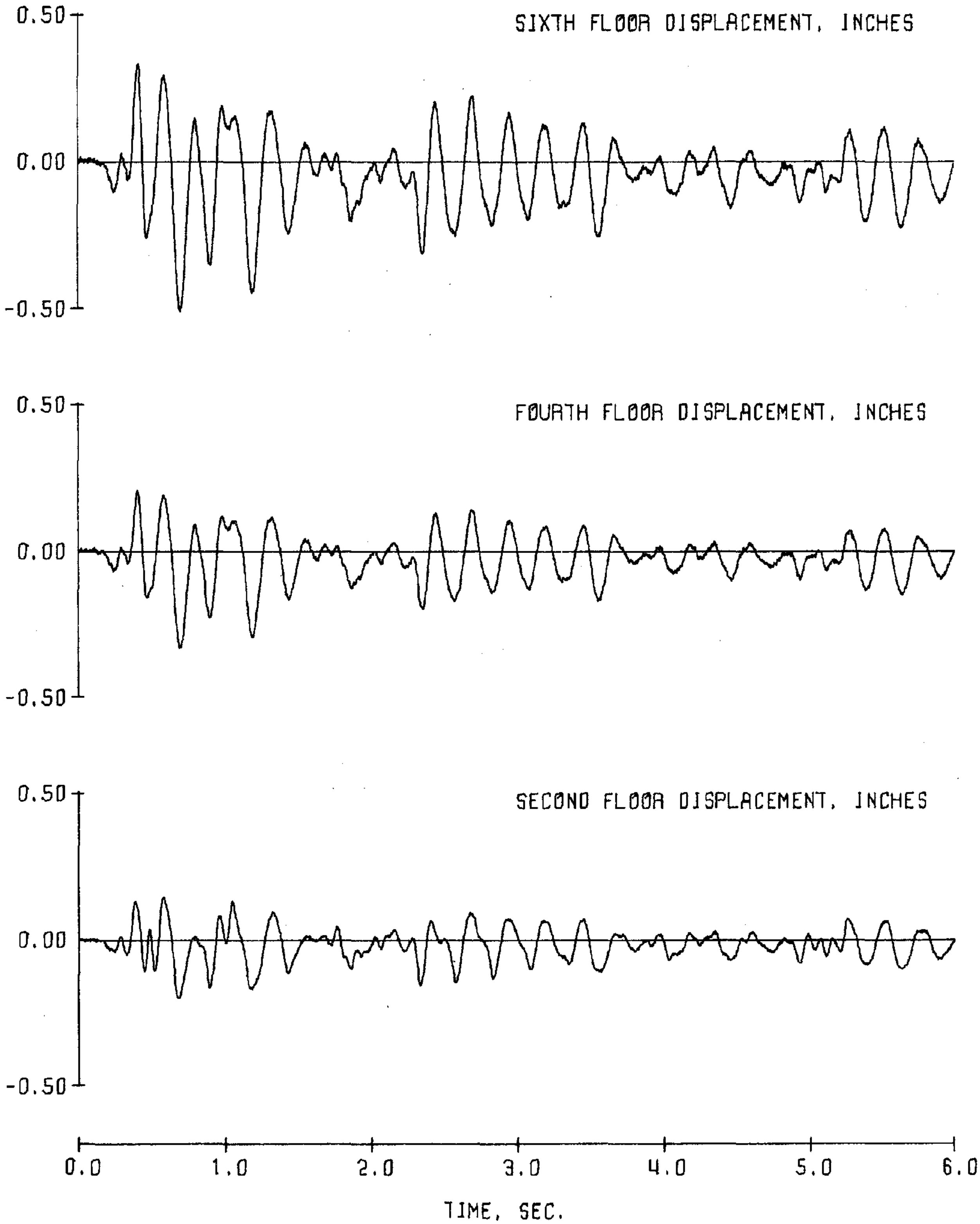
(b) Test Run D1-2. North Wall.

Figure 3.5 (contd.) Test Structure D1. Observed Horizontal Displacements



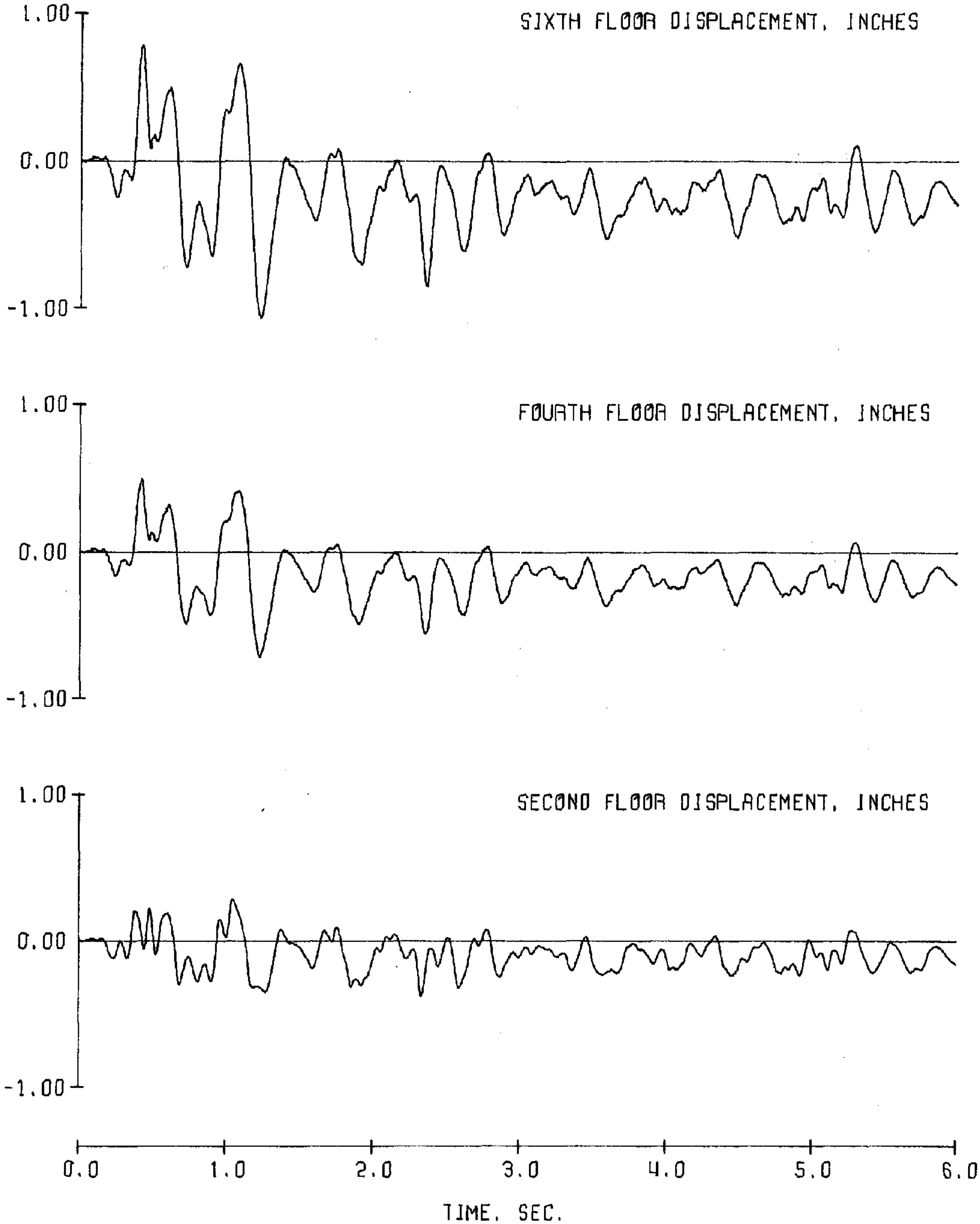
(c) Test Run D1-3. North Wall.

Figure 3.5 (contd.) Test Structure D1. Observed Horizontal Displacements



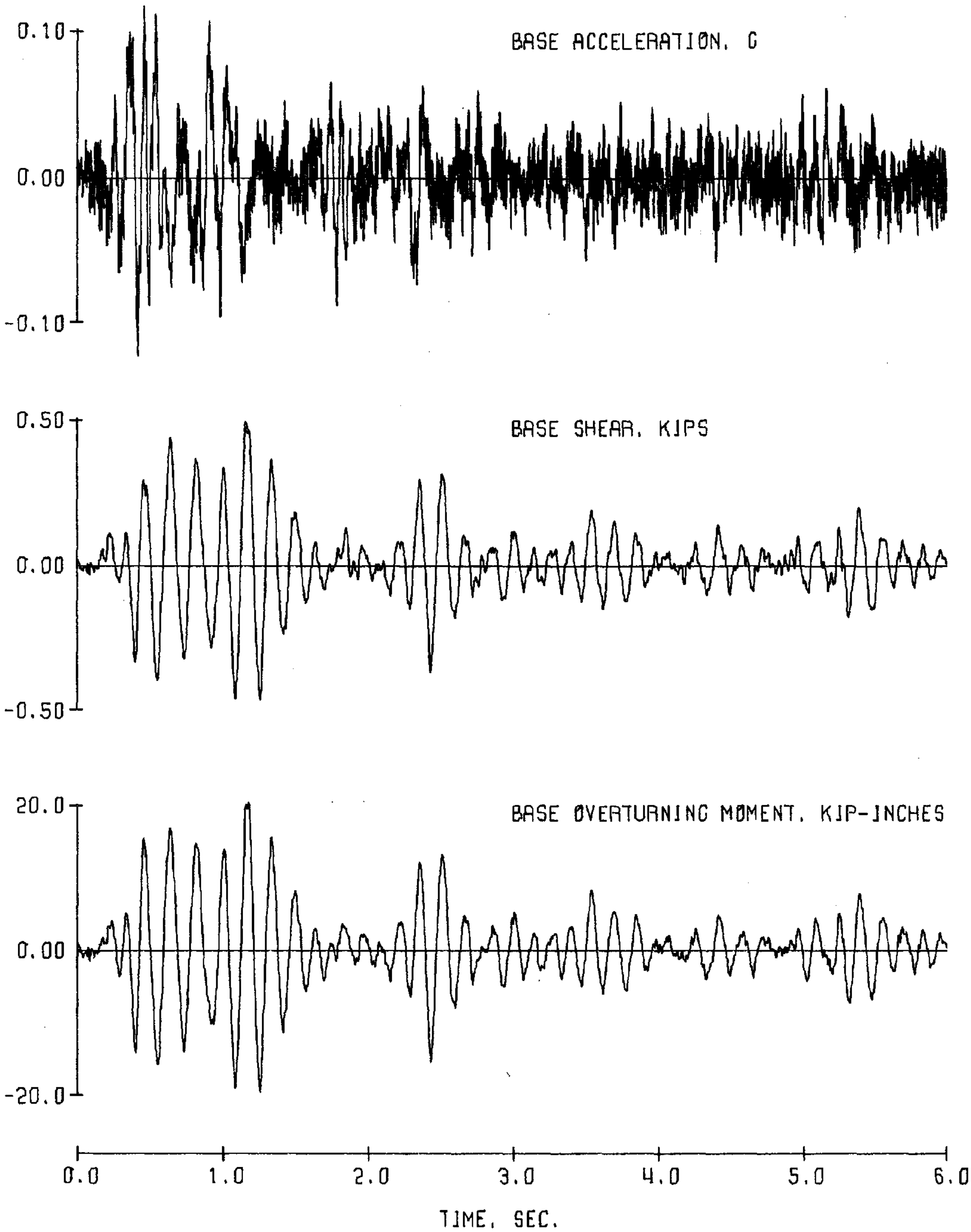
(d) Test Run D1-4. North Wall.

Figure 3.5 (contd.) Test Structure D1. Observed Horizontal Displacements



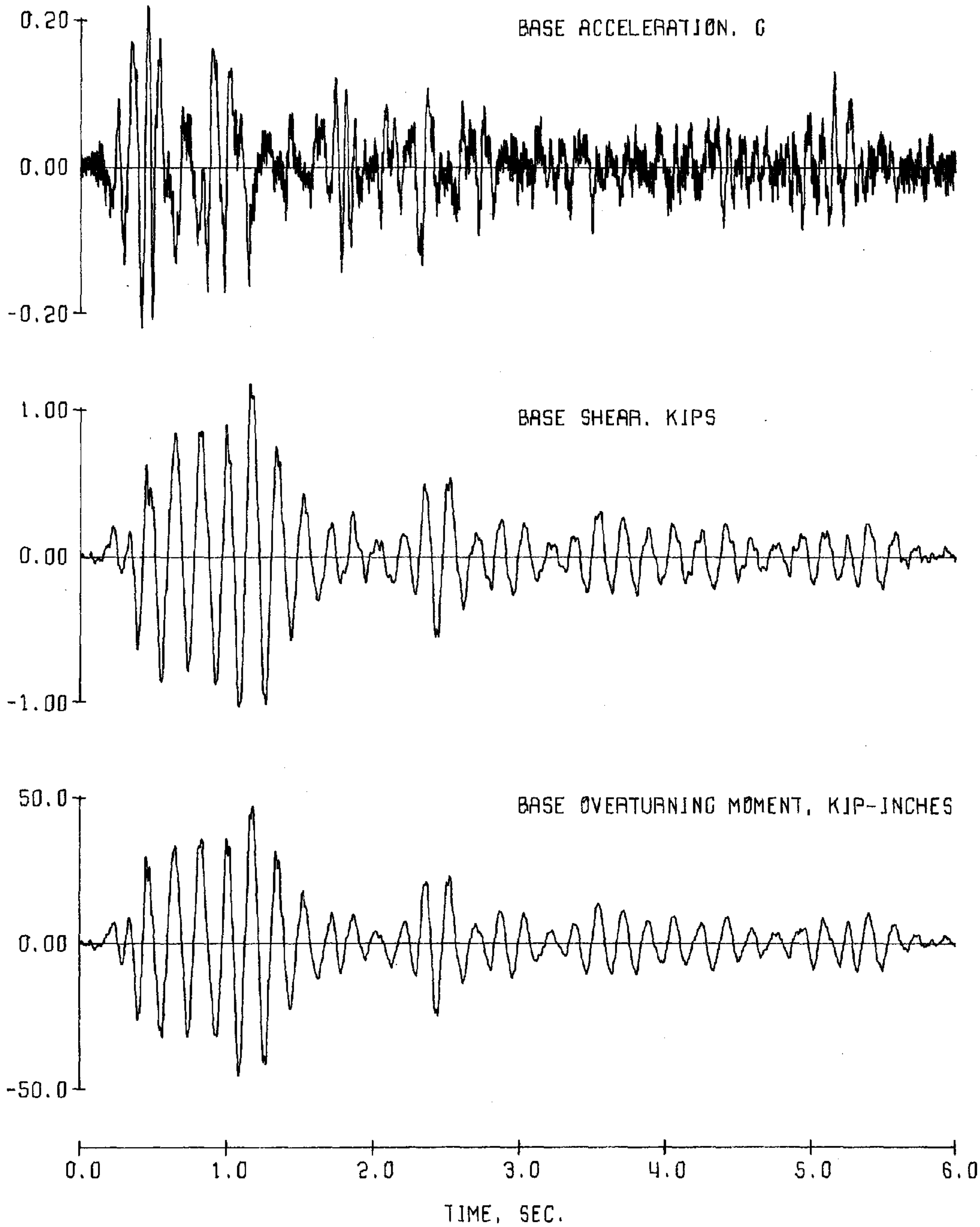
(e) Test Run D1-5. North Wall.

Figure 3.5 (contd.) Test Structure D1. Observed Horizontal Displacements



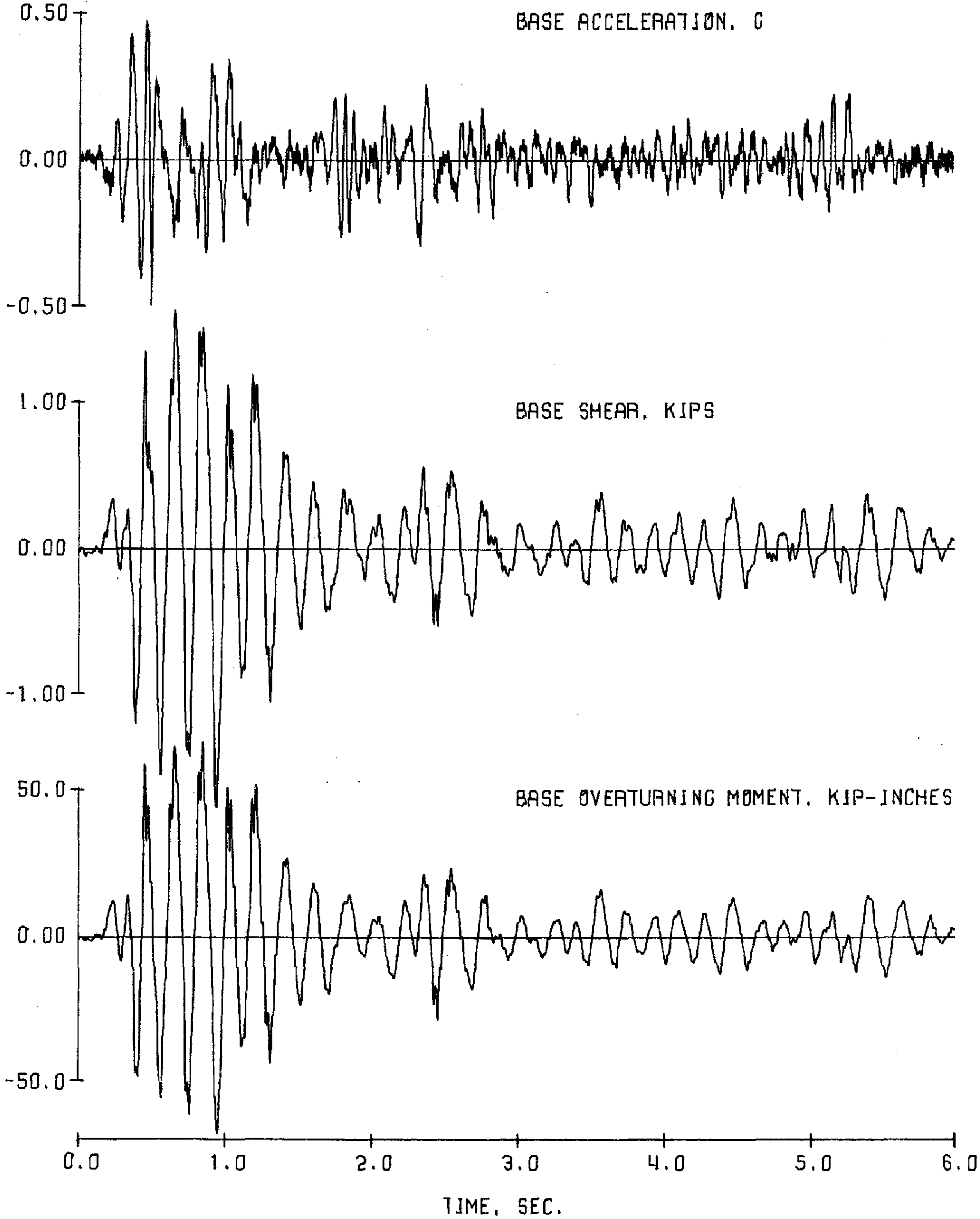
(a) Test Run D1-1. North Wall.

Figure 3.6 Test Structure D1. Observed Base Functions



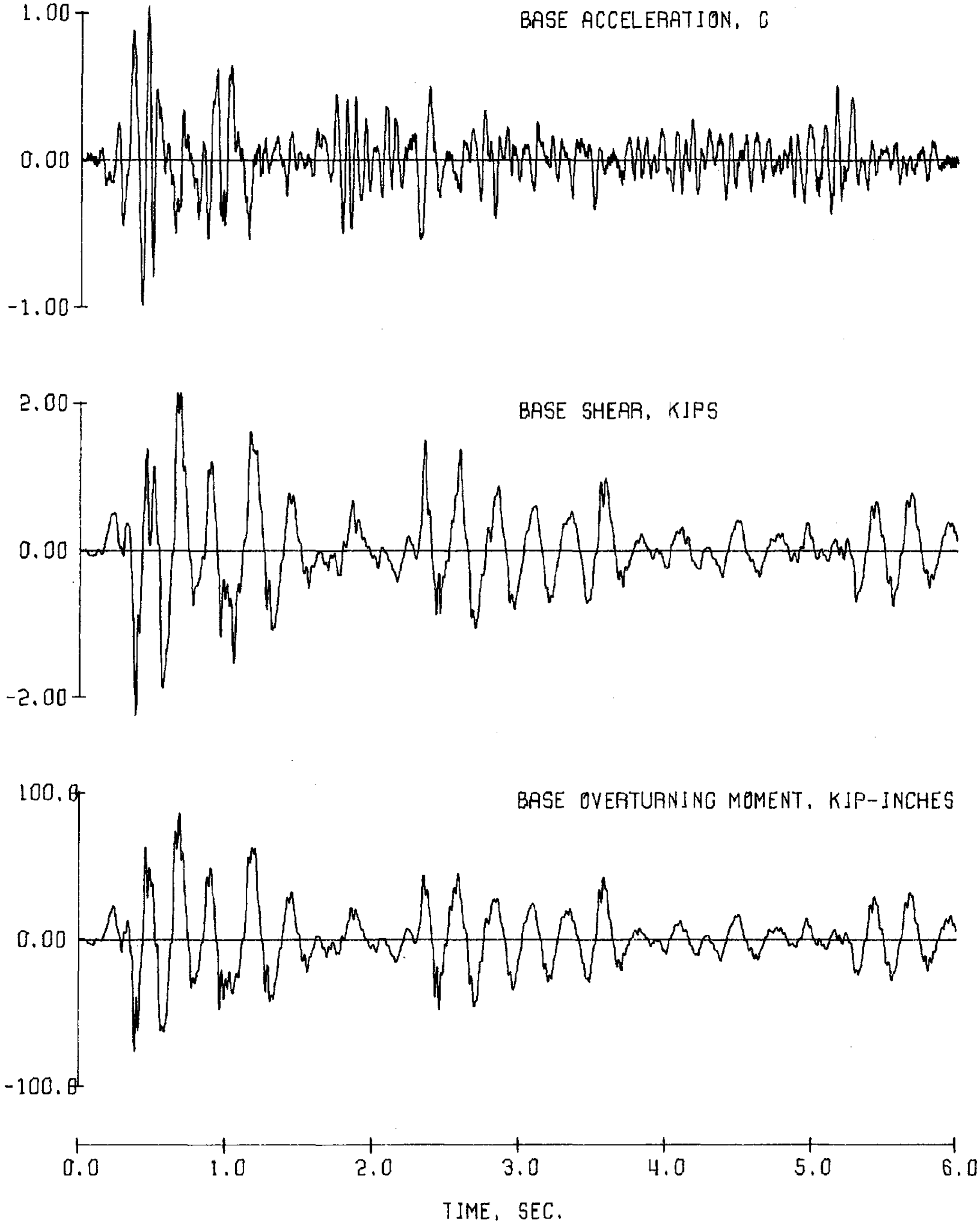
(b) Test Run D1-2. North Wall.

Fig. 3.6 (contd.) Test Structure D1. Observed Base Functions



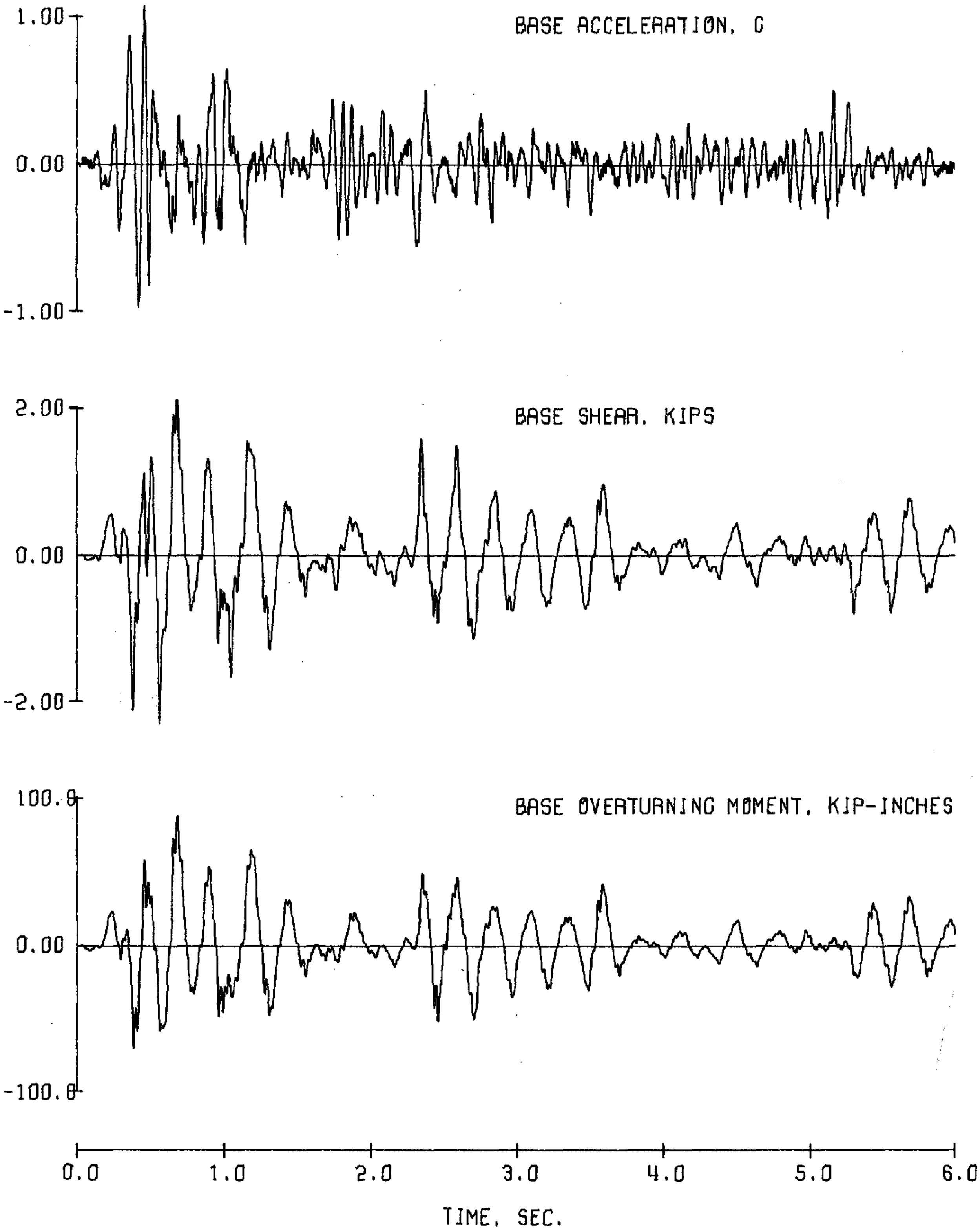
(c) Test Run D1-3. North Wall.

Figure 3.6 (contd.) Test Structure D1. Observed Base Functions



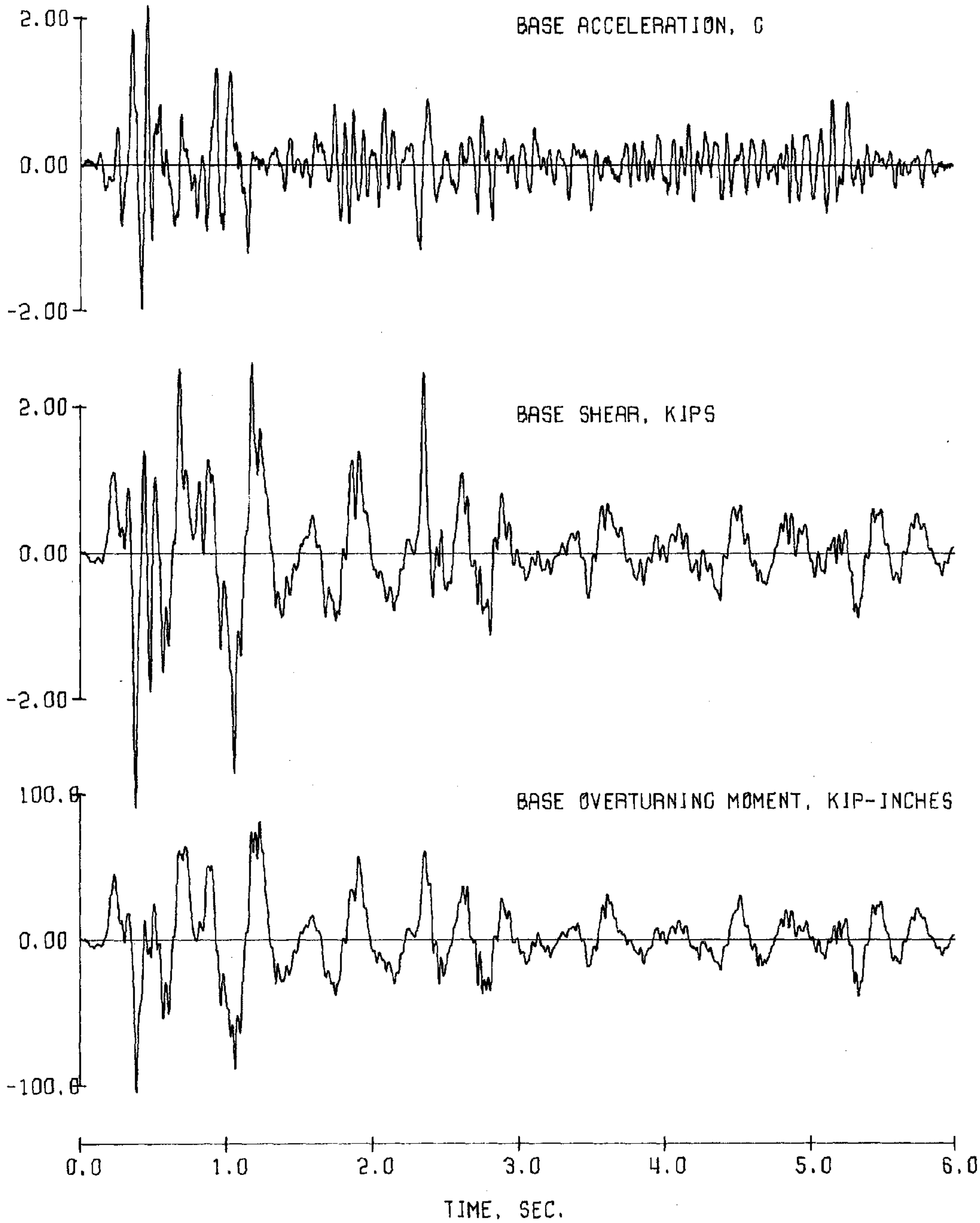
(d) Test Run D1-4. North Wall.

Figure 3.6 (contd.) Test Structure D1. Observed Base Functions



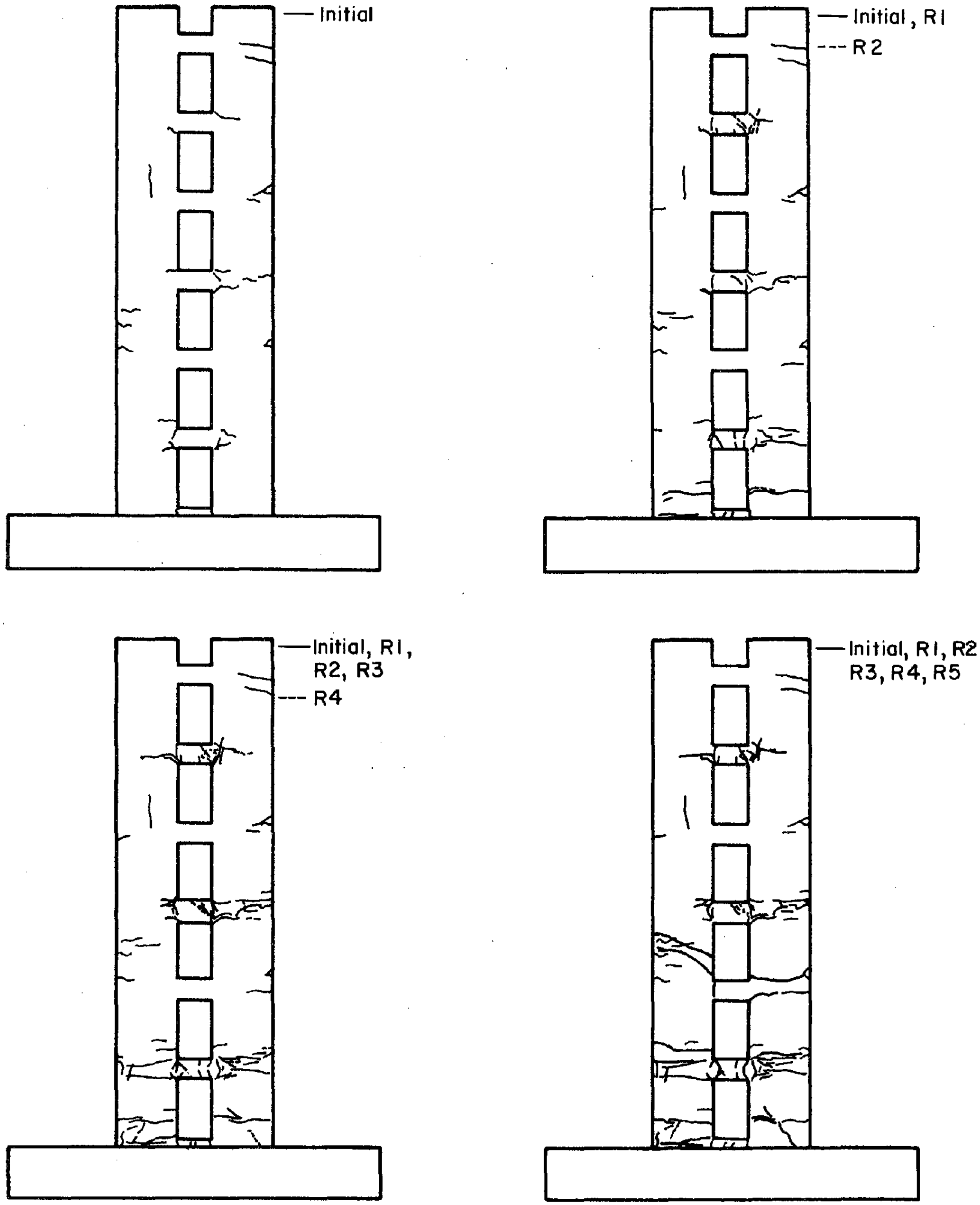
(e) Test Run D1-4. South Wall.

Figure 3.6 (contd.) Test Structure D1. Observed Base Functions



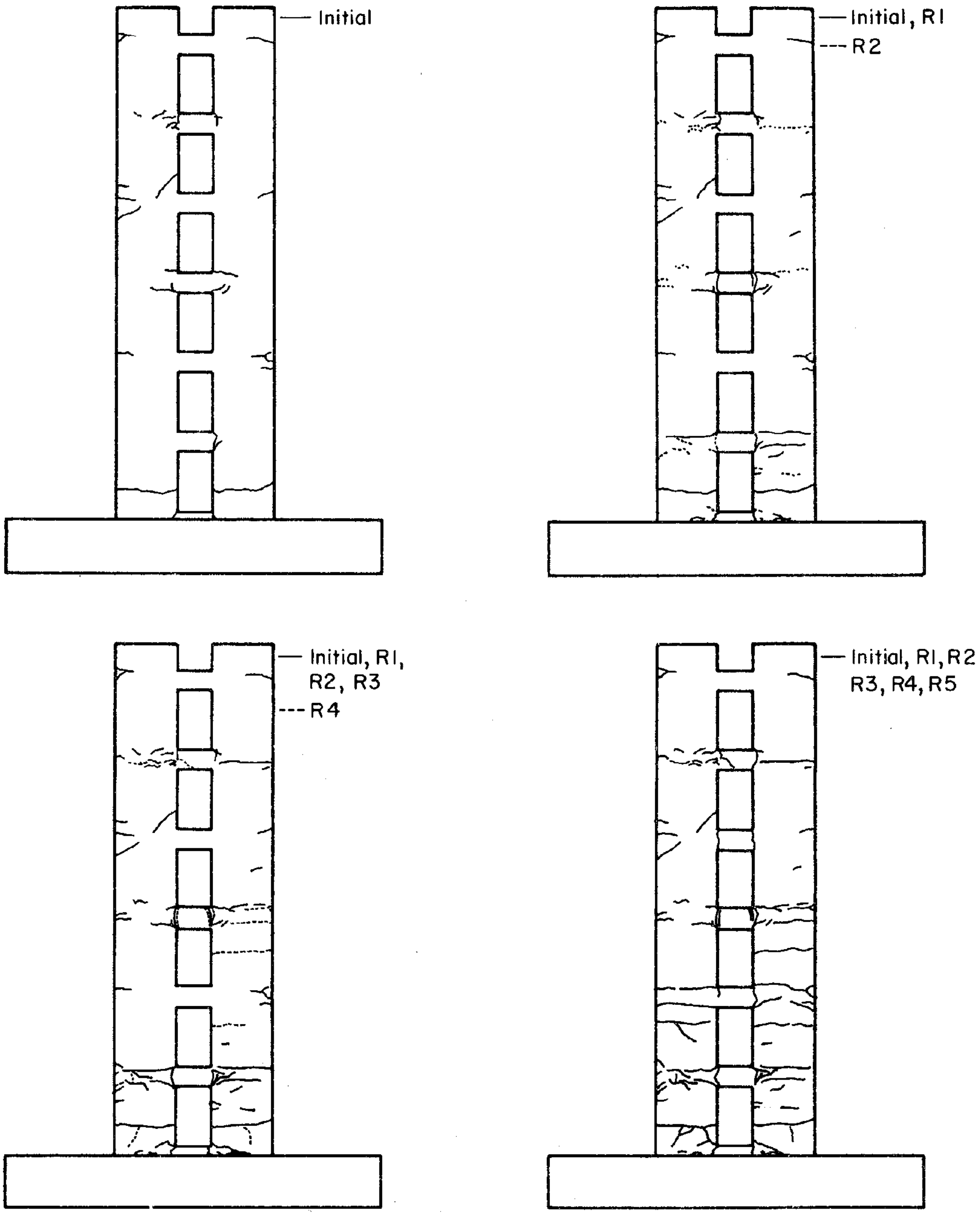
(f) Test Run D1-5. North Wall.

Figure 3.6 (contd.) Test Structure D1. Observed Base Functions



(a) North Wall

Figure 3.7 Test Structure D1. Observed Crack Patterns



(b) South Wall

Figure 3.7 (contd.) Test Structure D1. Observed Crack Patterns

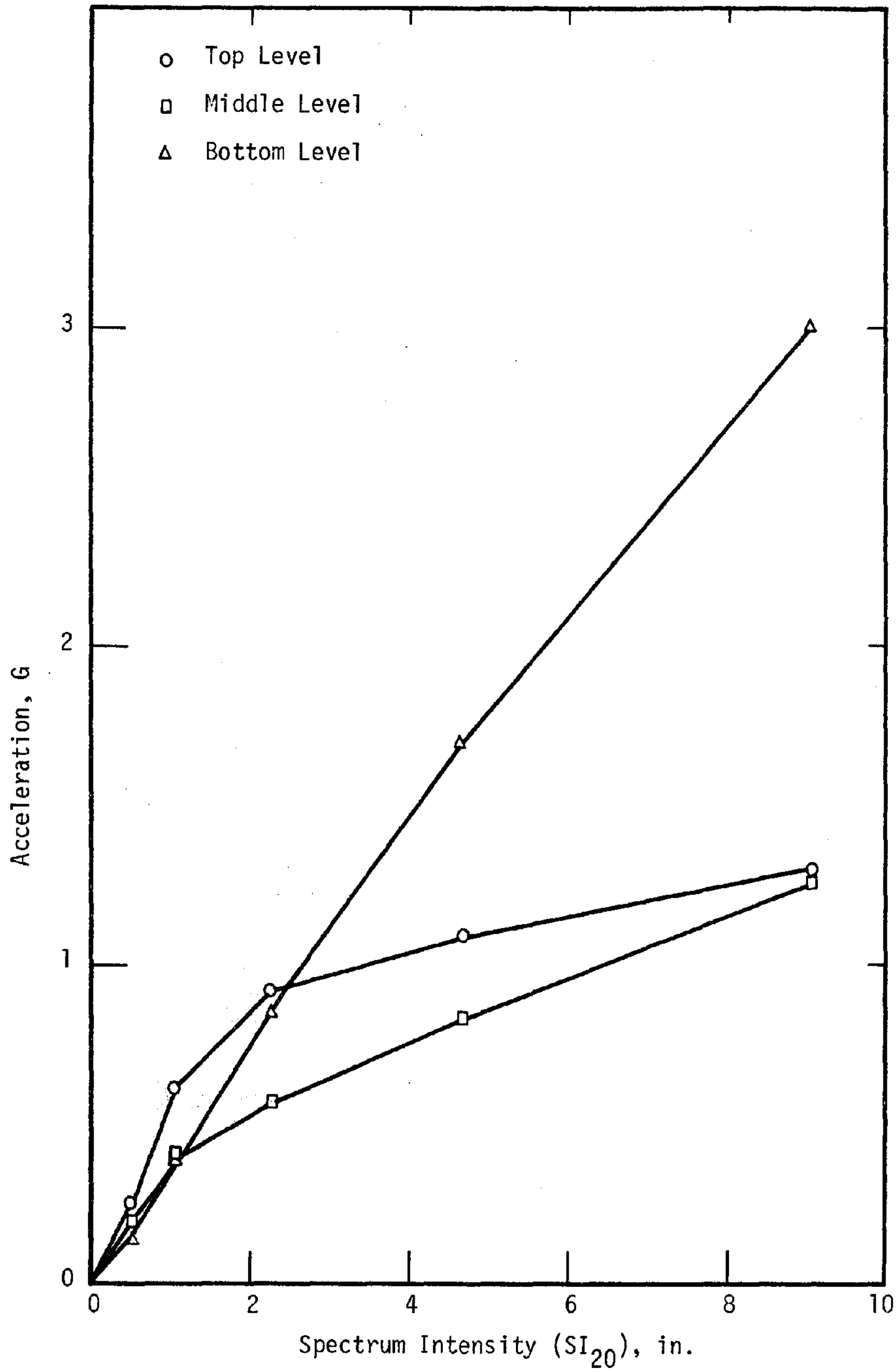


Figure 3.8 Type A Test Structure. Variation of Spectrum Intensity with Horizontal Acceleration

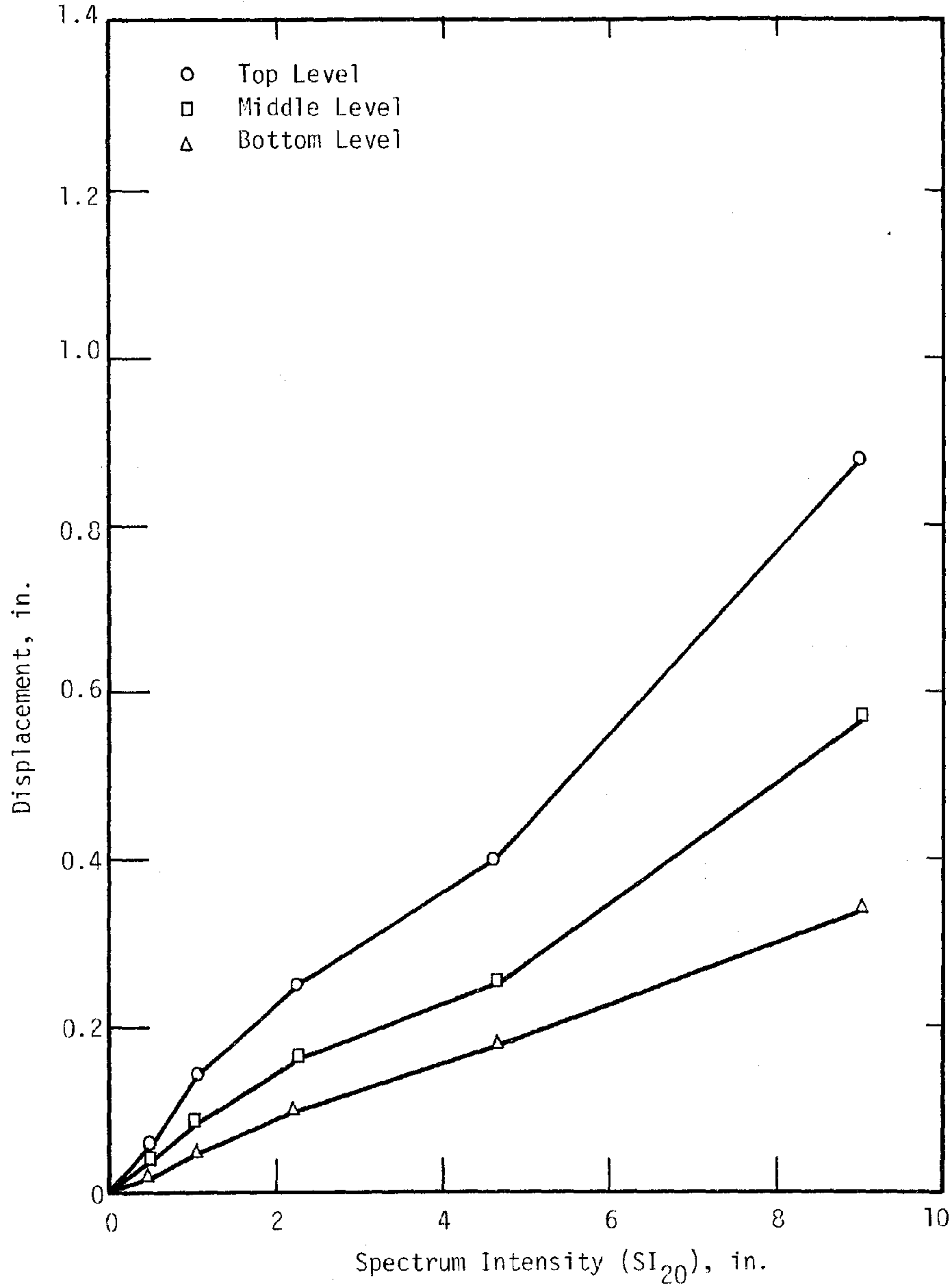


Figure 3.9 Type A Test Structure. Variation of Spectrum Intensity with One-Half of Average Horizontal Double Amplitude Displacement

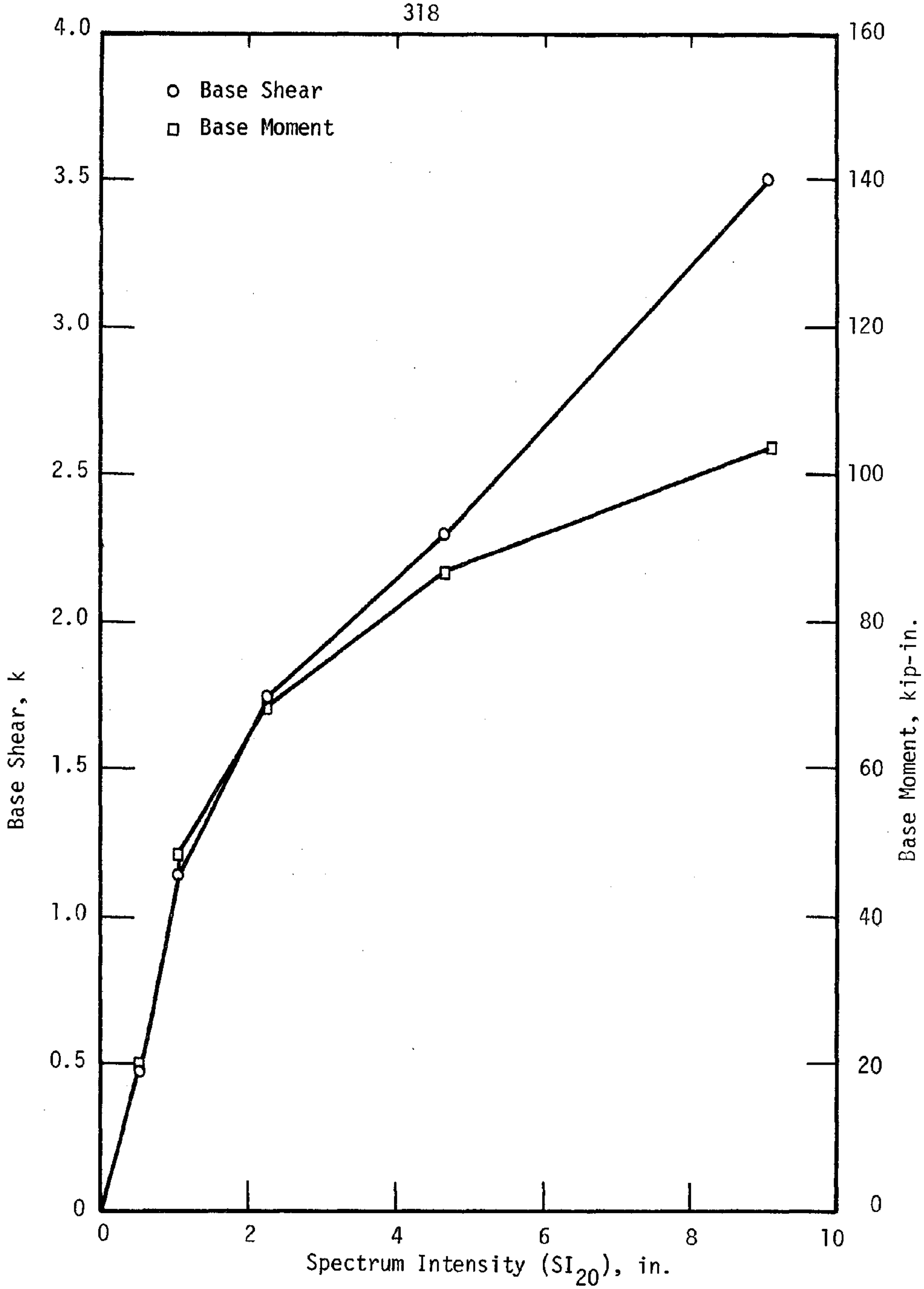


Figure 3.10 Type A Test Structure. Variation of Spectrum Intensity with Average Base Shear and Average Base Moment

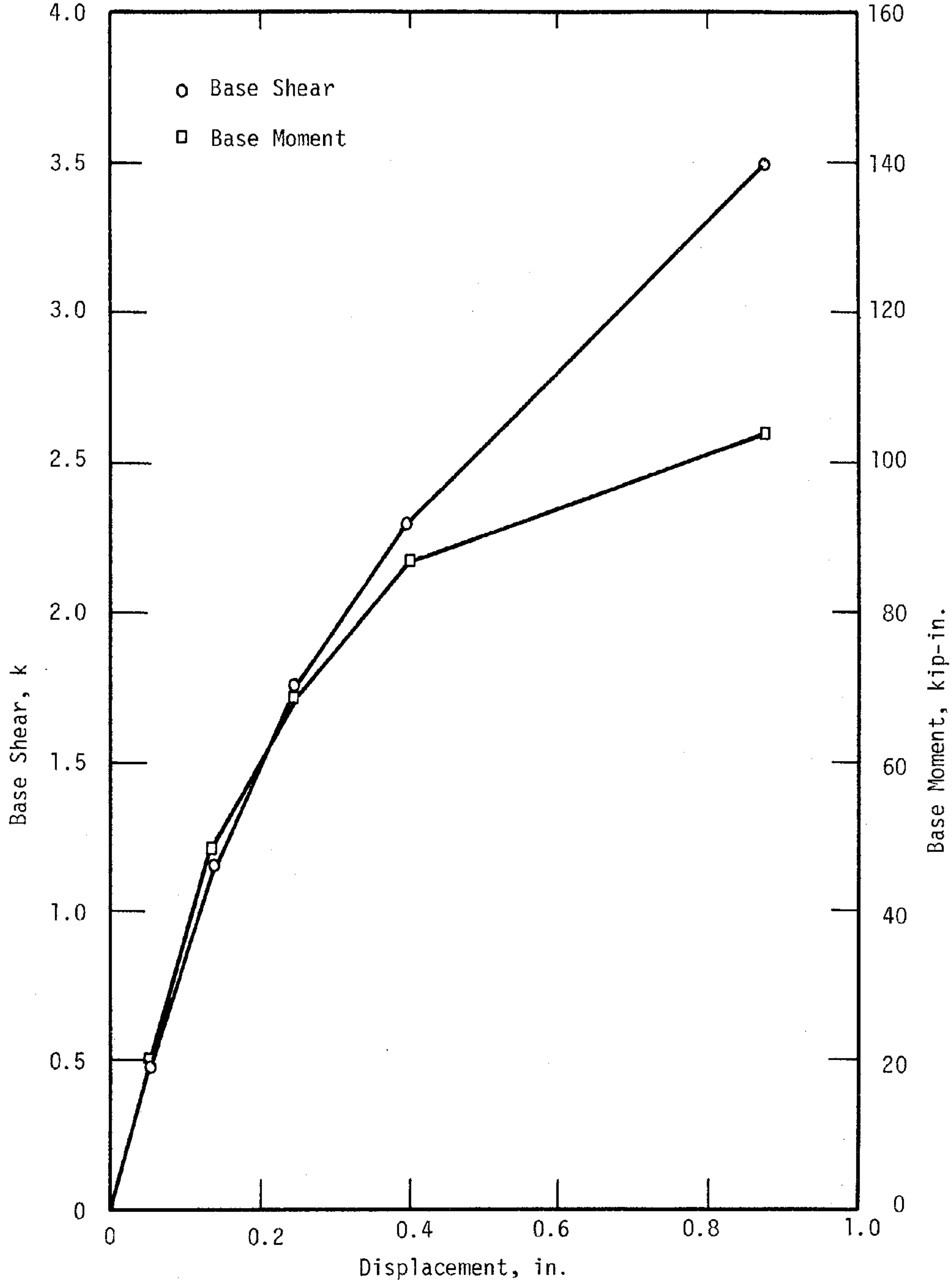
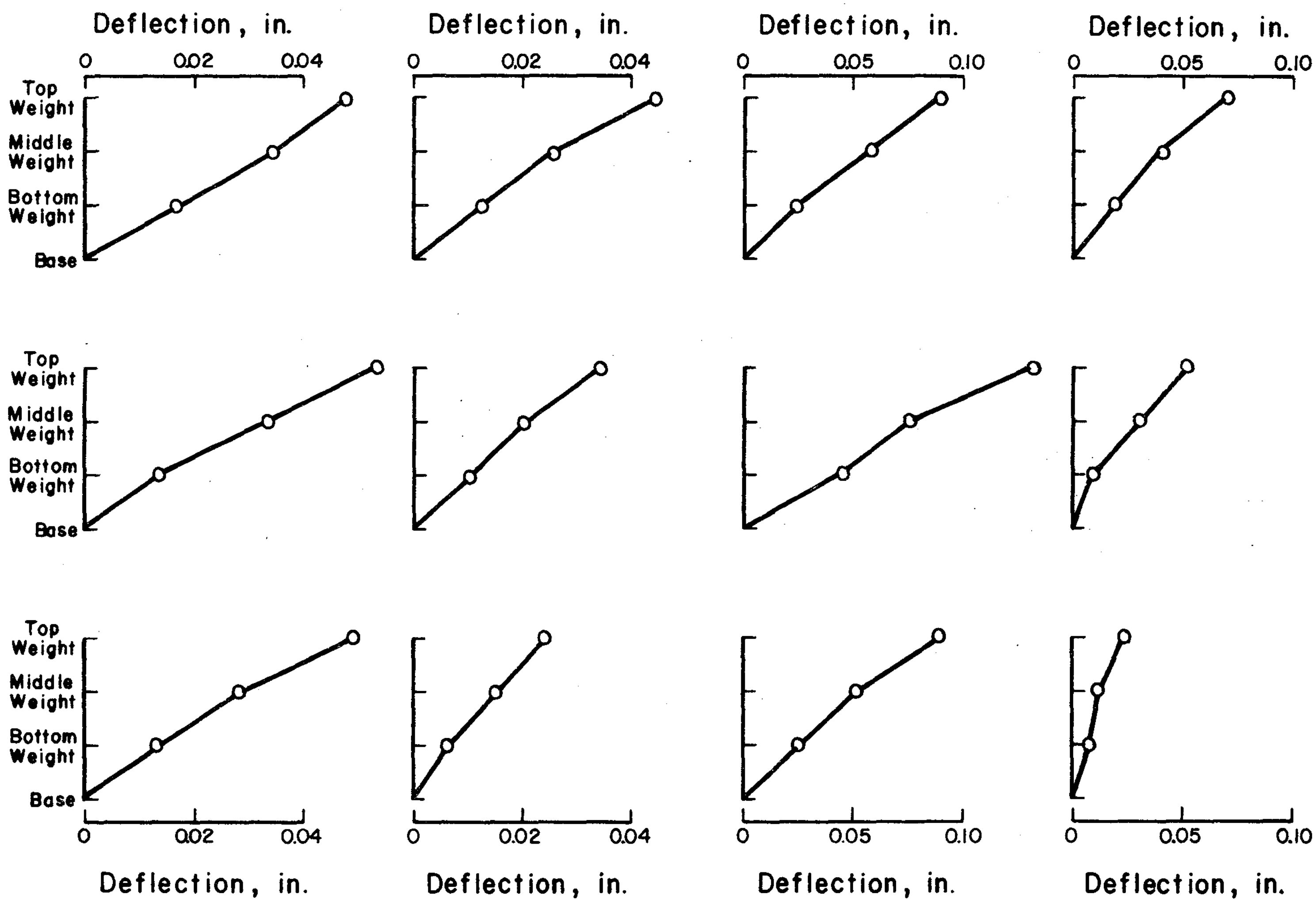


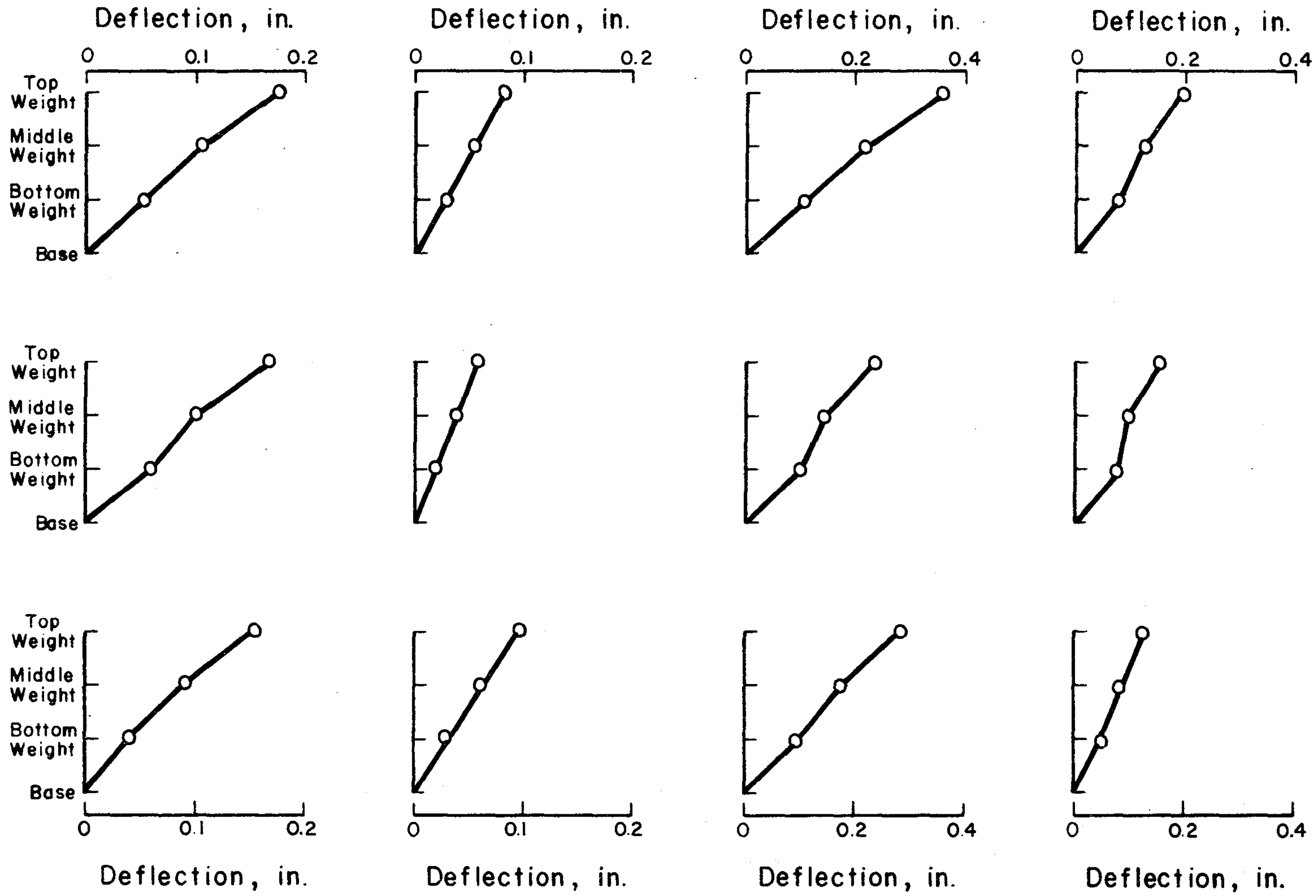
Figure 3.11 Type A Test Structure. Variation of Average Base Shear and Base Moment with One-Half of Average Double-Amplitude Top Level Displacement



(a) Test Run D1-1

(b) Test Run D1-2

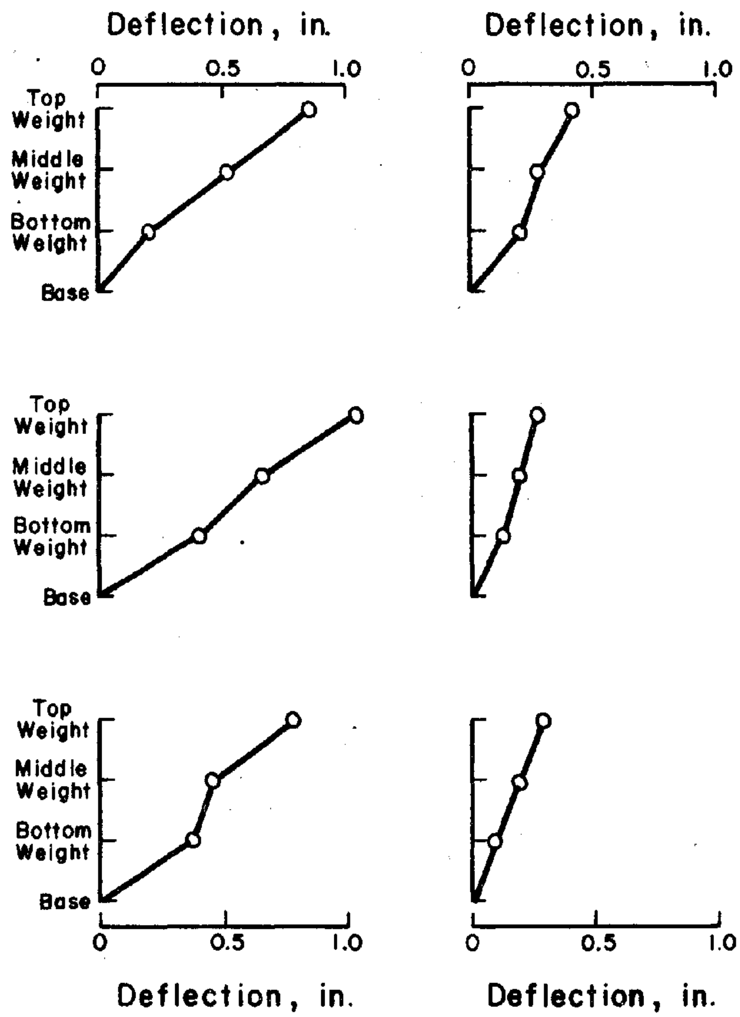
Figure 3.12 Type A Test Structure. Variation of Observed Deflection with Height at Several Times. South Wall



(c) Test Run D1-3

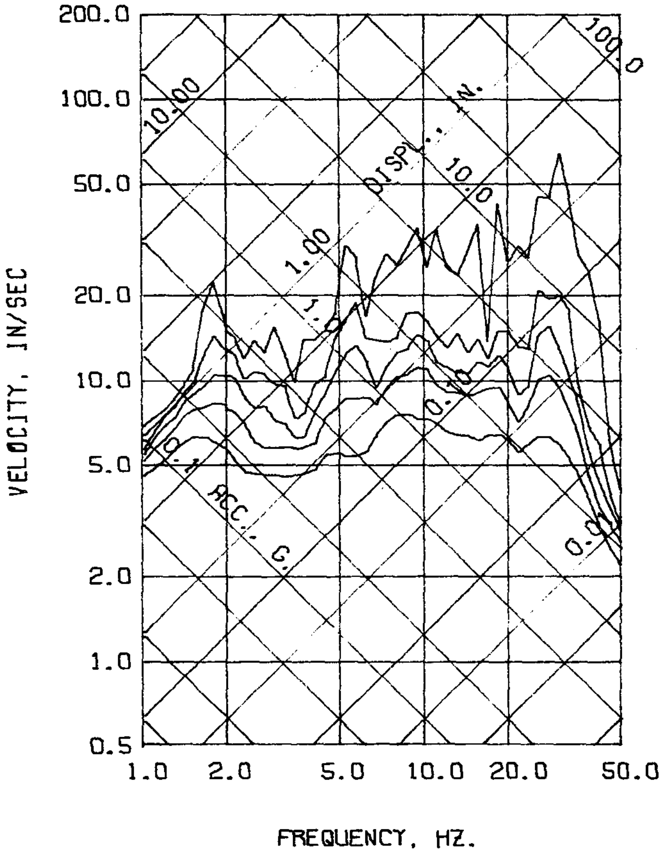
(d) Test Run D1-4

Figure 3.12 (contd.) Type A Test Structure. Variation of Observed Deflection with Height at Several Times. South Wall

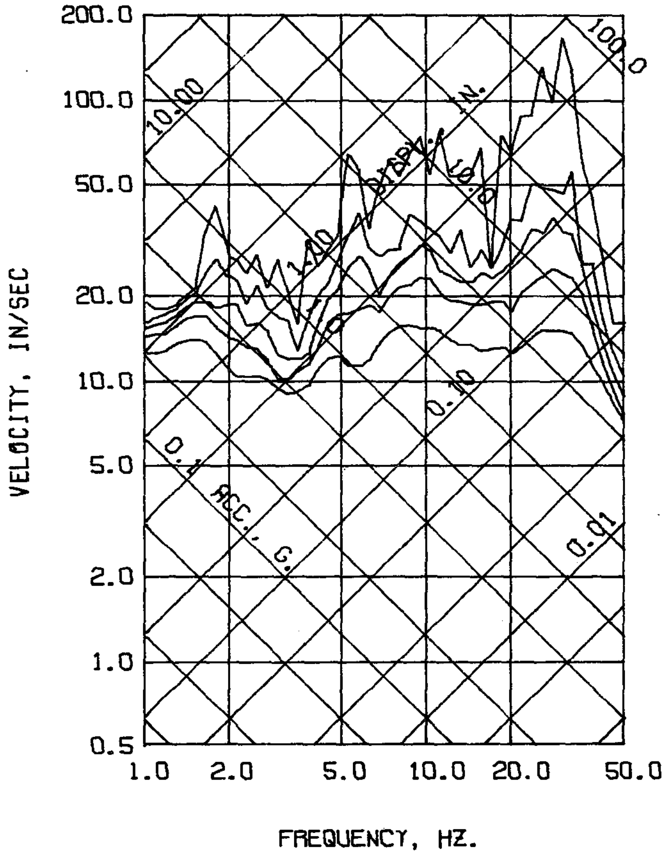


(e) Test Run D1-5

Figure 3.12 (contd.) Type A Test Structure, Variation of Observed Deflection with Height at Several Times. South Wall

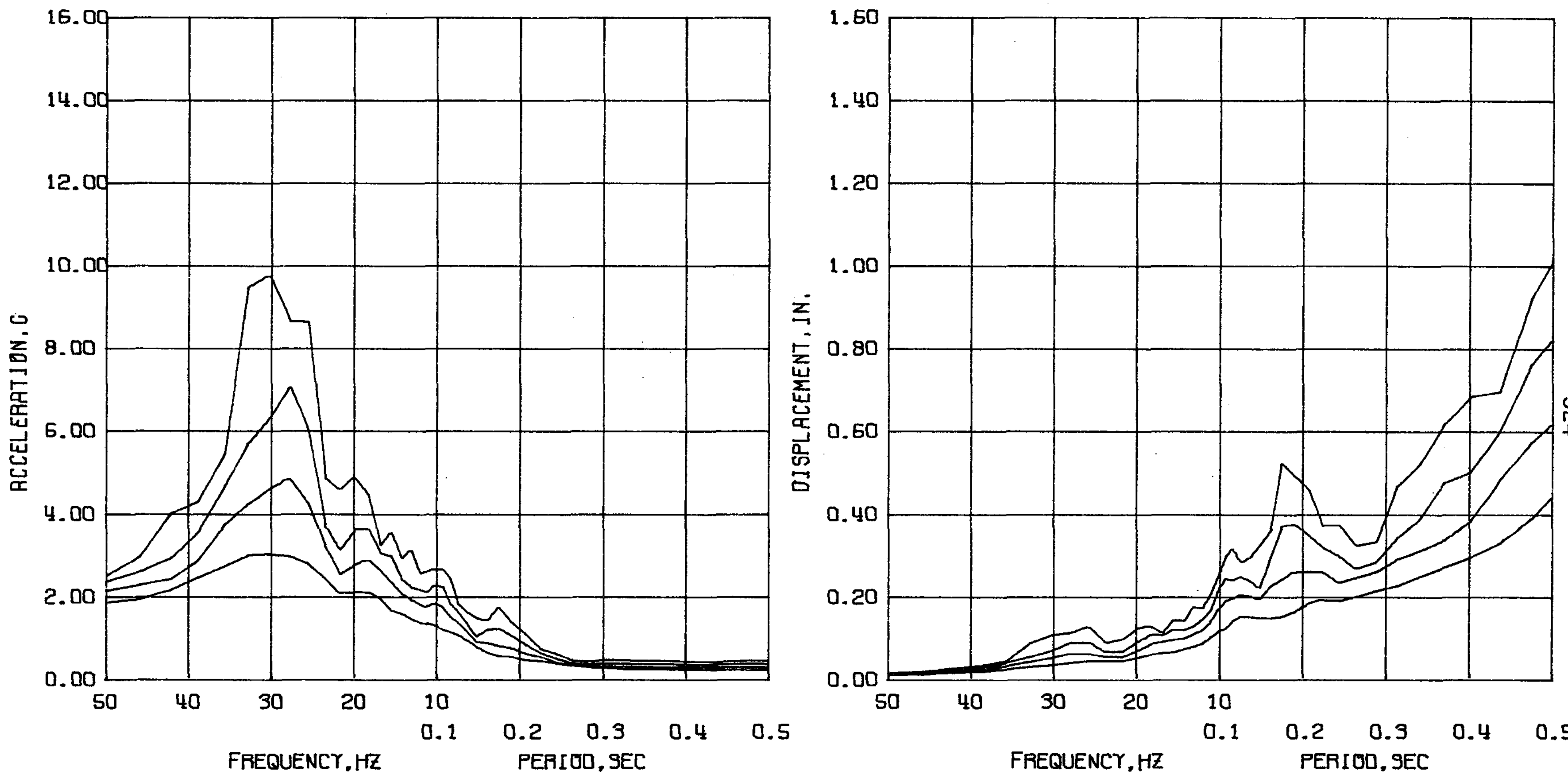


(a) Test Run D2-1



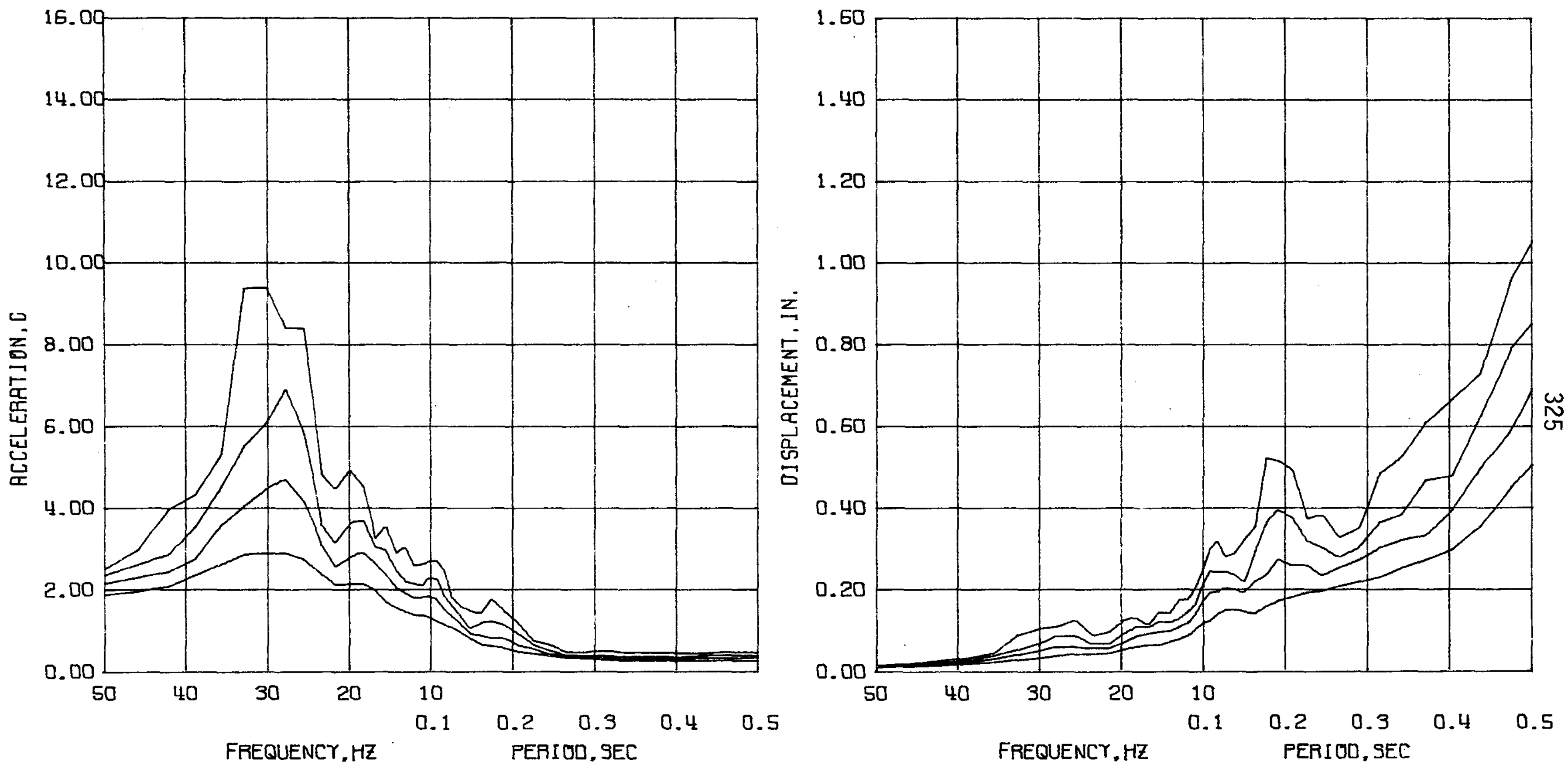
(b) Test Run D2-2

Figure 3.13 Test Structure D2. Linear Response Spectra. Tripartite Format.
(β = 0.0, 0.02, 0.05, 0.10, 0.20)



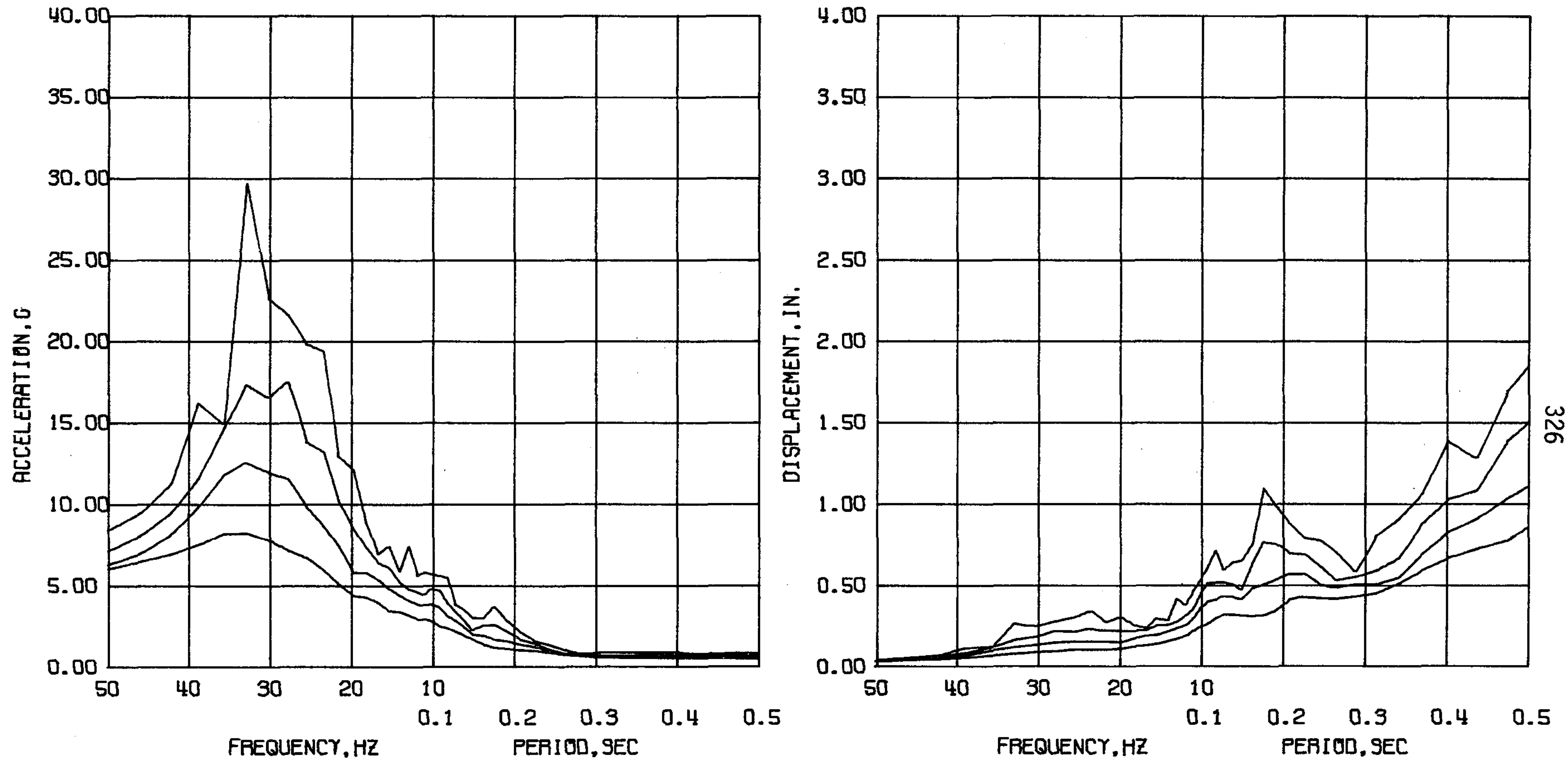
(a) Test Run D2-1. North Wall.

Figure 3.14 Test Structure D2. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



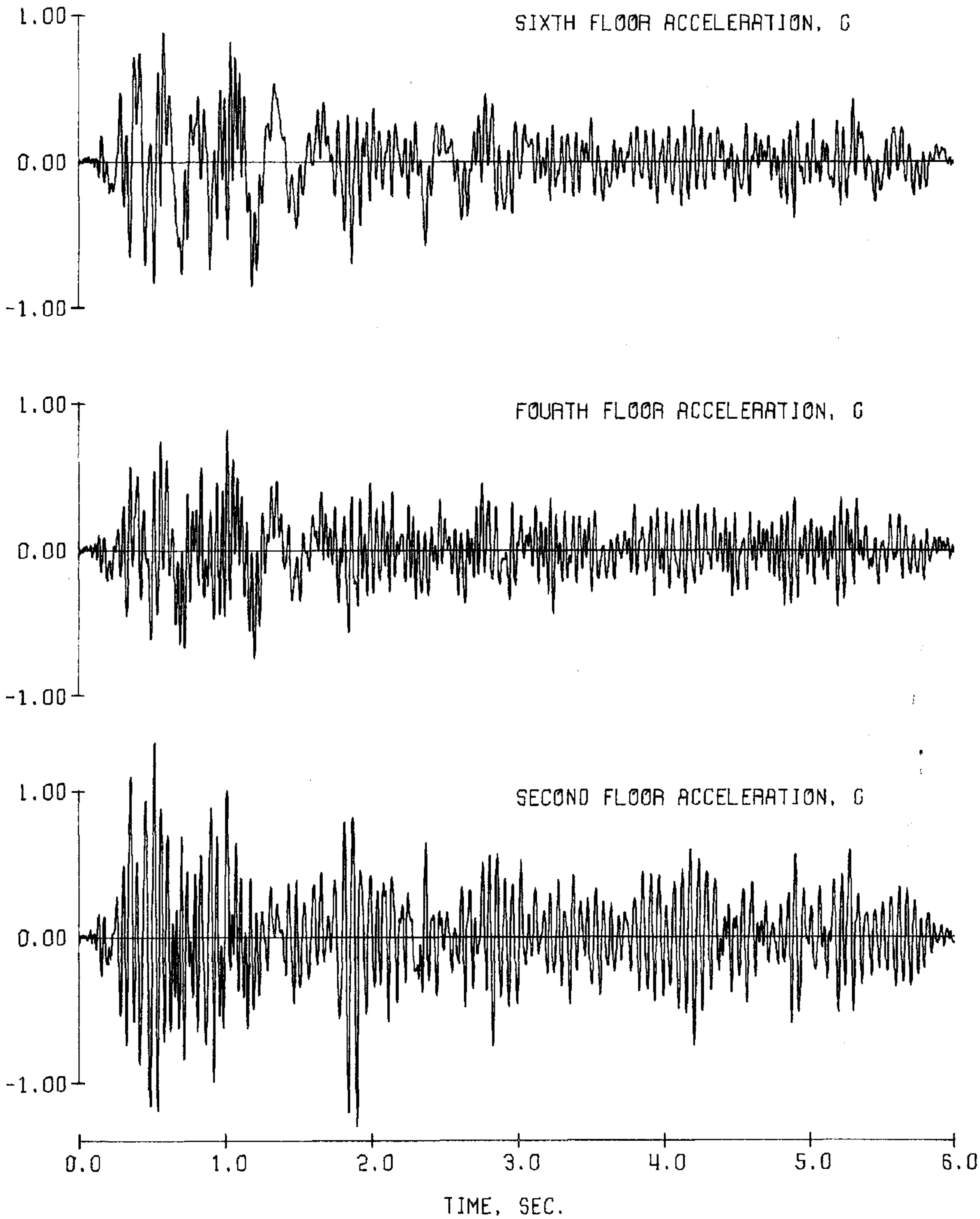
(b) Test Run D2-1. South Wall

Figure 3.14 (contd.) Test Structure D2. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



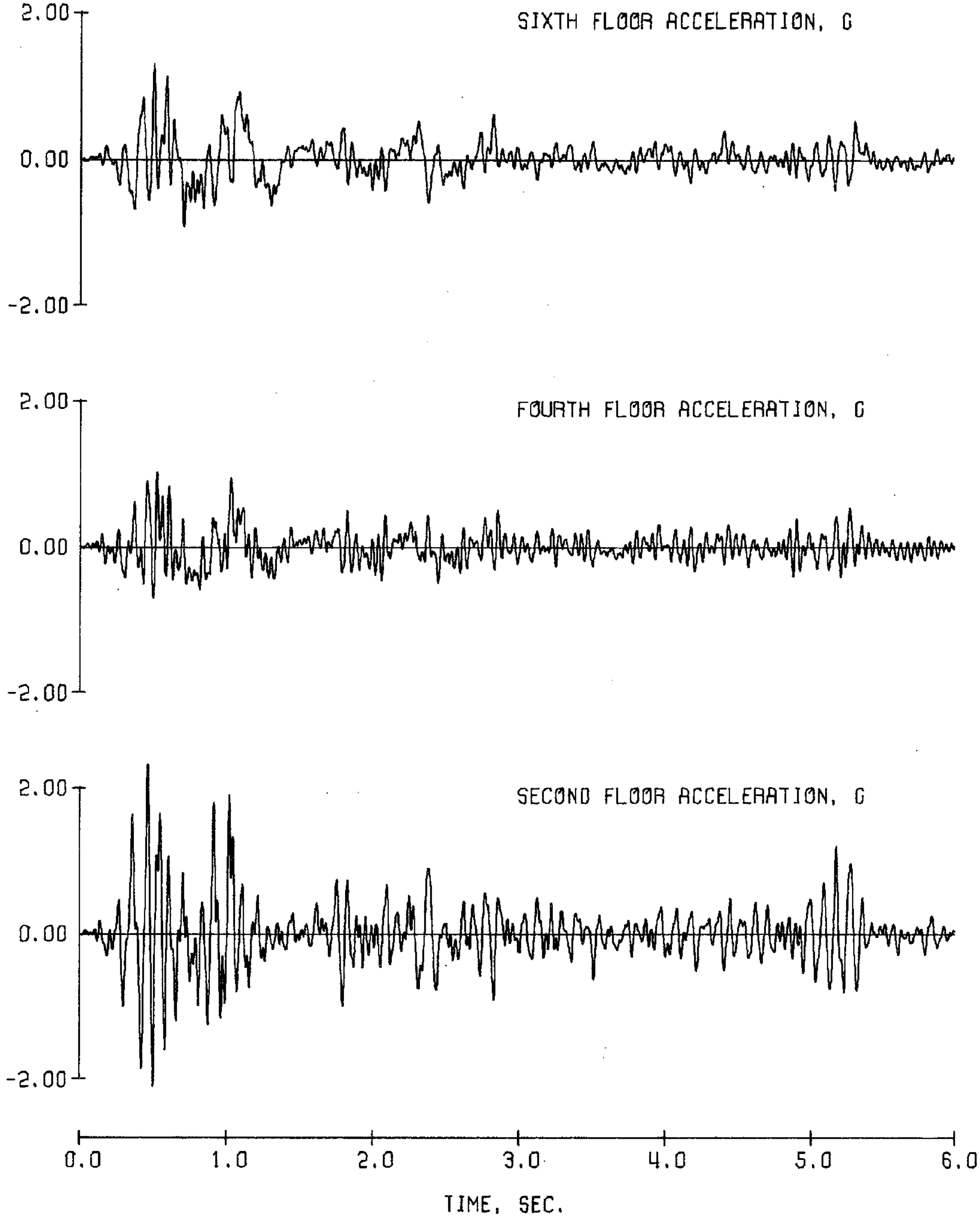
(c) Test Run D2-2. North Wall.

Figure 3.14 (contd.) Test Structure D2. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



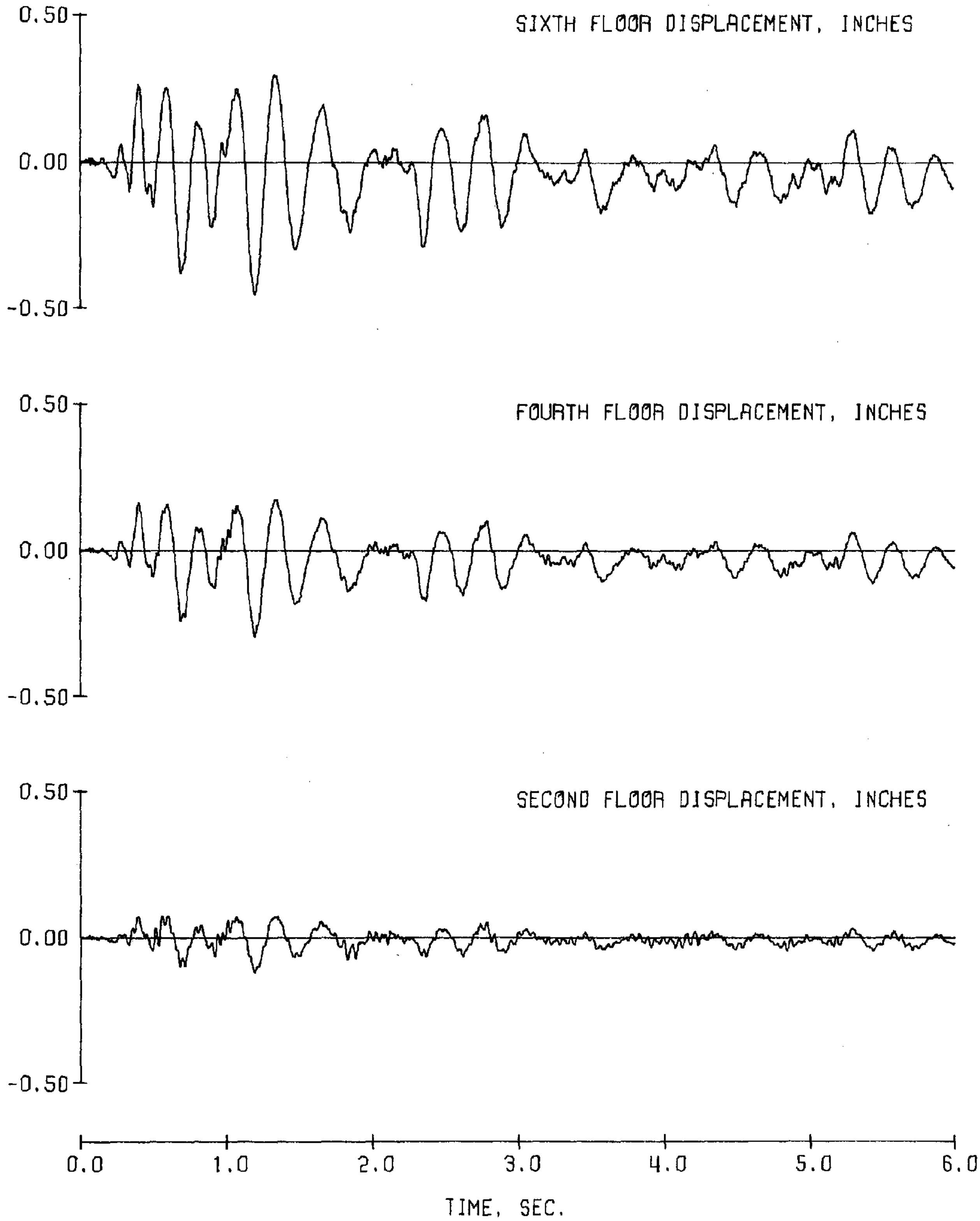
(a) Test Run D2-1. North Wall.

Figure 3.15 Test Structure D2. Observed Horizontal Accelerations



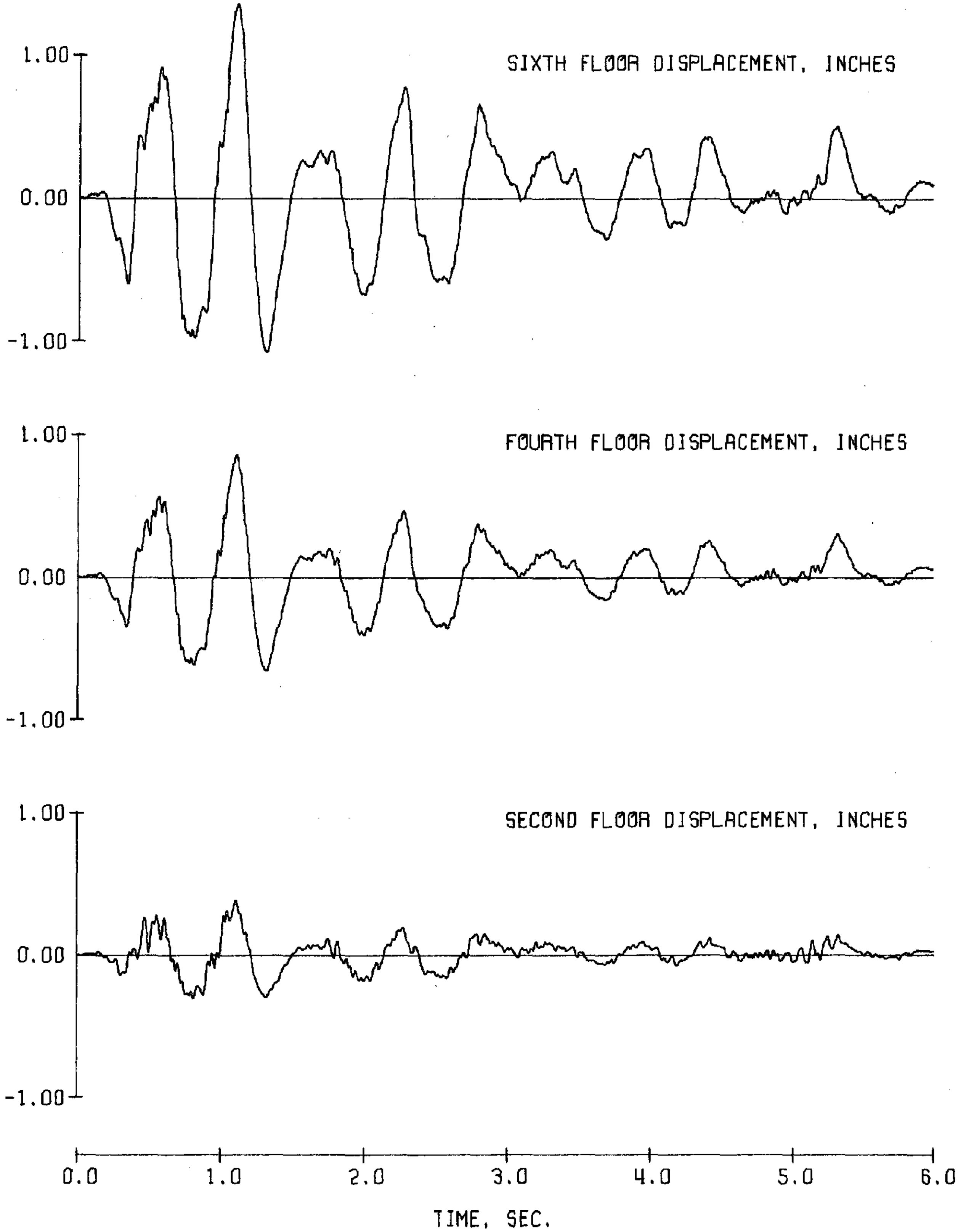
(b) Test Run D2-2. North Wall.

Figure 3.15 (contd.) Test Structure D2. Observed Horizontal Accelerations



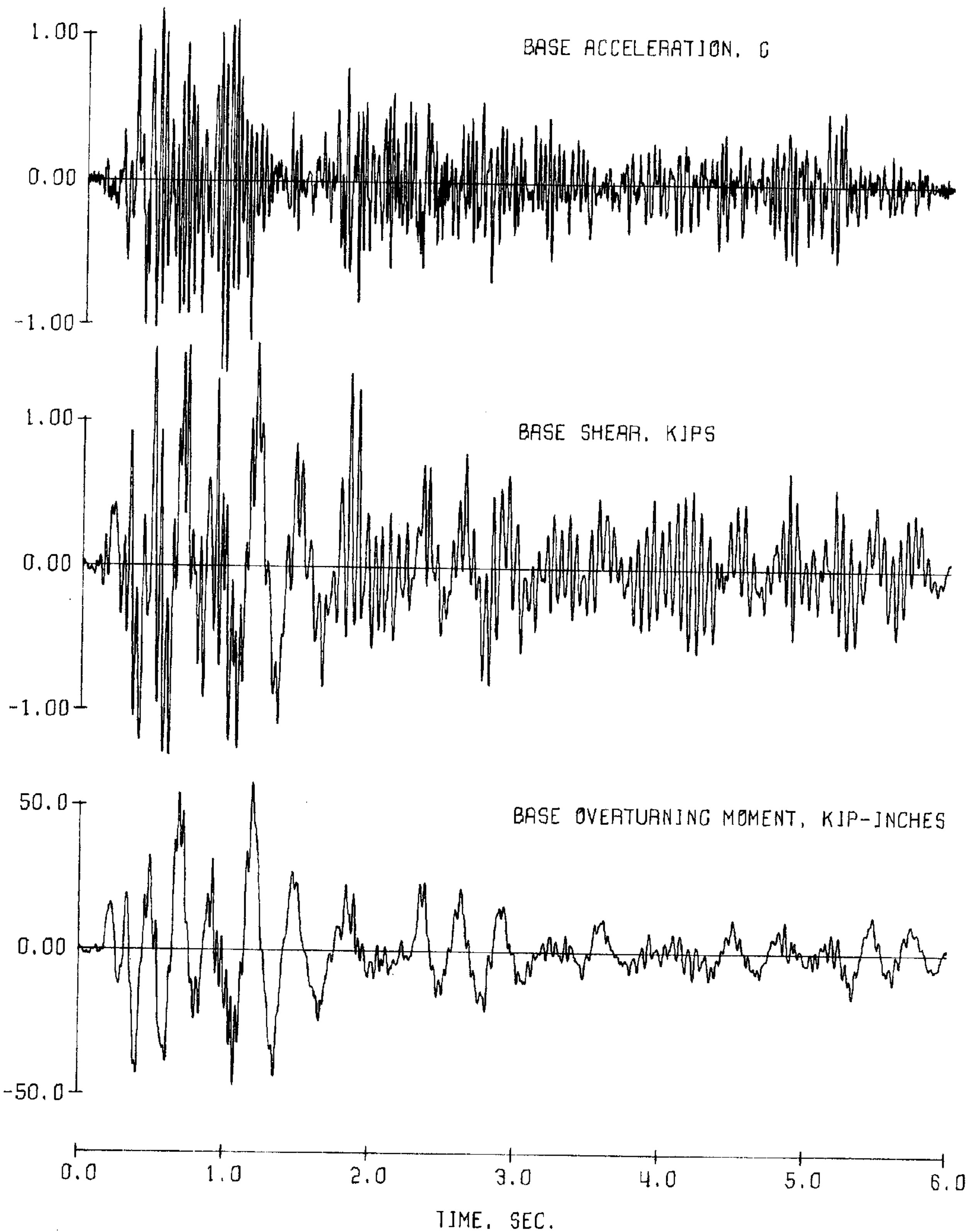
(a) Test Run D2-1. North Wall.

Figure 3.16 Test Structure D2. Observed Horizontal Displacements



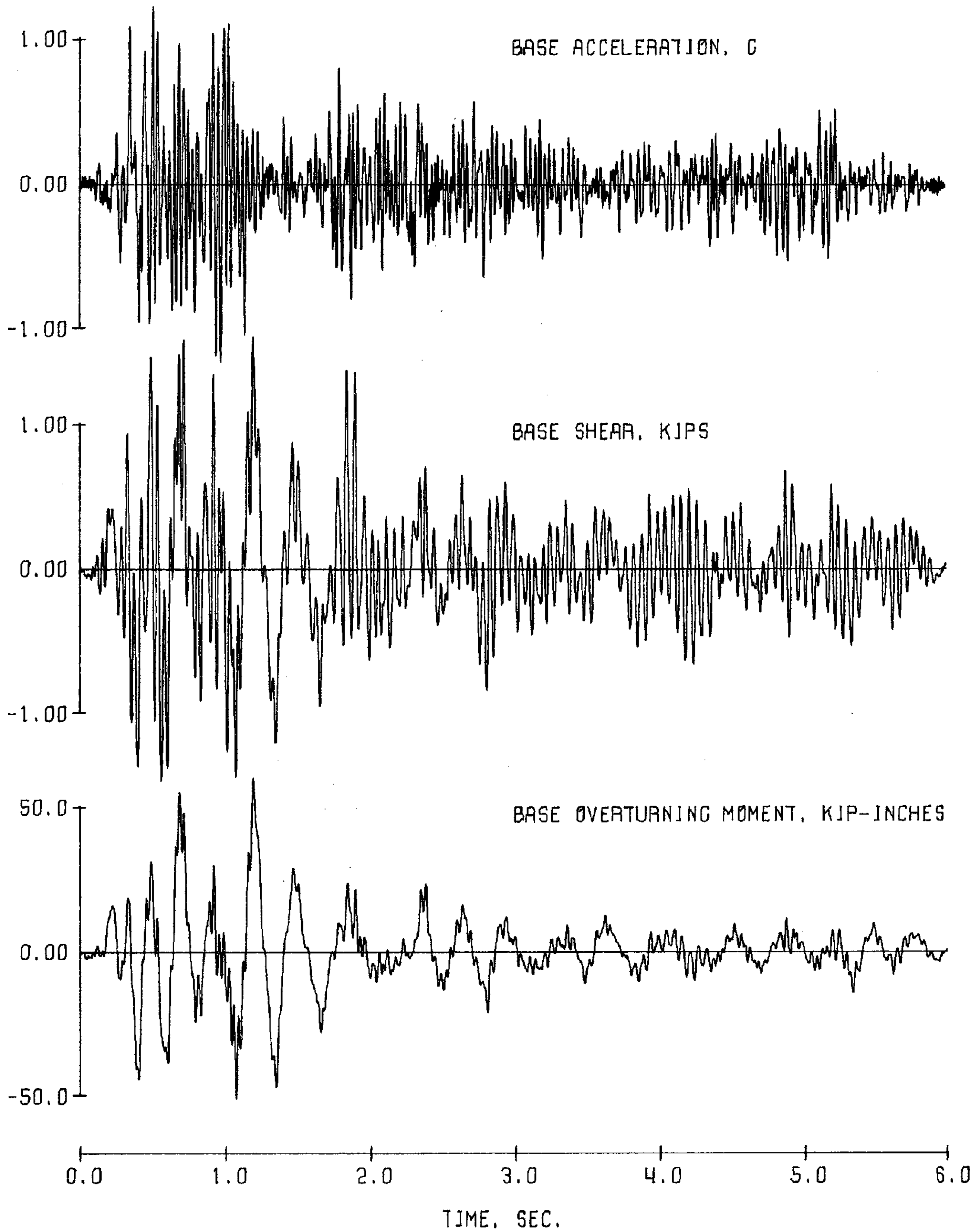
(b) Test Run D2-2. North Wall.

Figure 3.16 (contd.) Test Structure D2. Observed Horizontal Displacements



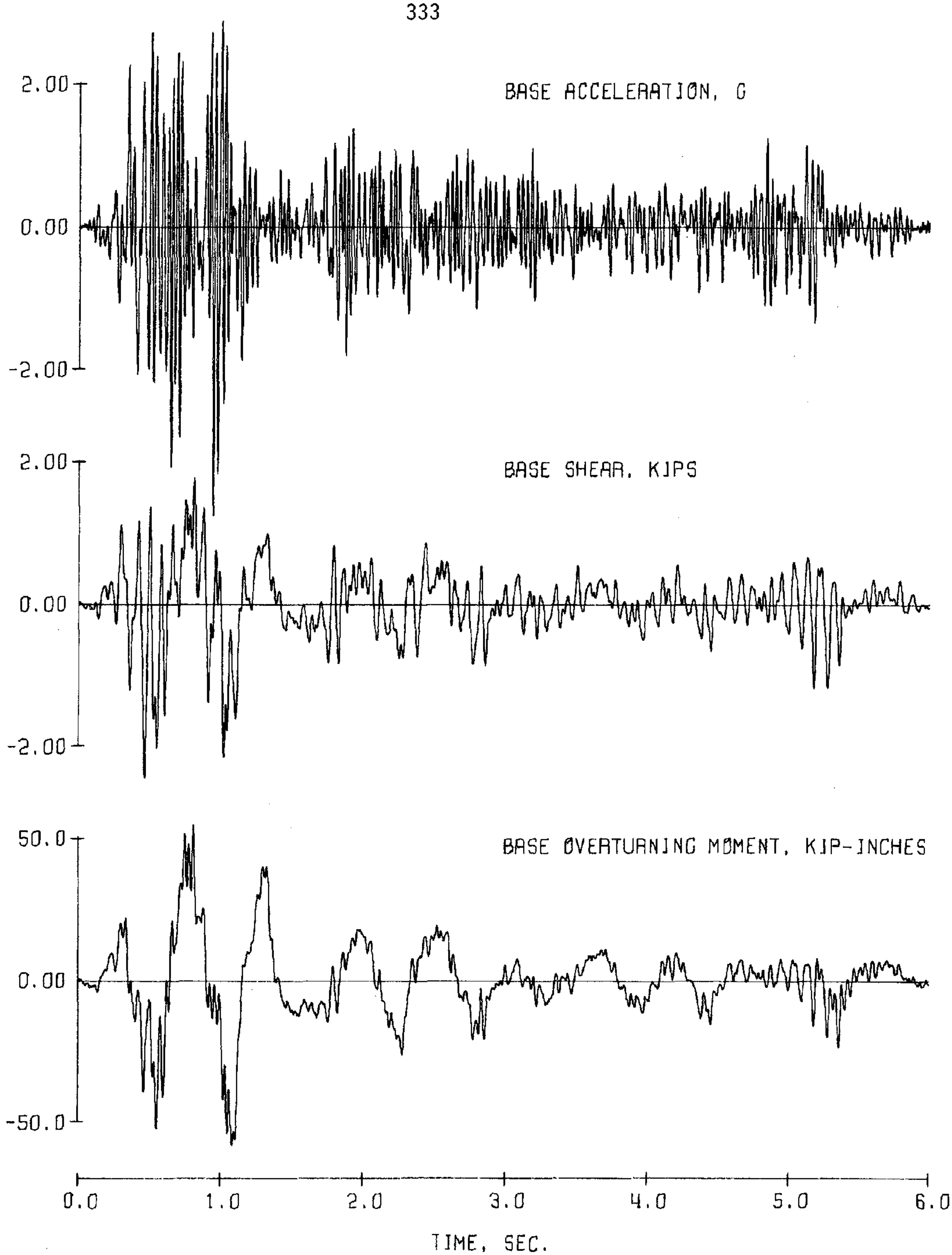
(a) Test Run D2-1. North Wall.

Figure 3.17 Test Structure D2. Observed Base Functions



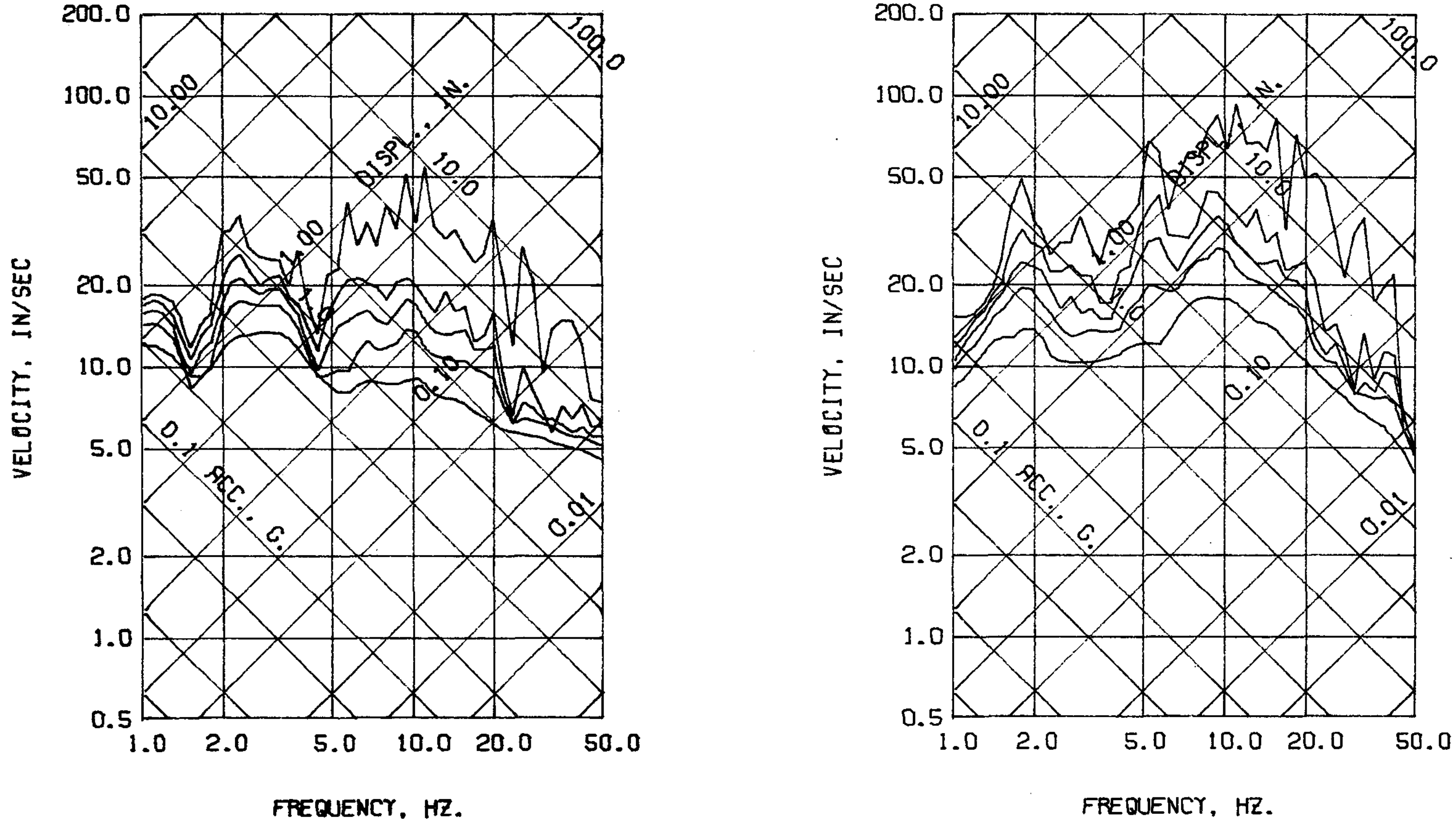
(b) Test Run D2-1. South Wall.

Figure 3.17 (contd.) Test Structure D2. Observed Base Functions



(c) Test Run D2-2. North Wall.

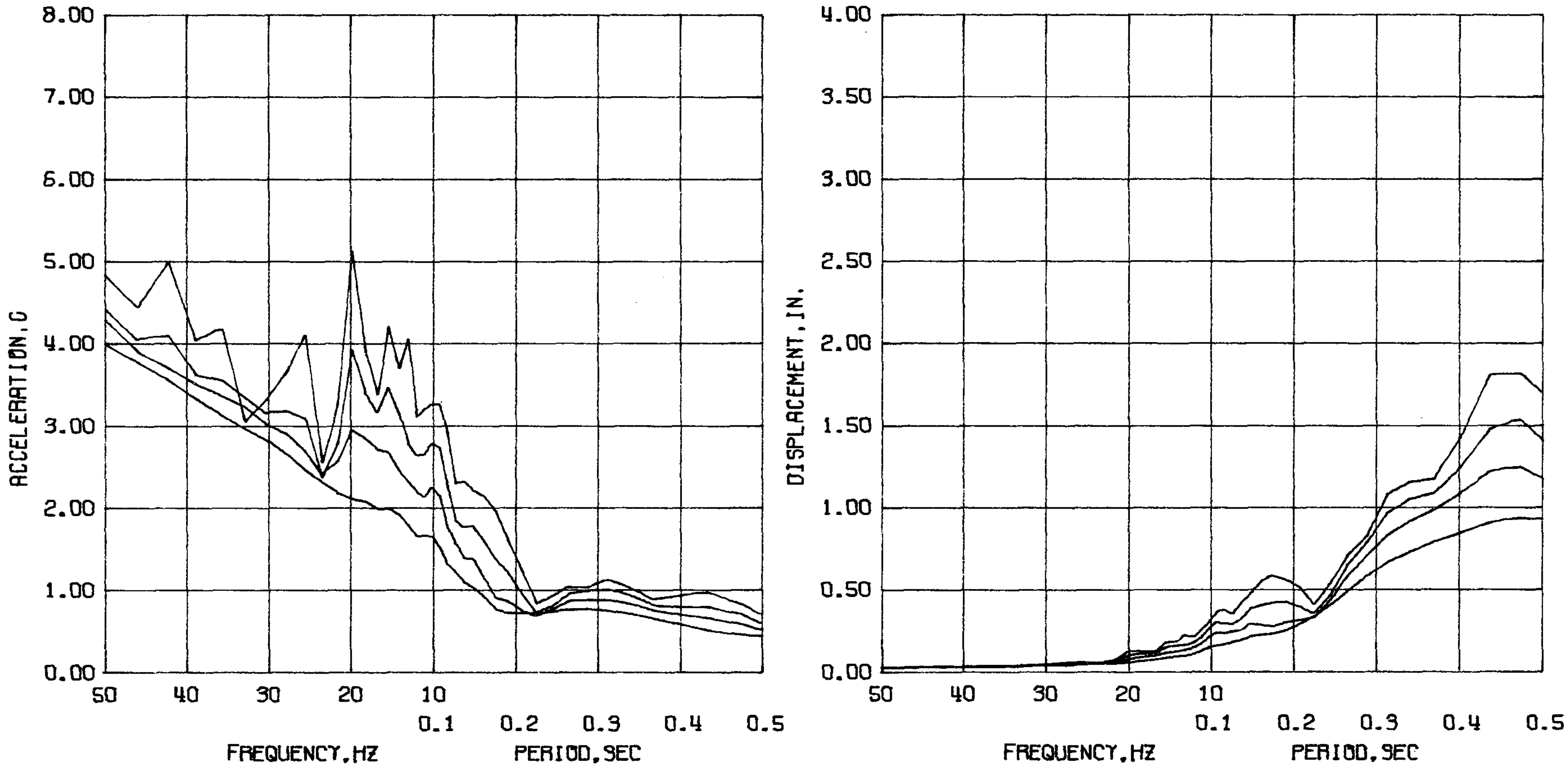
Figure 3.17 (contd.) Test Structure D2. Observed Base Functions



(a) Test Run D3-1

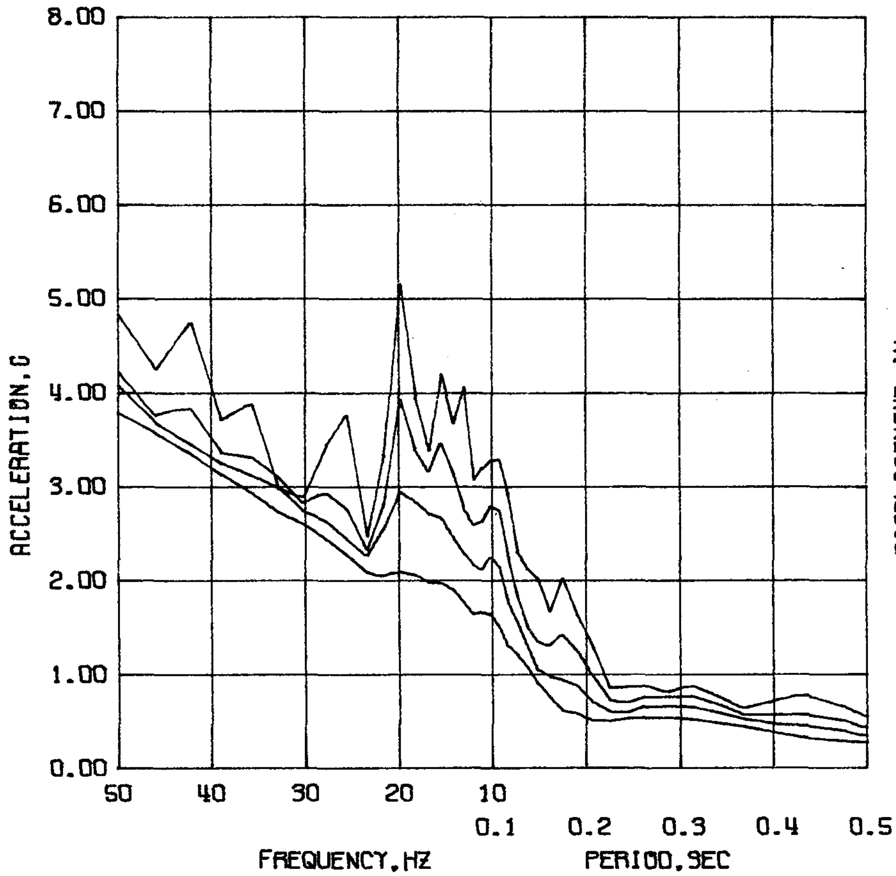
(b) Test Run D3-2

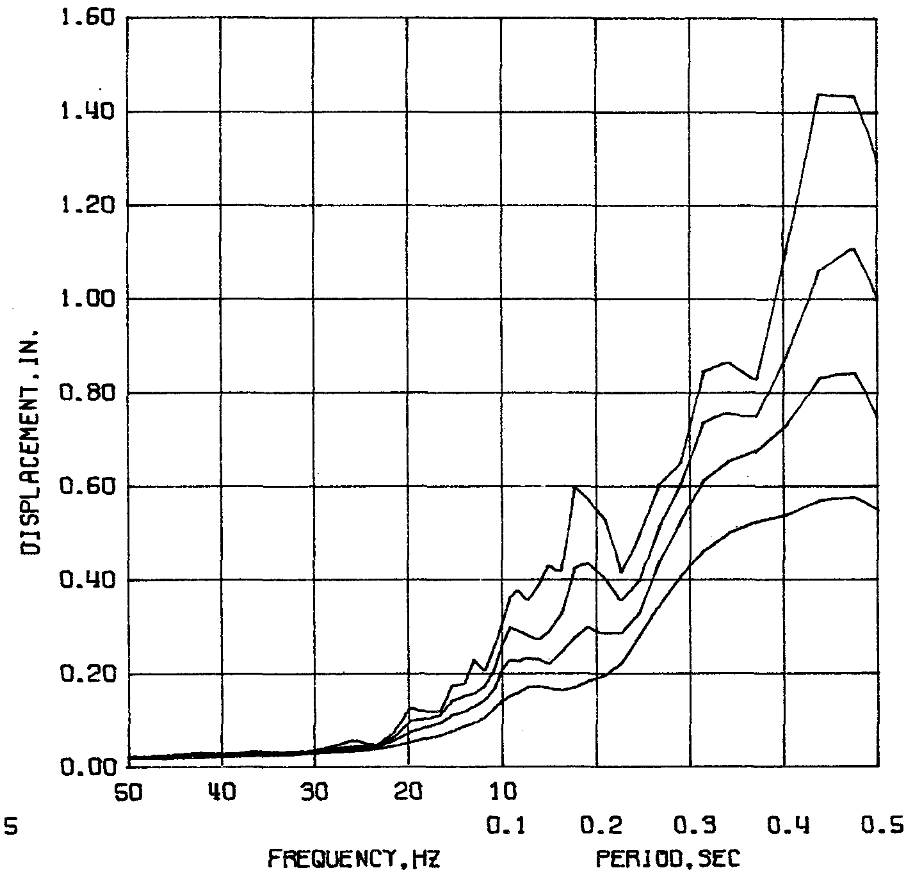
Figure 3.18 Test Structure D3. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)



(a) Test Run D3-1. North Wall.

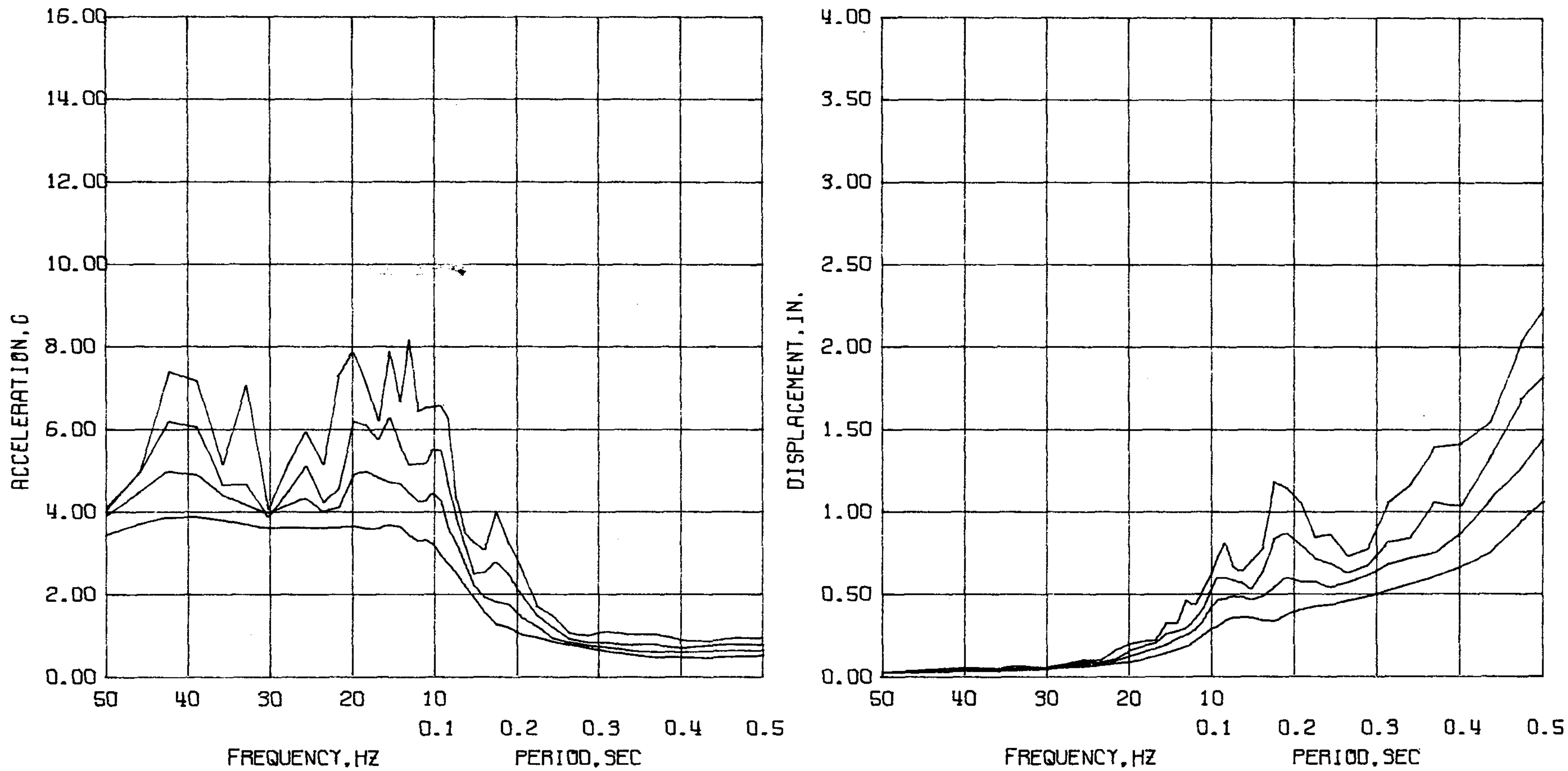
Figure 3.19 Test Structure D3. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)





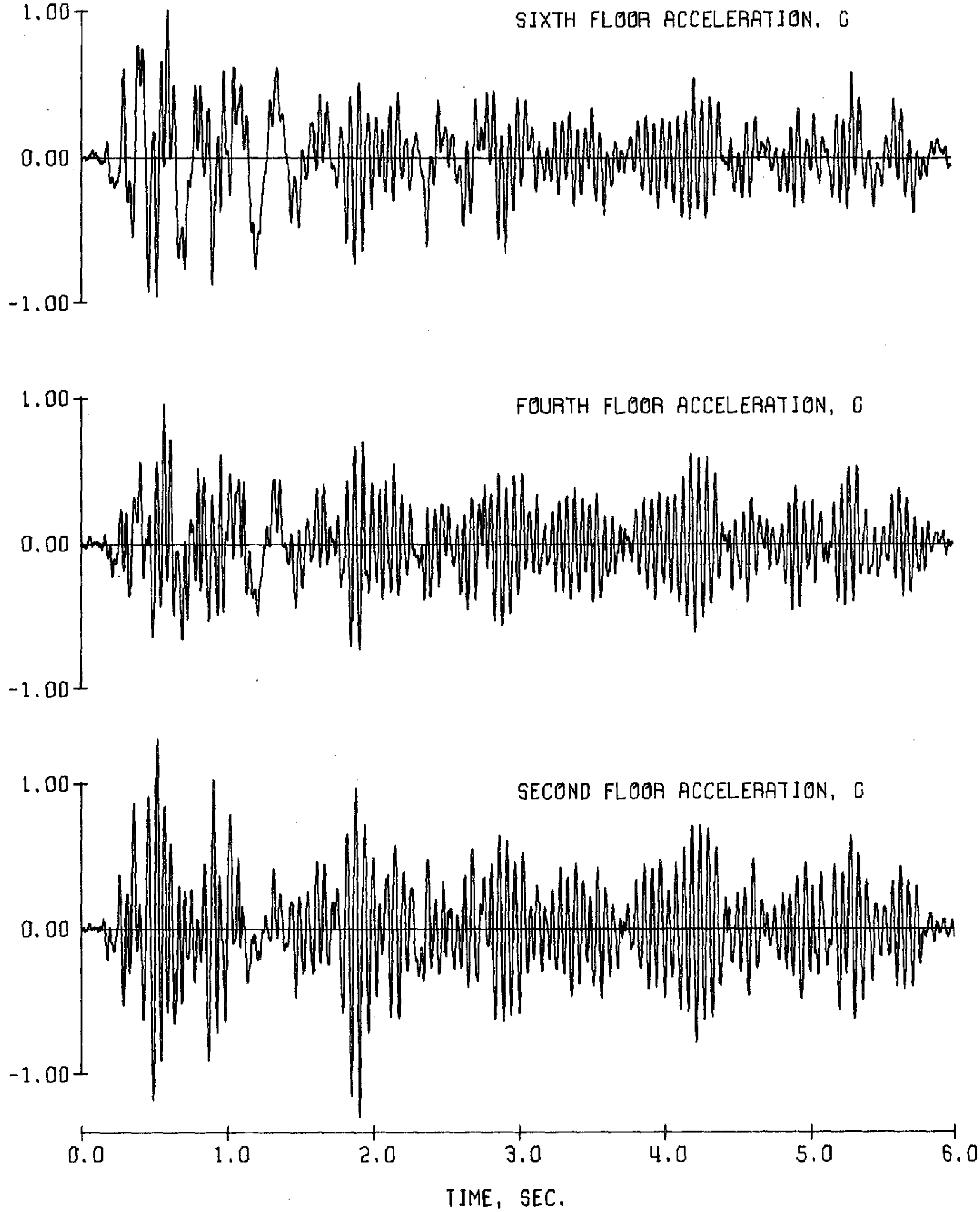
(b) Test Run D3-1. South Wall.

Figure 3.19 (contd.) Test Structure D3. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



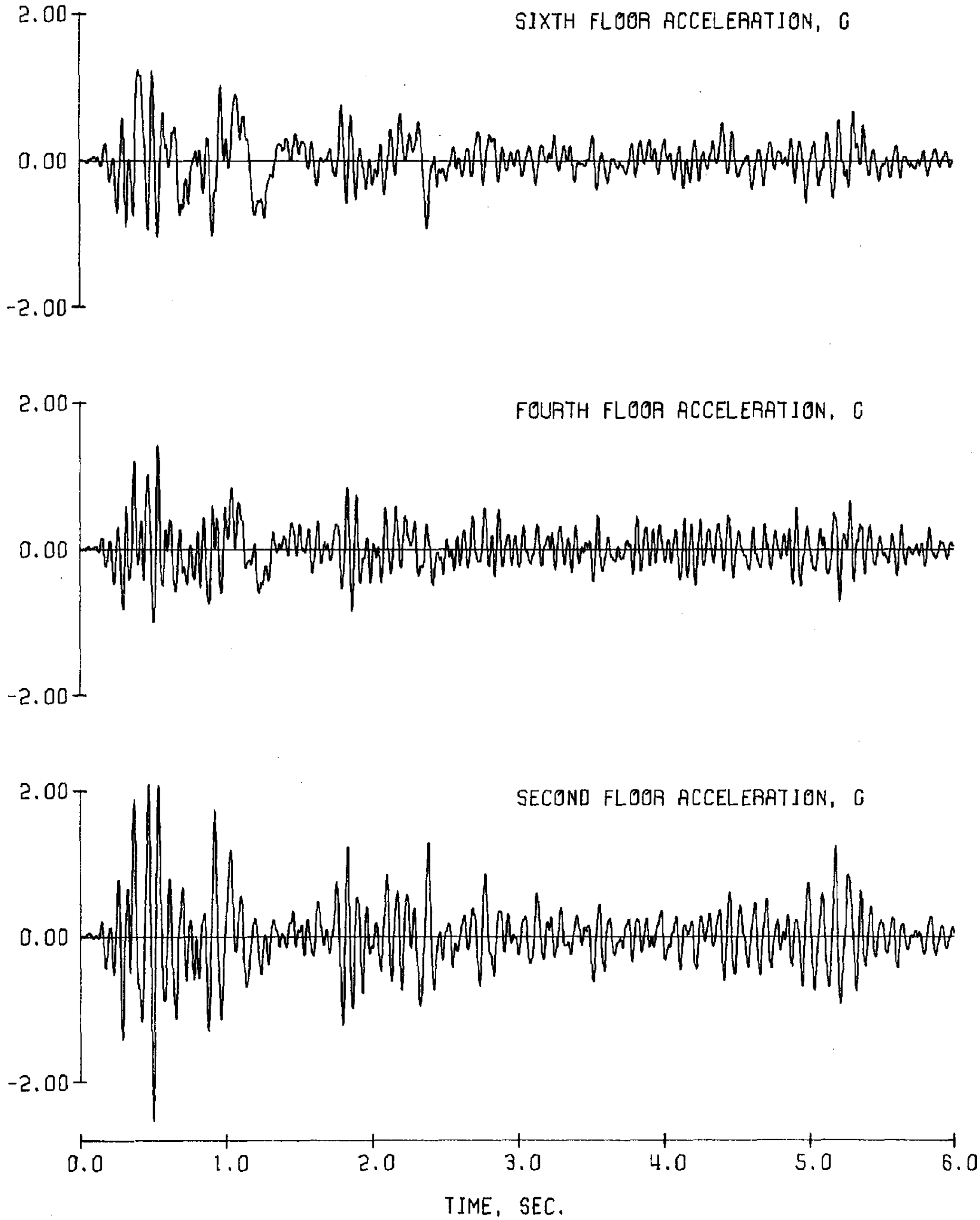
(c) Test Run D3-2. North Wall.

Figure 3.19 (contd.) Test Structure D3. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



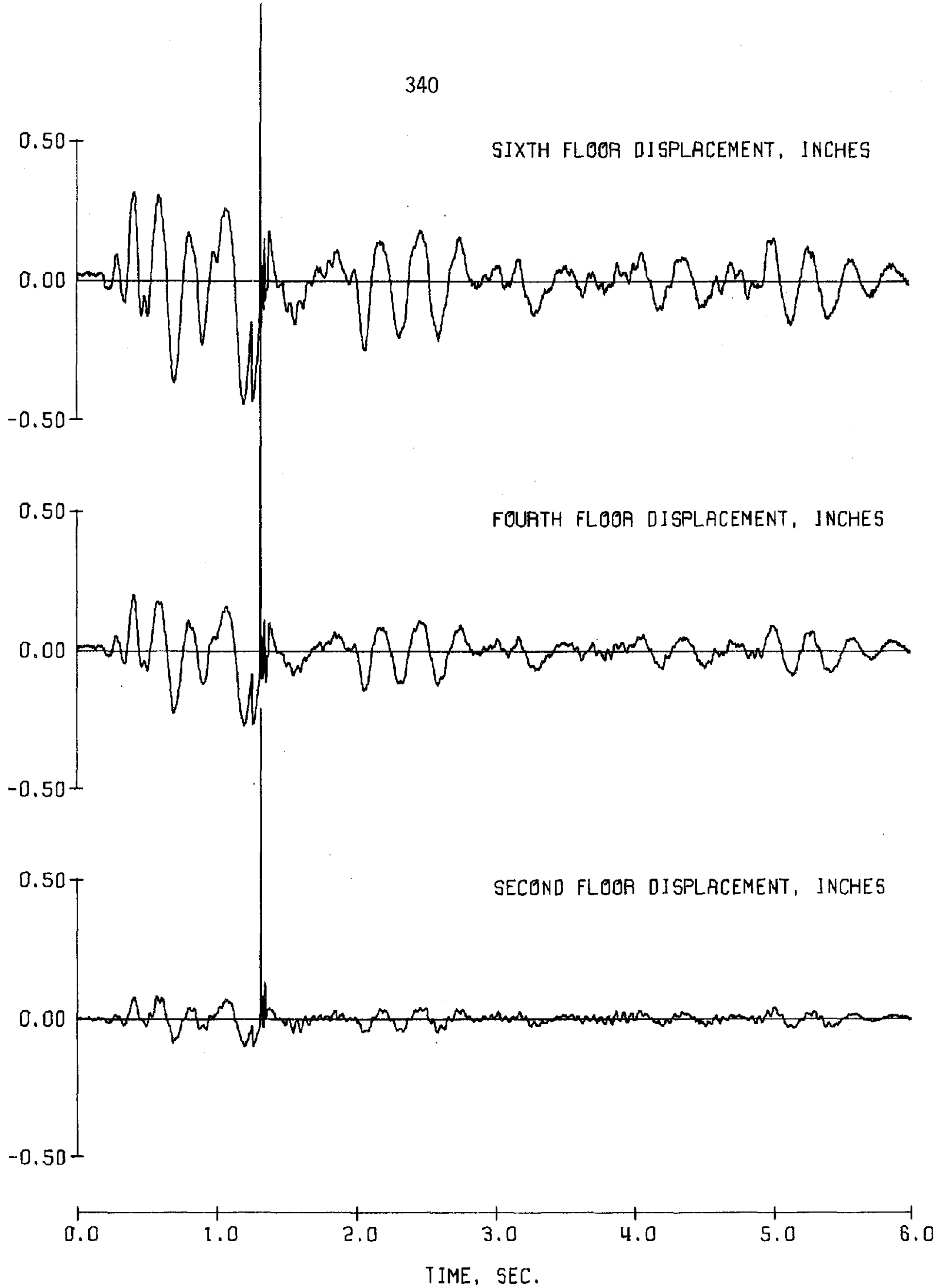
(a) Test Run D3-1. North Wall.

Figure 3.20 Test Structure D3. Observed Horizontal Accelerations



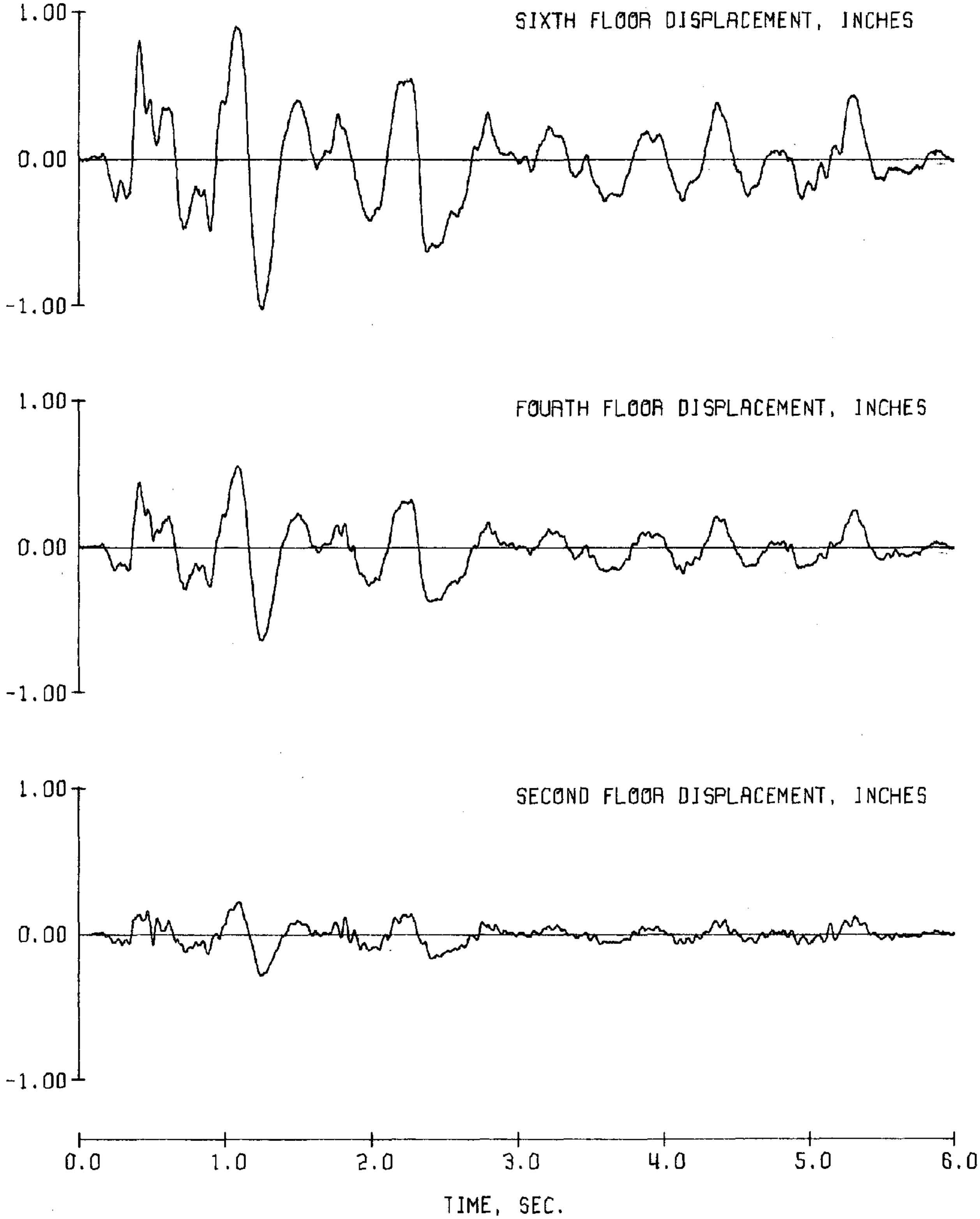
(b) Test Run D3-2. North Wall.

Figure 3.20 (contd.) Test Structure D3. Observed Horizontal Accelerations



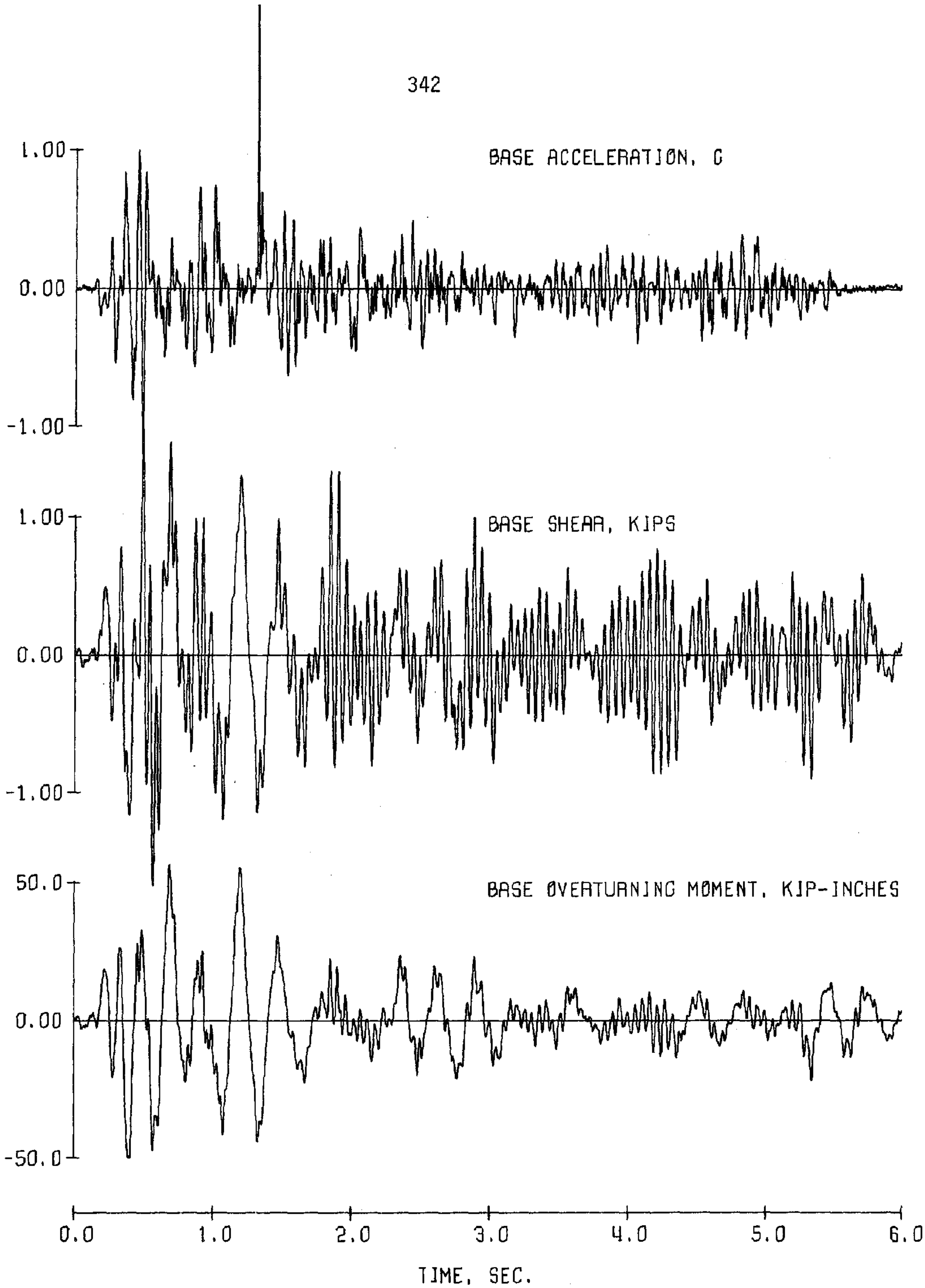
(a) Test Run D3-1. North Wall.

Figure 3.21 Test Structure D3. Observed Horizontal Displacements



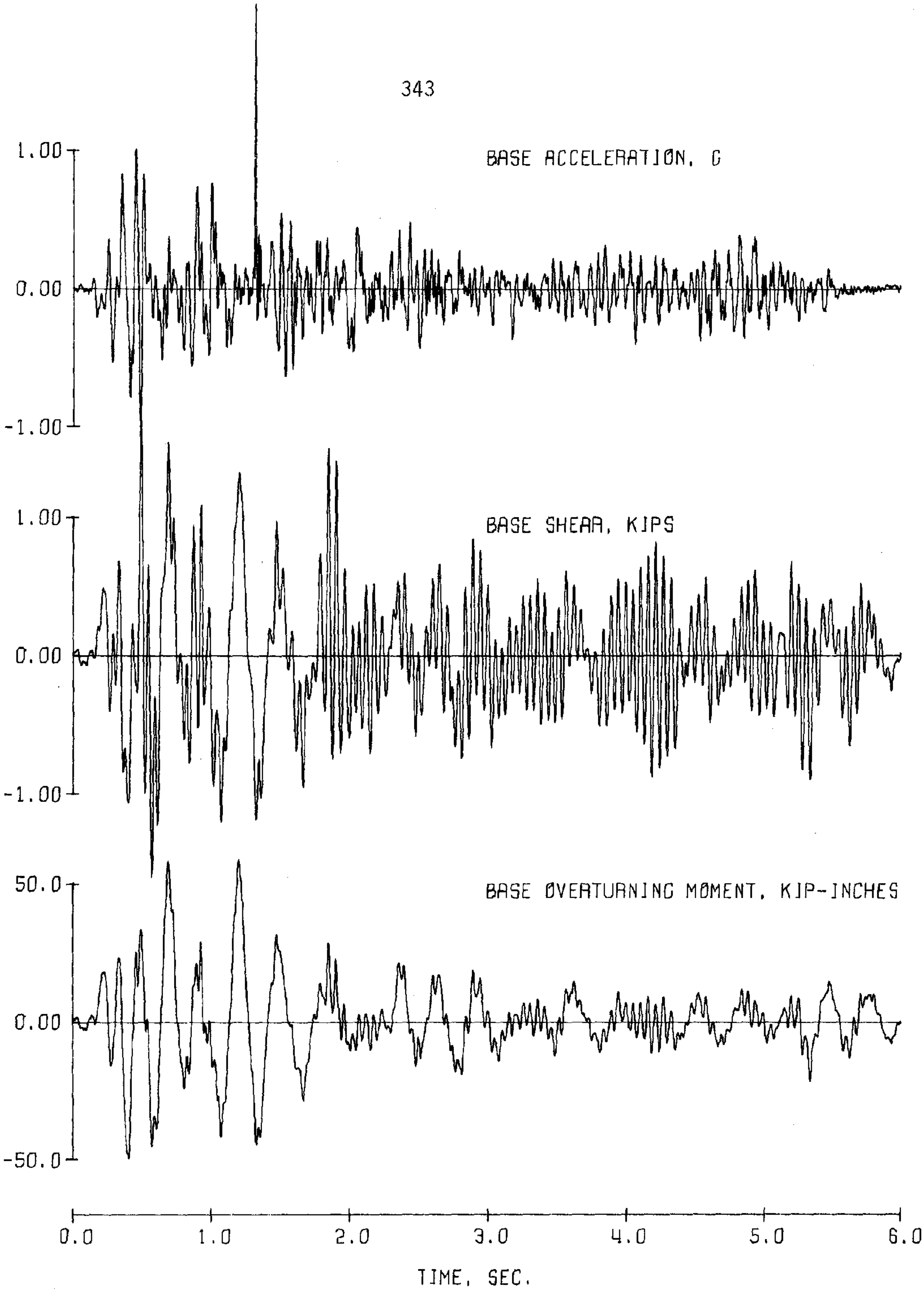
(b) Test Run D3-2. North Wall.

Figure 3.21 (contd.) Test Structure D3. Observed Horizontal Displacements



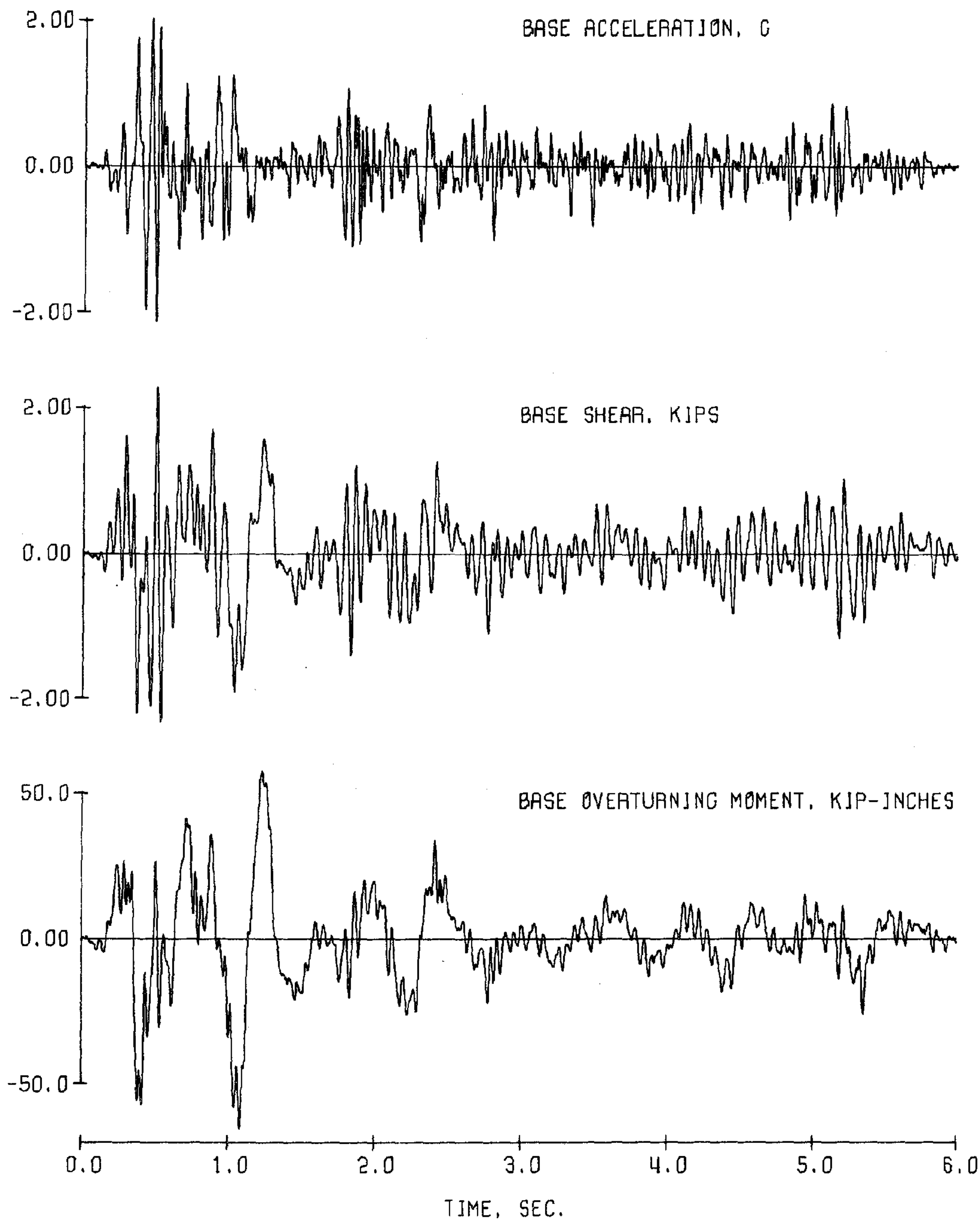
(a) Test Run D3-1. North Wall.

Figure 3.22 Test Structure D3. Observed Base Functions



(b) Test Run D3-1. South Wall.

Figure 3.22 (contd.) Test Structure D3. Observed Base Functions



(c) Test Run D3-2. North Wall.

Figure 3.22 (contd.) Test Structure D3. Observed Base Functions

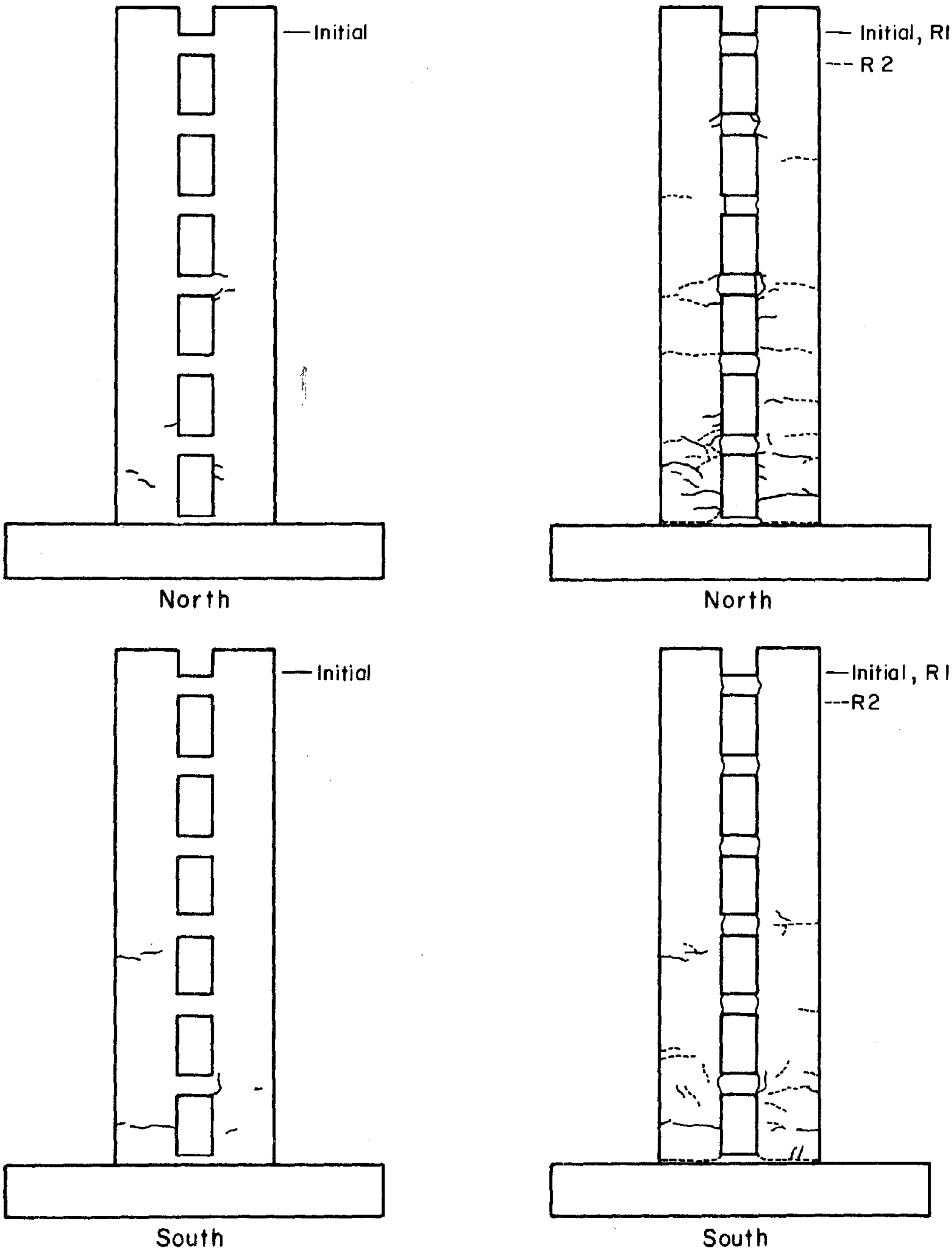


Figure 3.23 Test Structure D2. Observed Crack Patterns

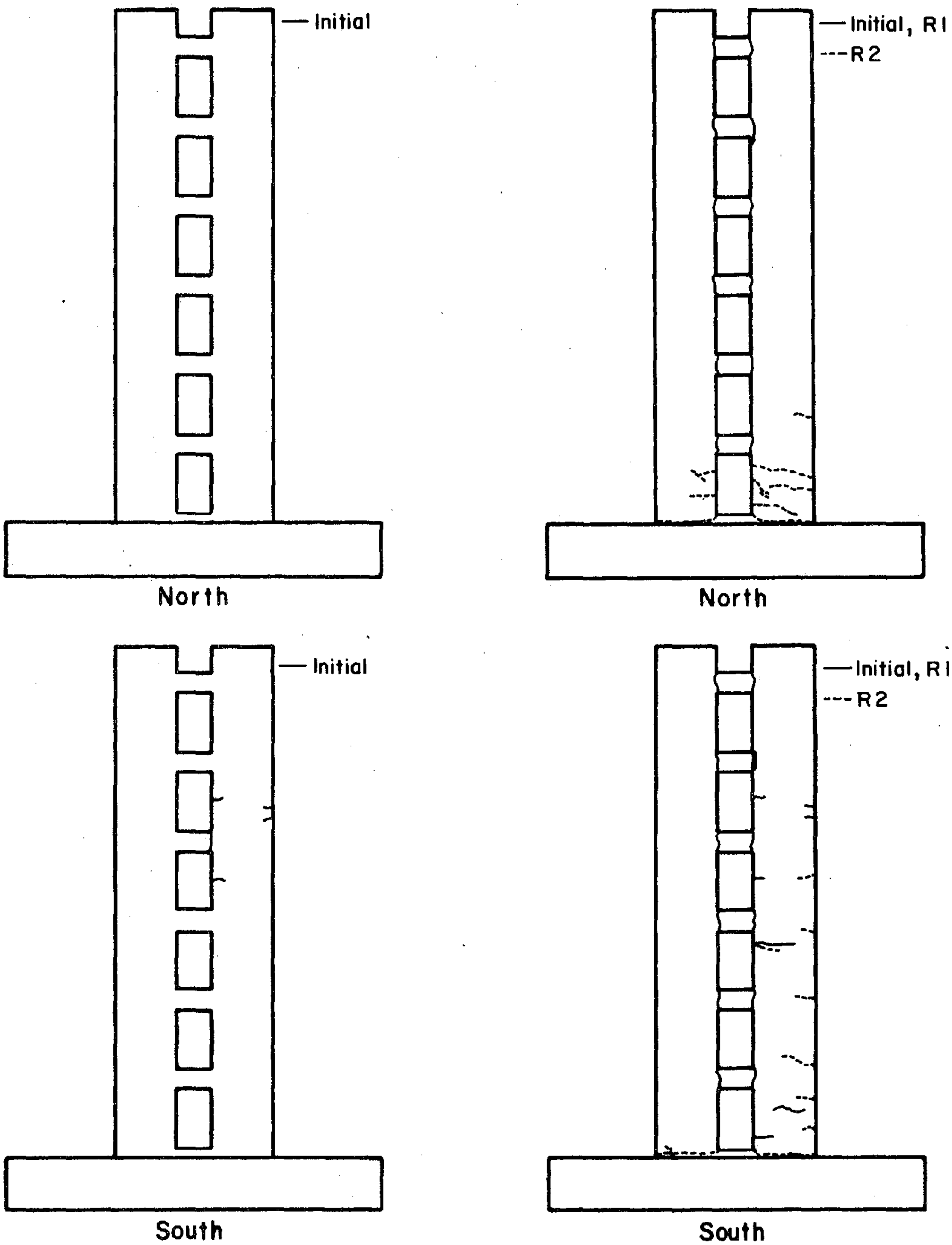


Figure 3.24 Test Structure D3. Observed Crack Patterns

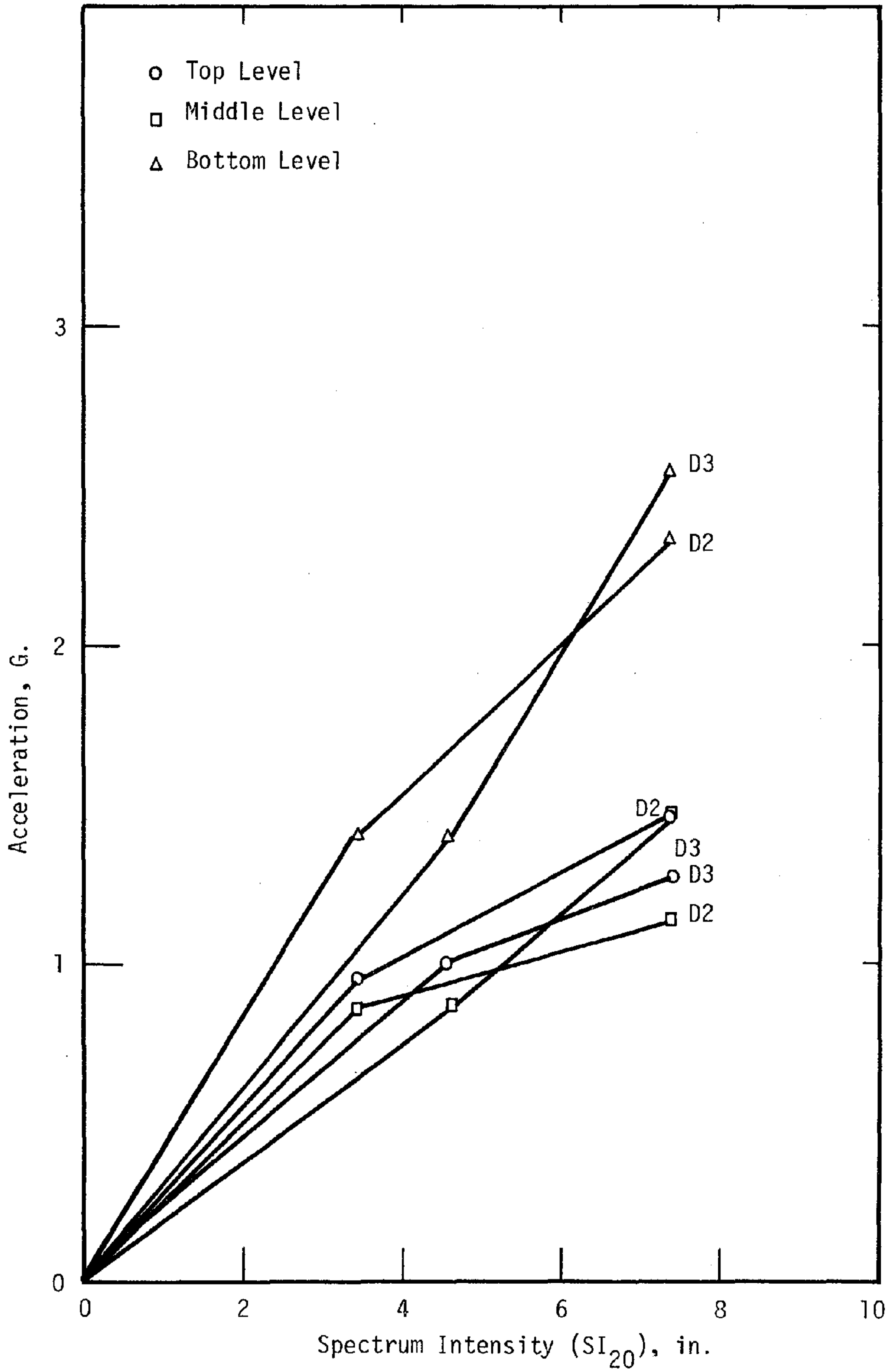


Figure 3.25 Type B Test Structures. Variation of Spectrum Intensity with Horizontal Acceleration

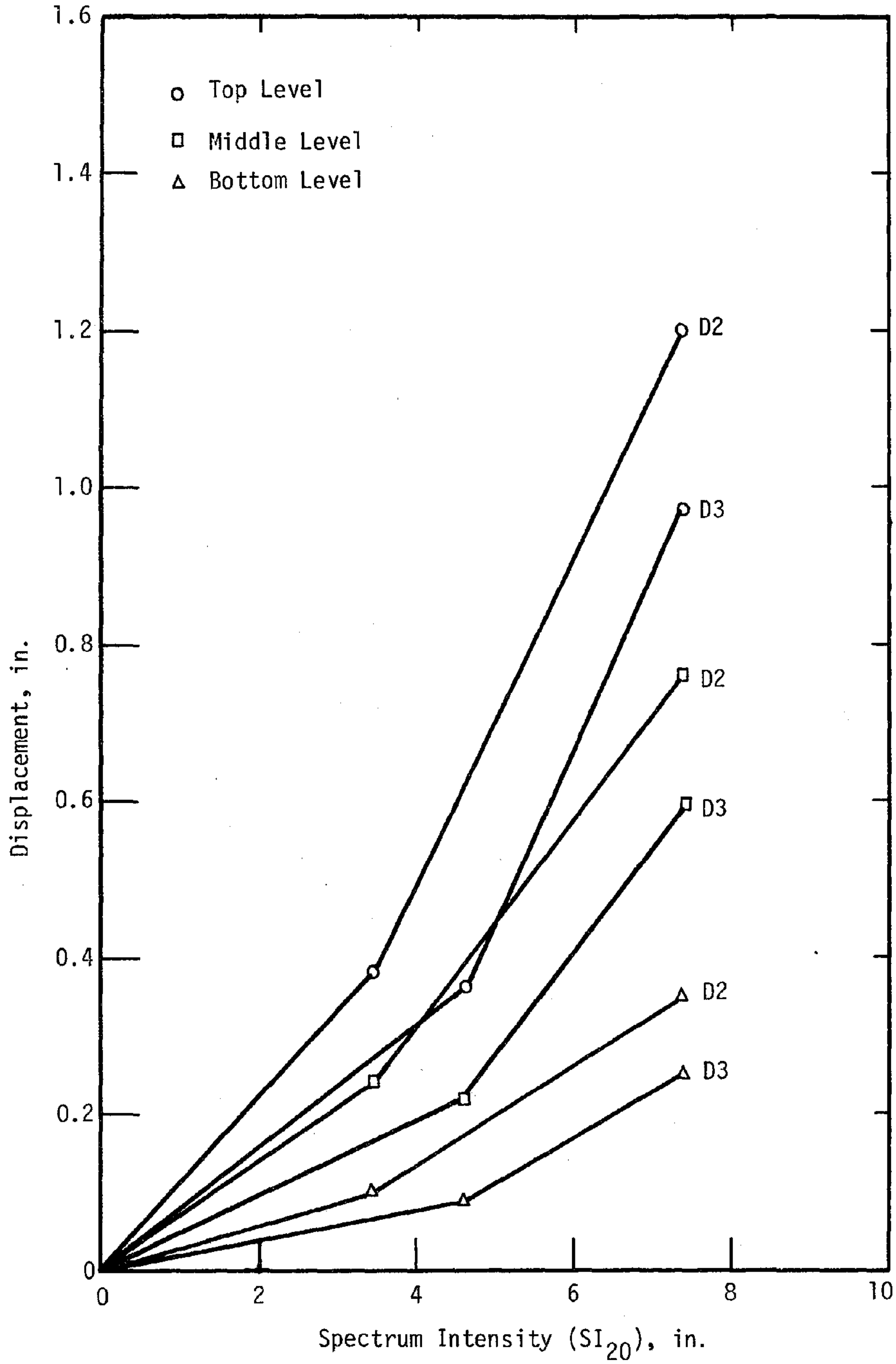


Figure 3.26 Type B Test Structures. Variation of Spectrum Intensity with One-Half of Average Horizontal Double Amplitude Displacement

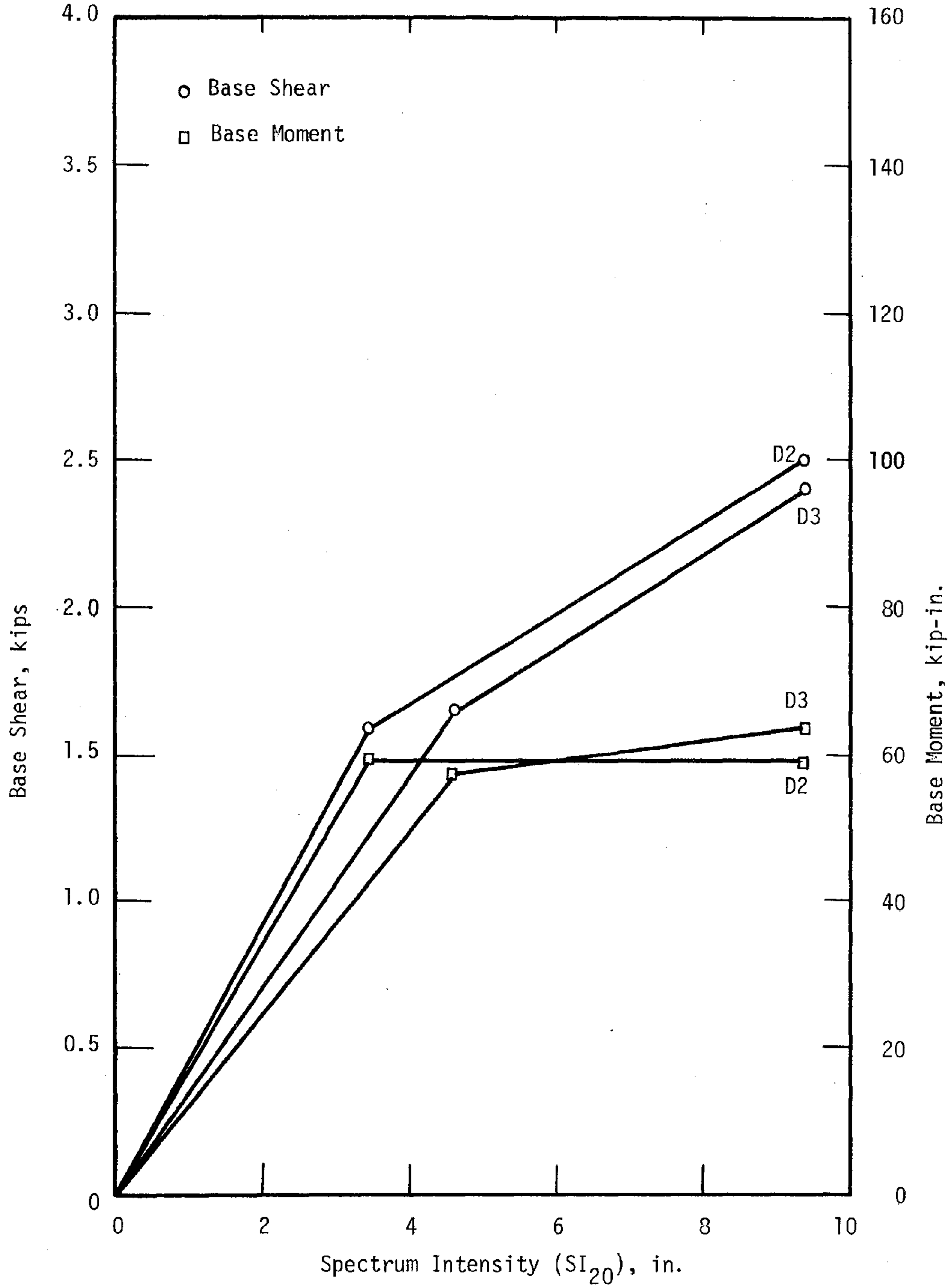


Figure 3.27 Type B Test Structures. Variation of Spectrum Intensity with Average Base Shear and Average Base Moment

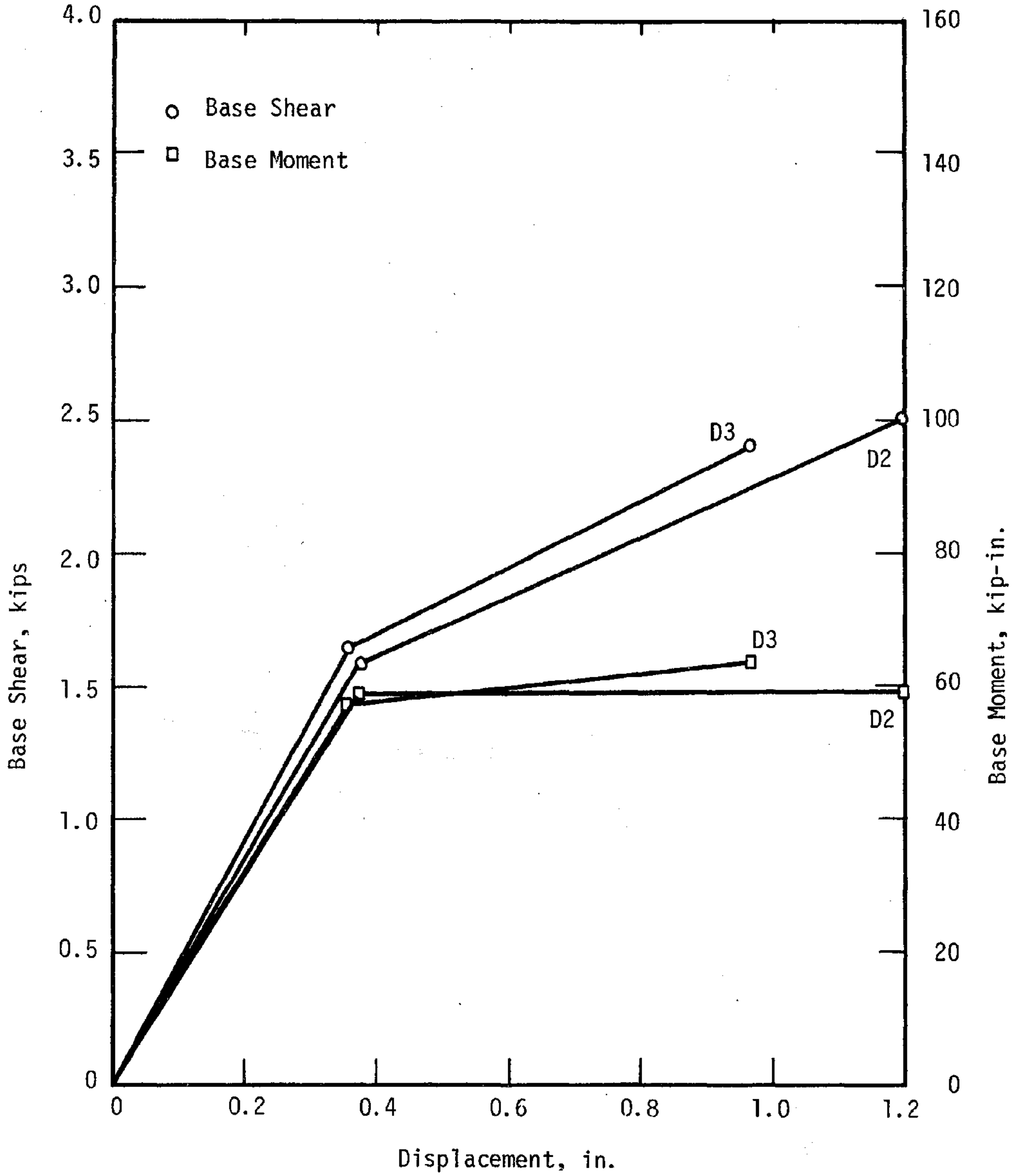
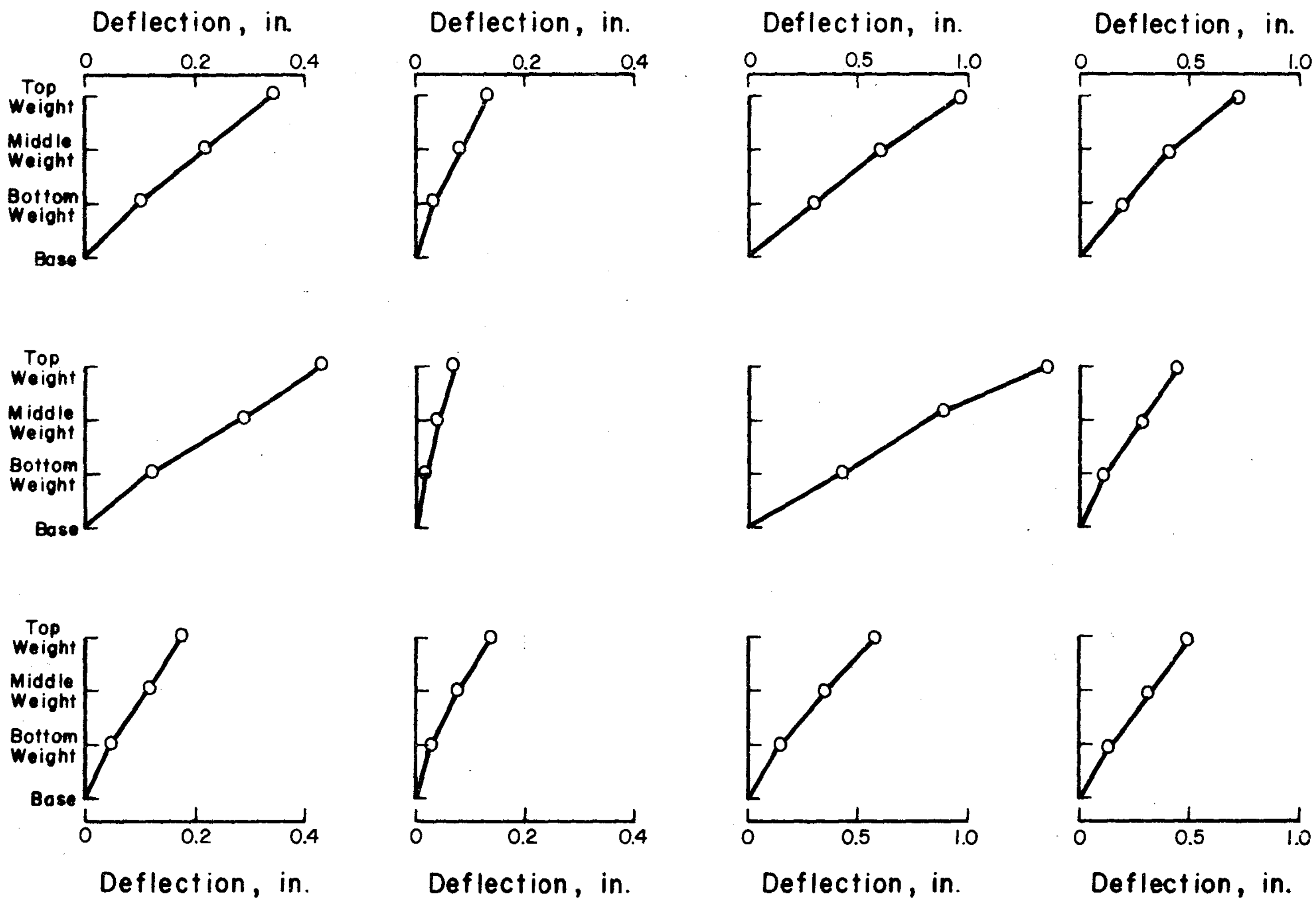


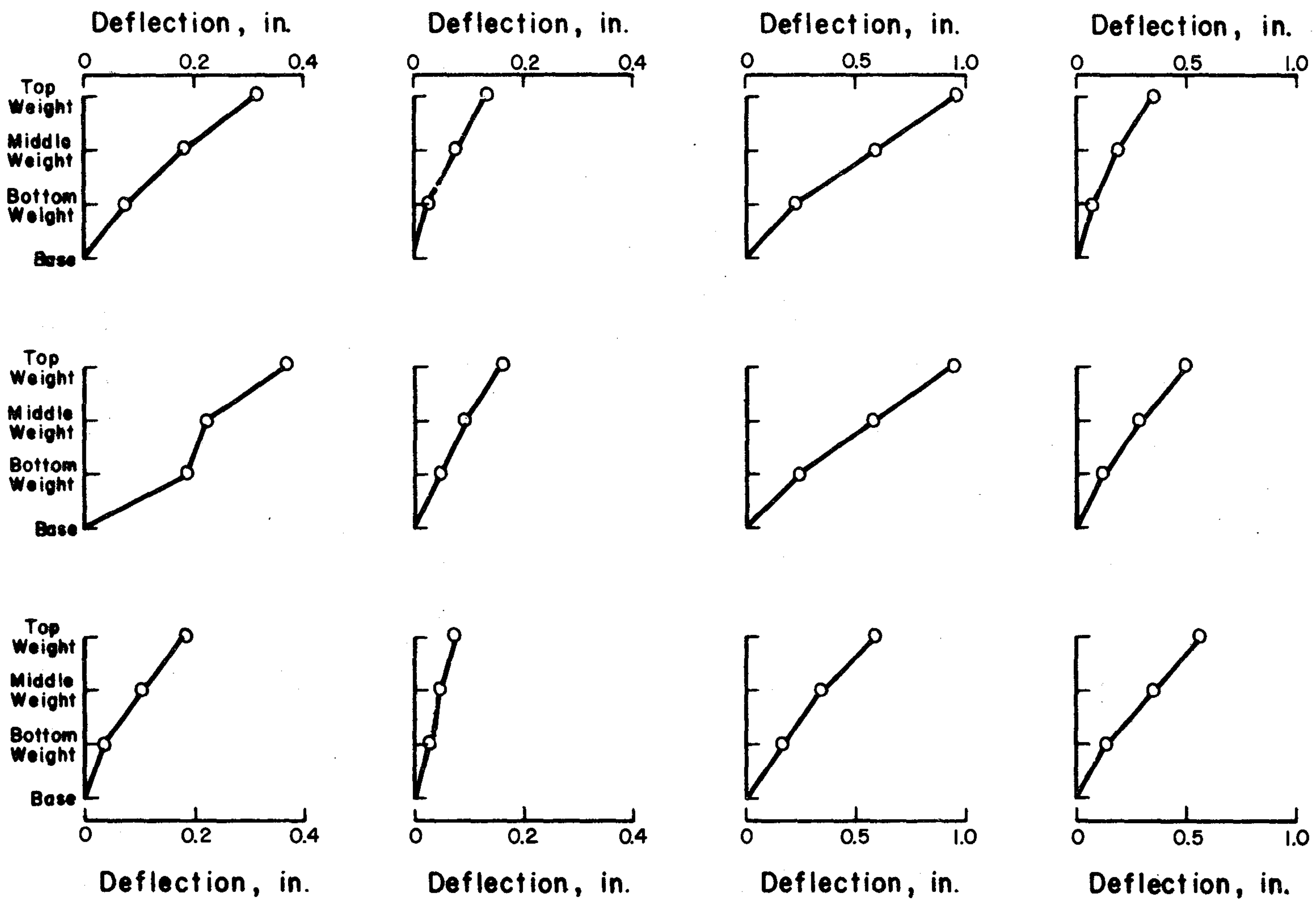
Fig. 3.28 Type B Test Structures. Variation of Average Base Shear and Base Moment with One-Half of Average Double Amplitude Top-Level Displacement



(a) Test Run D2-1

(b) Test Run D2-2

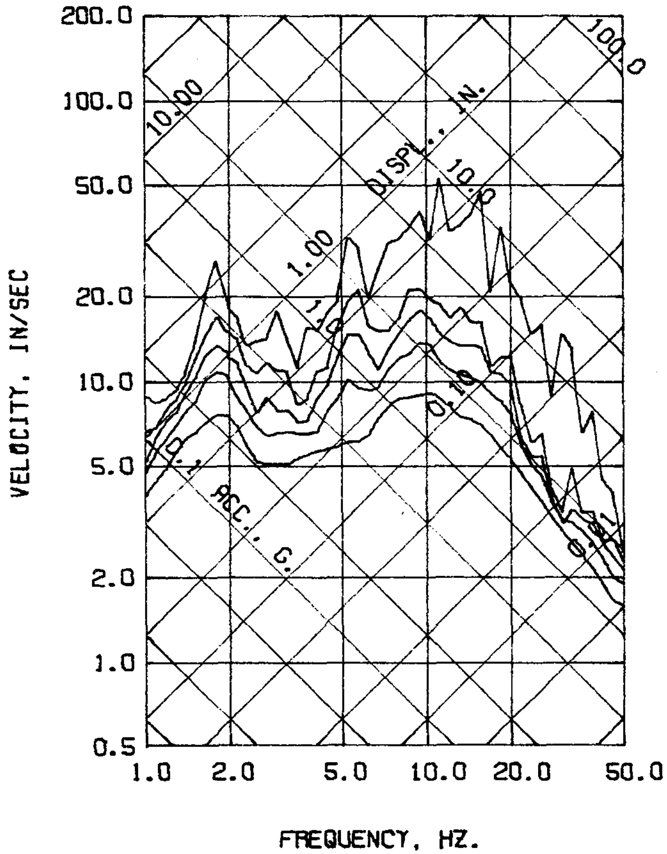
Figure 3.29 Type B Test Structures. Variation of Observed Deflection with Height at Several Times. Structure D2. South Wall



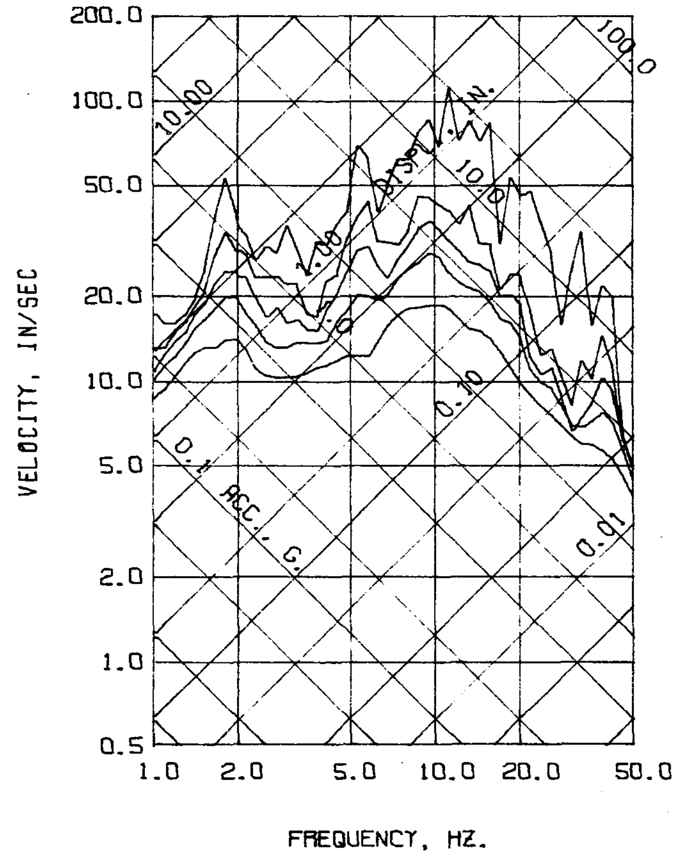
(a) Test Run D3-1

(b) Test Run D3-2

Figure 3.30 Type B Test Structures. Variation of Observed Deflection with Height at Several Times. Structure D3. South Wall

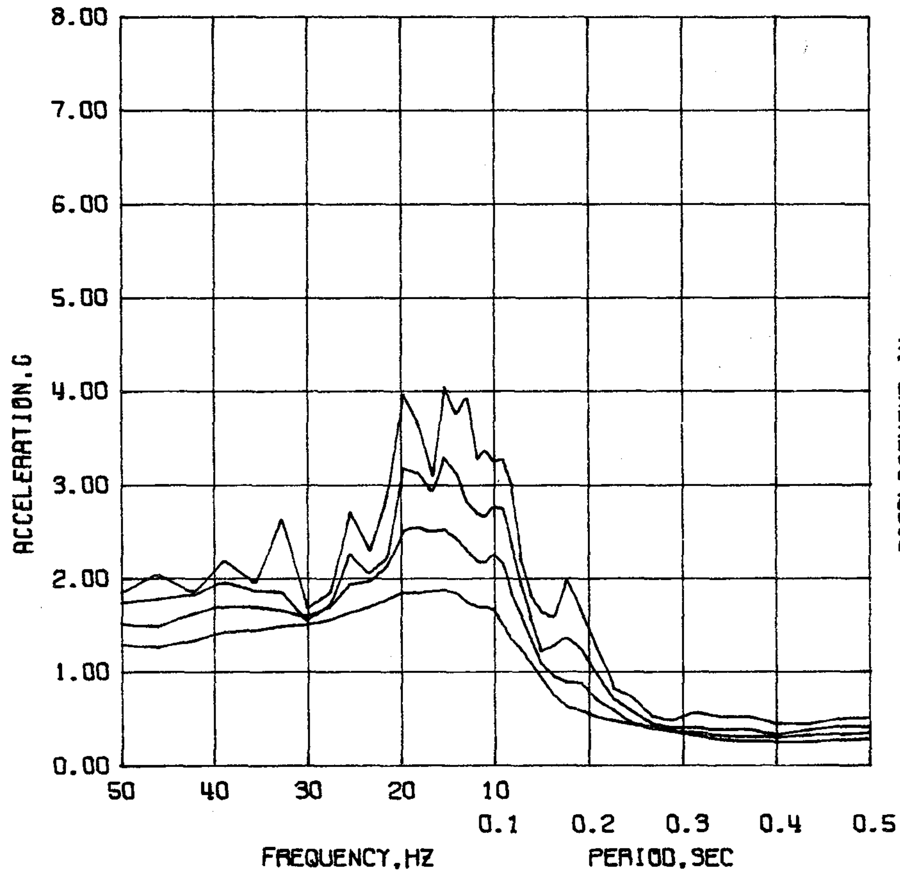


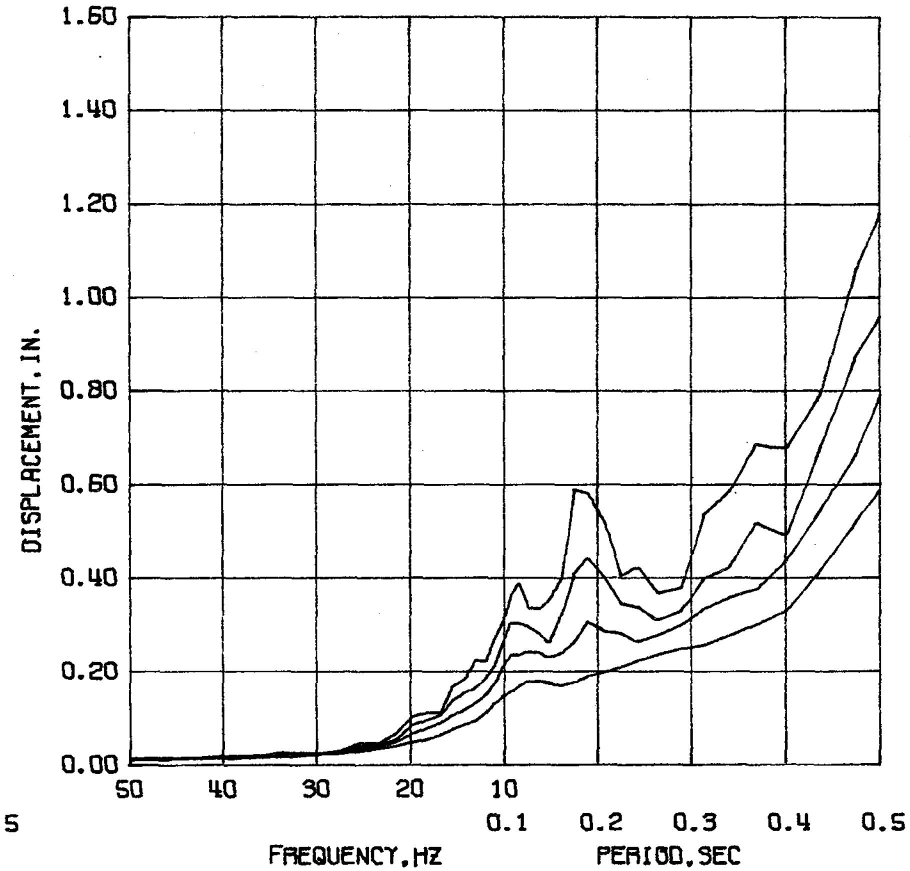
(a) Test Run D4-1



(b) Test Run D4-2

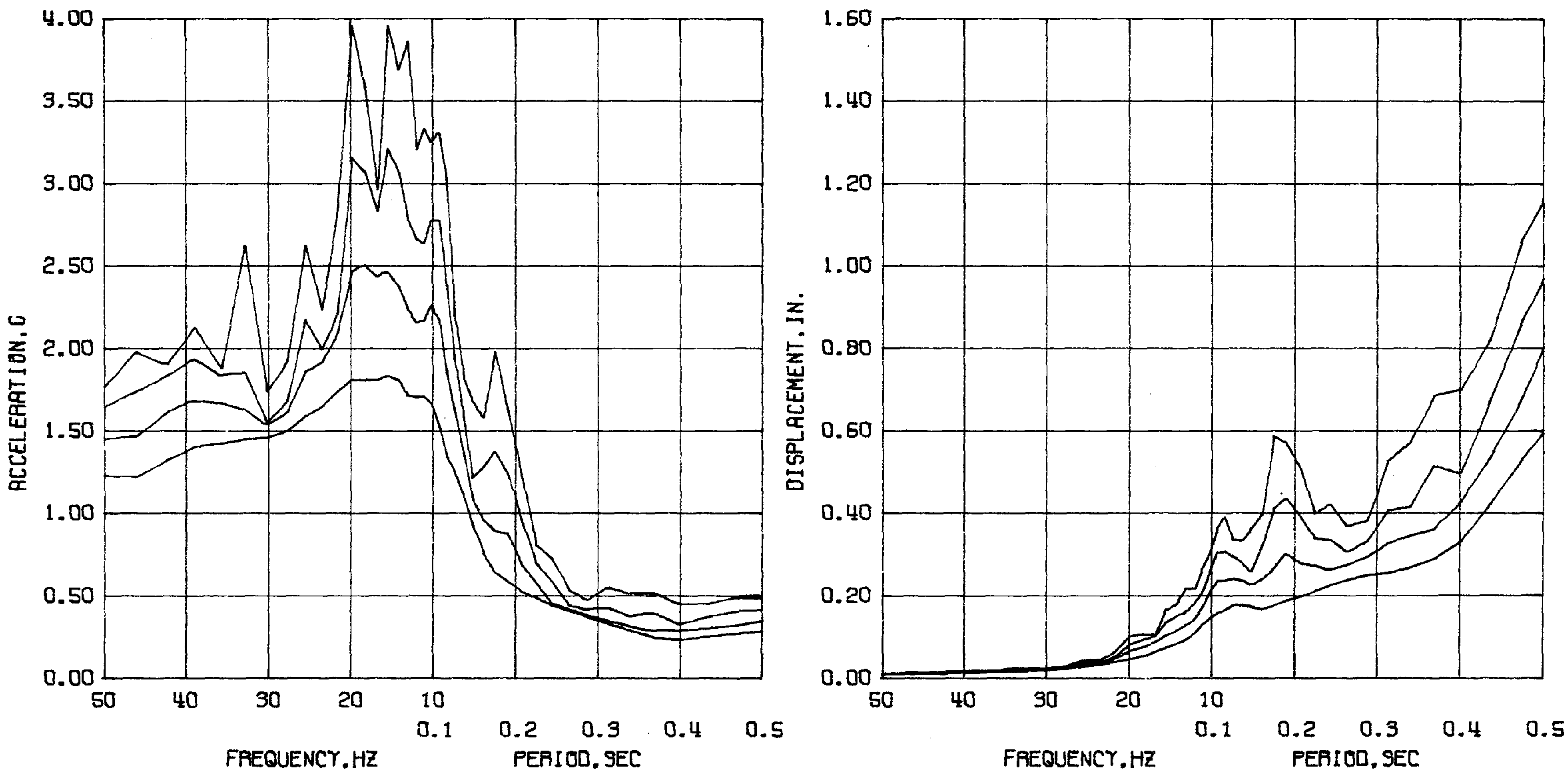
Figure 3.31 Test Structure D4. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)





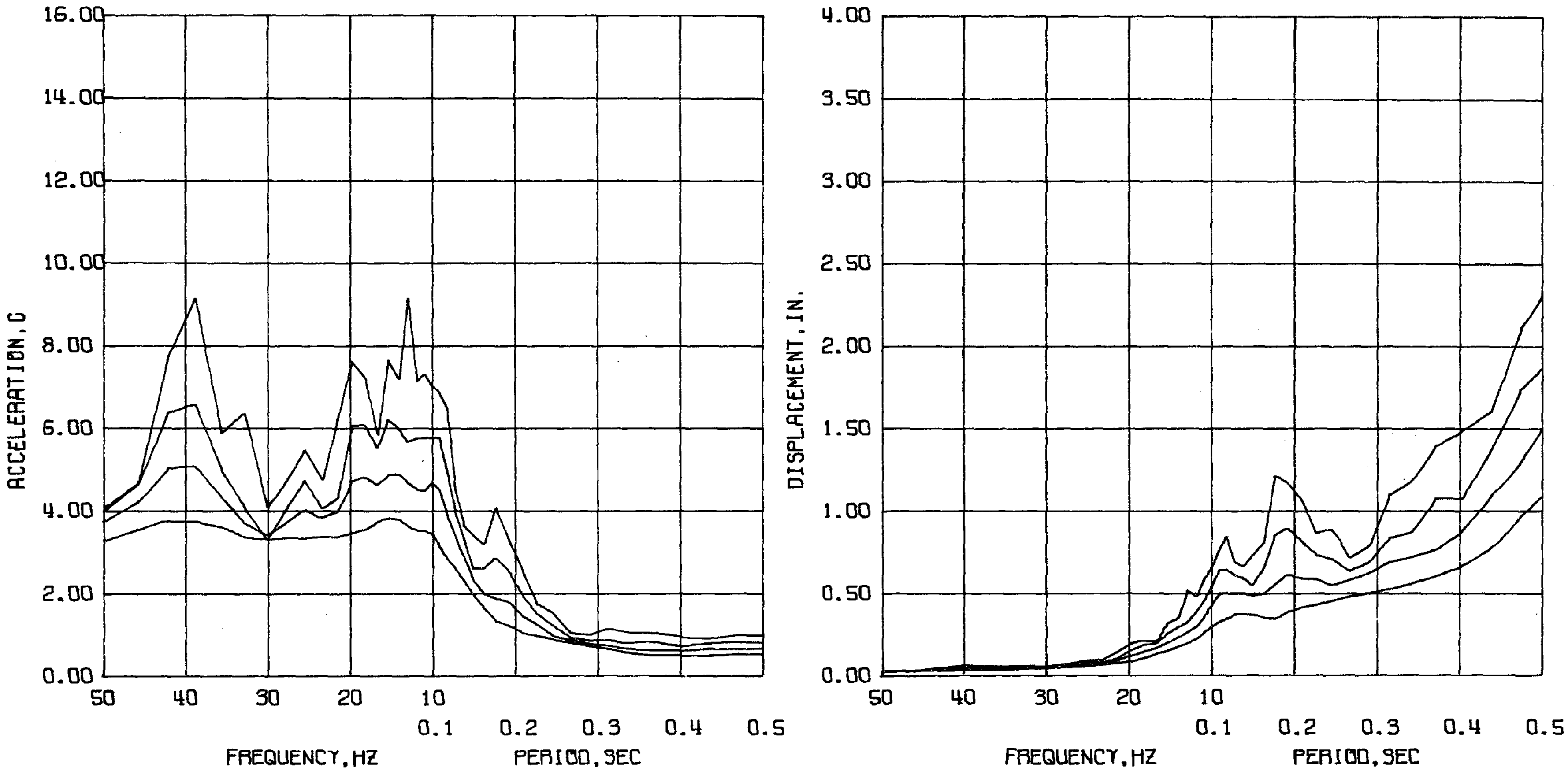
(a) Test Run D4-1. North Wall.

Figure 3.32 Test Structure D4. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



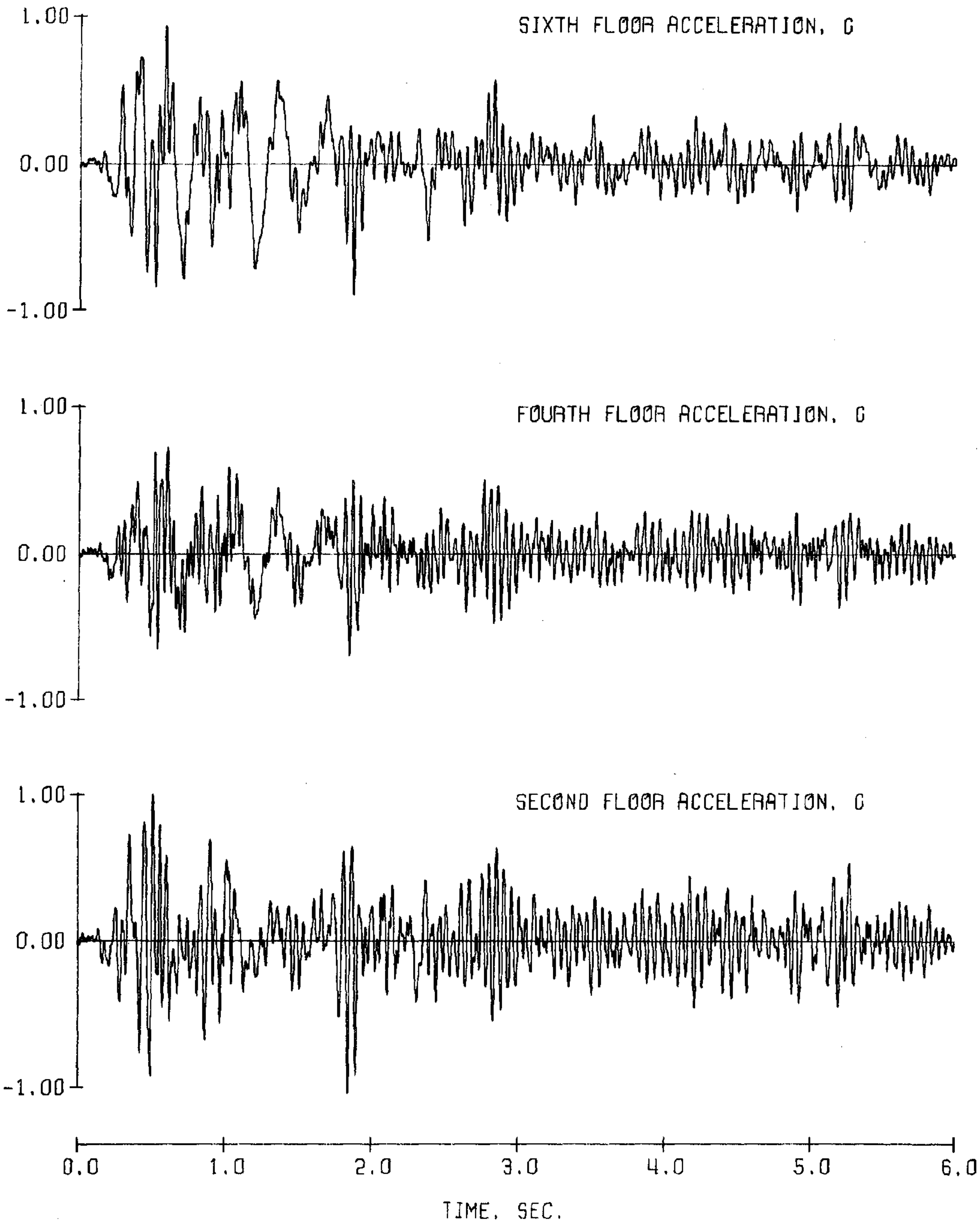
(b) Test Run D4-1. South Wall.

Figure 3.32 (contd.) Test Structure D4. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



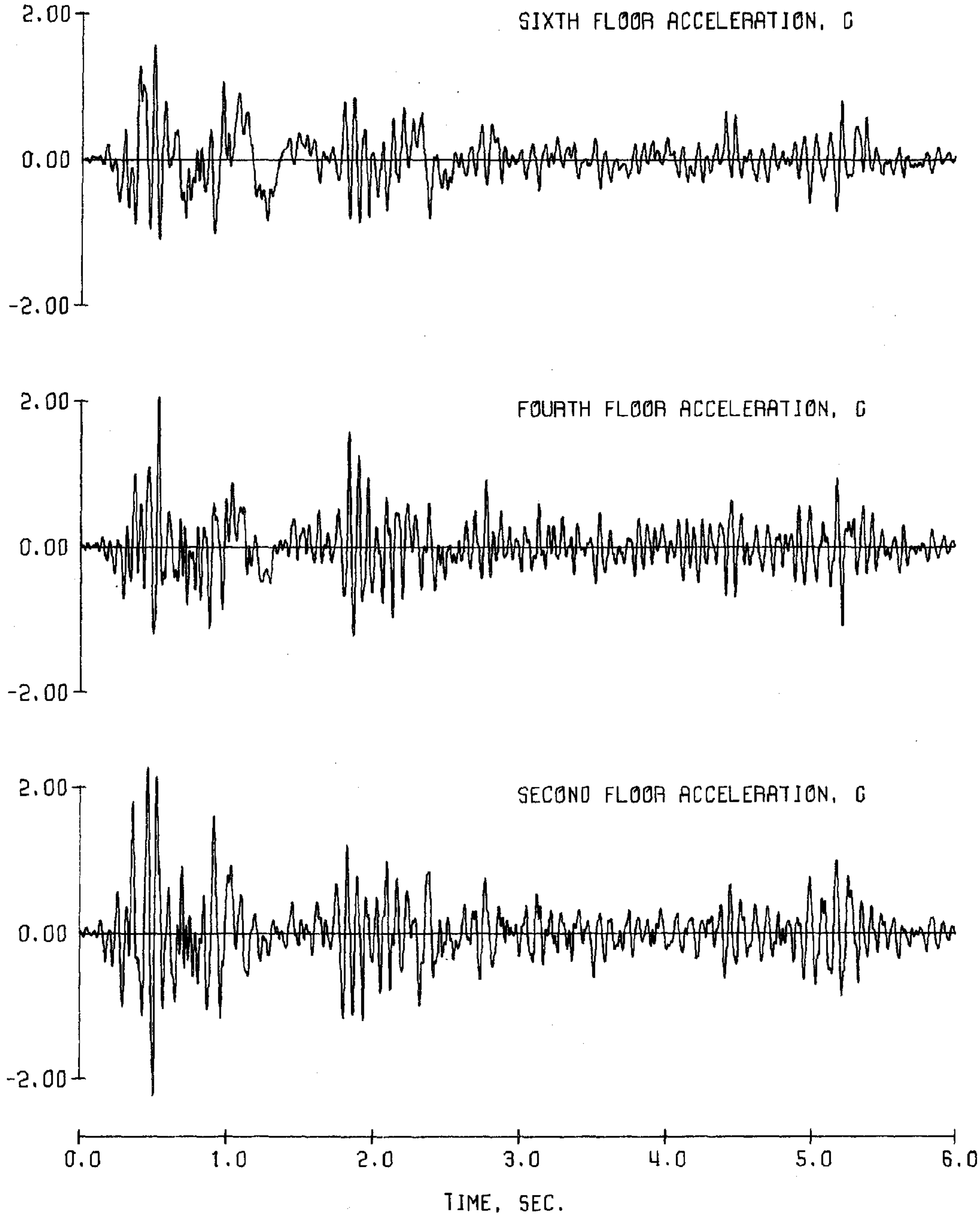
(c) Test Run D4-2. North Wall.

Figure 3.32 (contd.) Test Structure D4. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



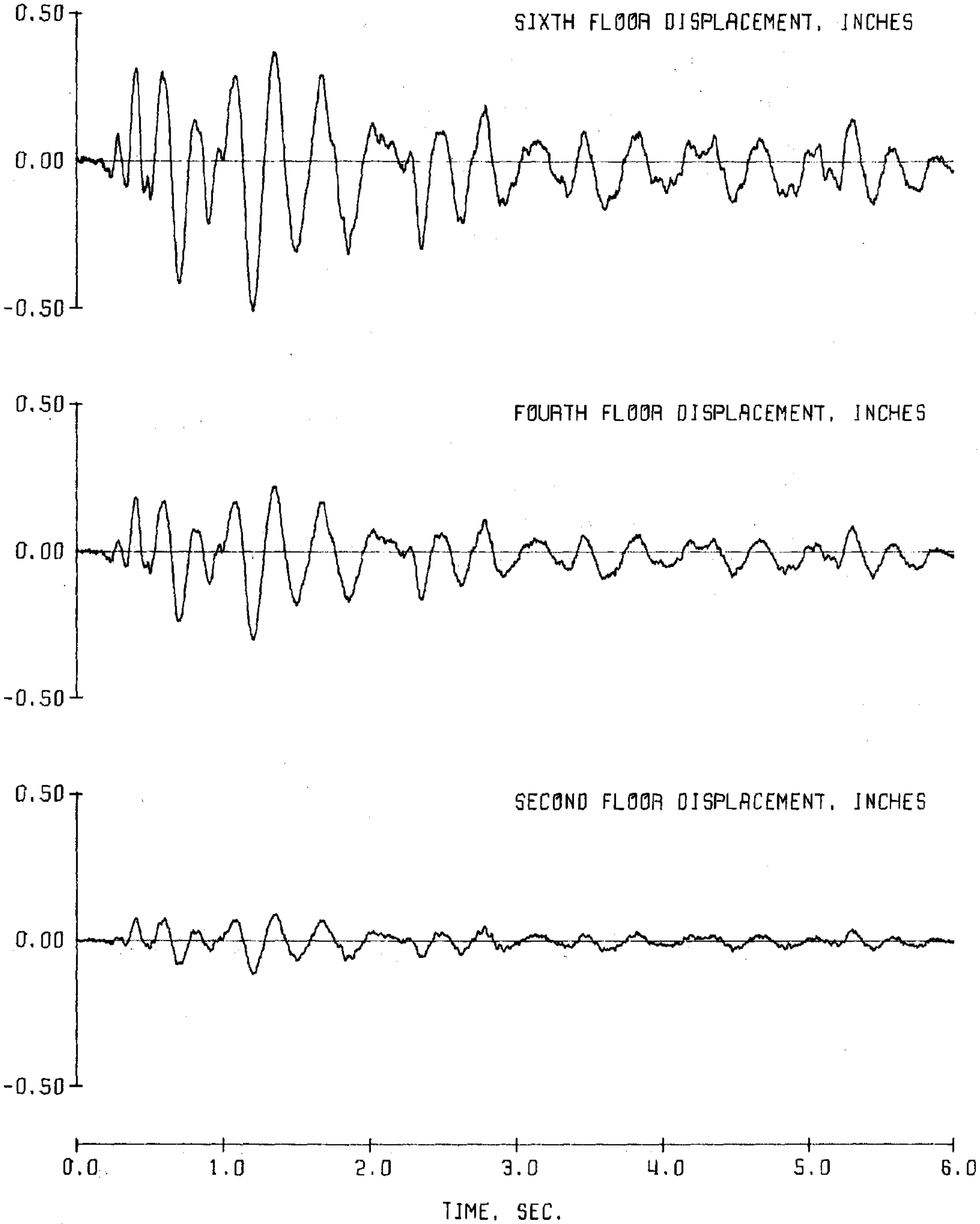
(a) Test Run D4-1. North Wall.

Figure 3.33 Test Structure D4. Observed Horizontal Accelerations



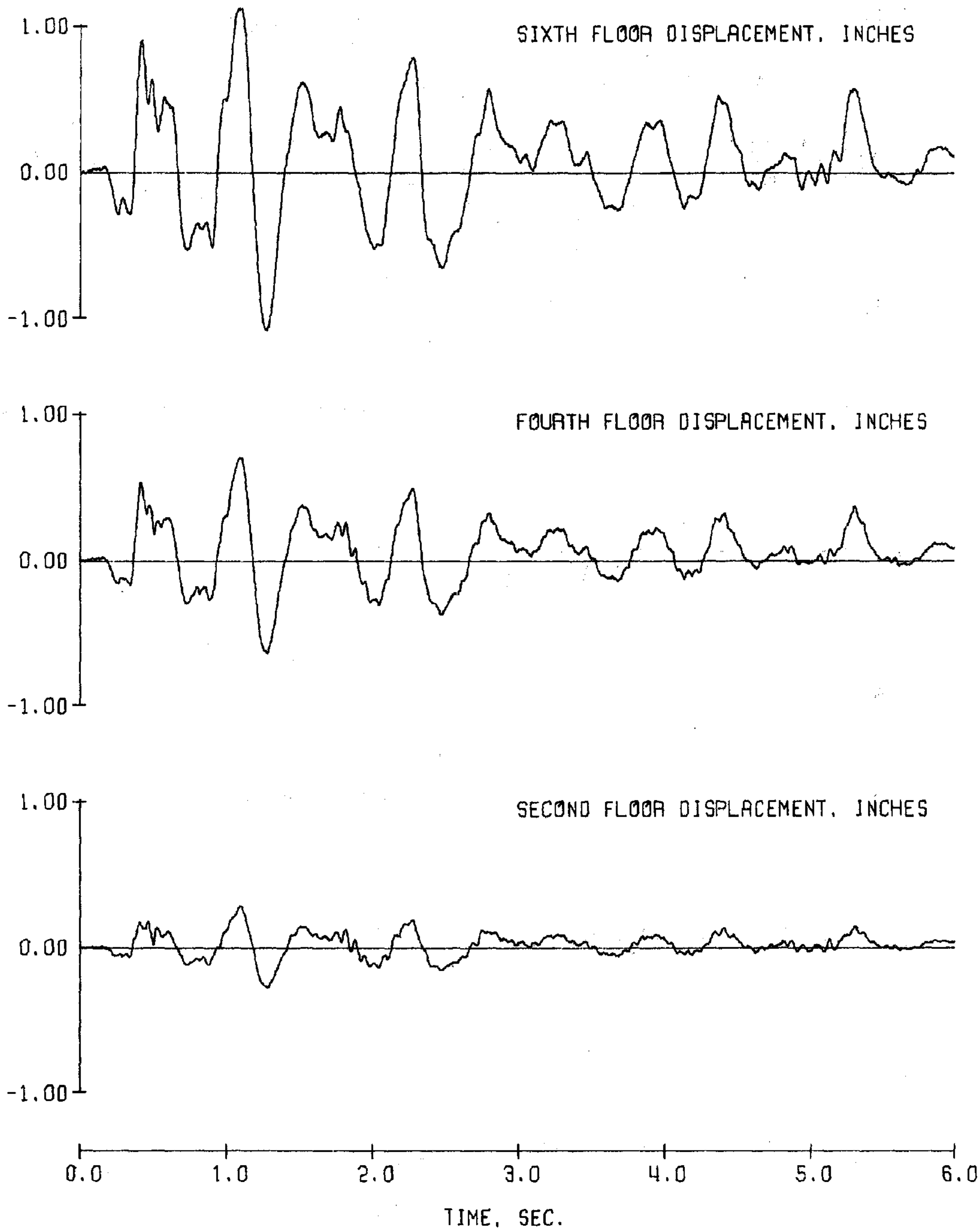
(b) Test Run D4-2. North Wall.

Figure 3.33 (contd.) Test Structure D4. Observed Horizontal Accelerations



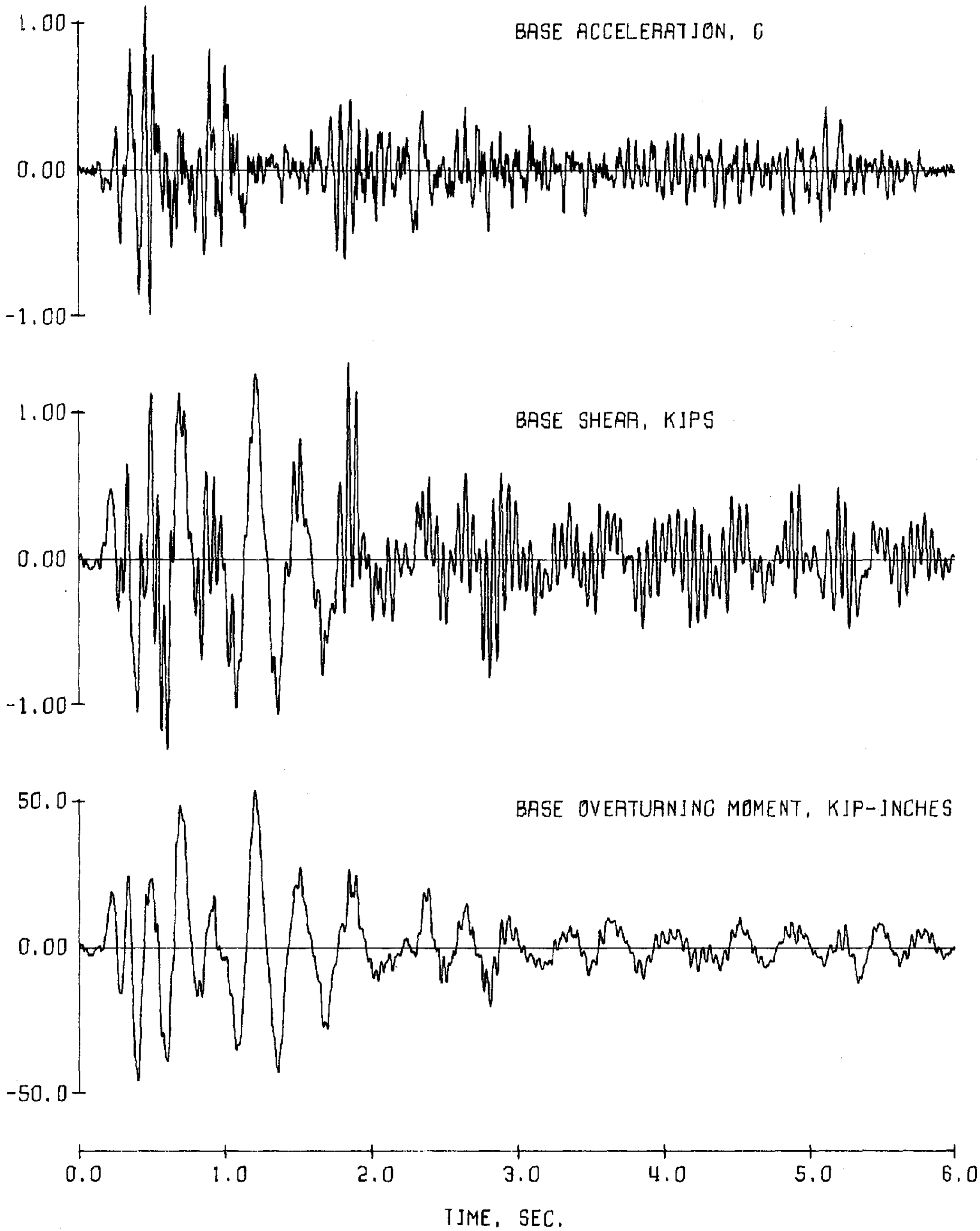
(a) Test Run D4-1. North Wall

Figure 3.34 Test Structure D4. Observed Horizontal Displacements



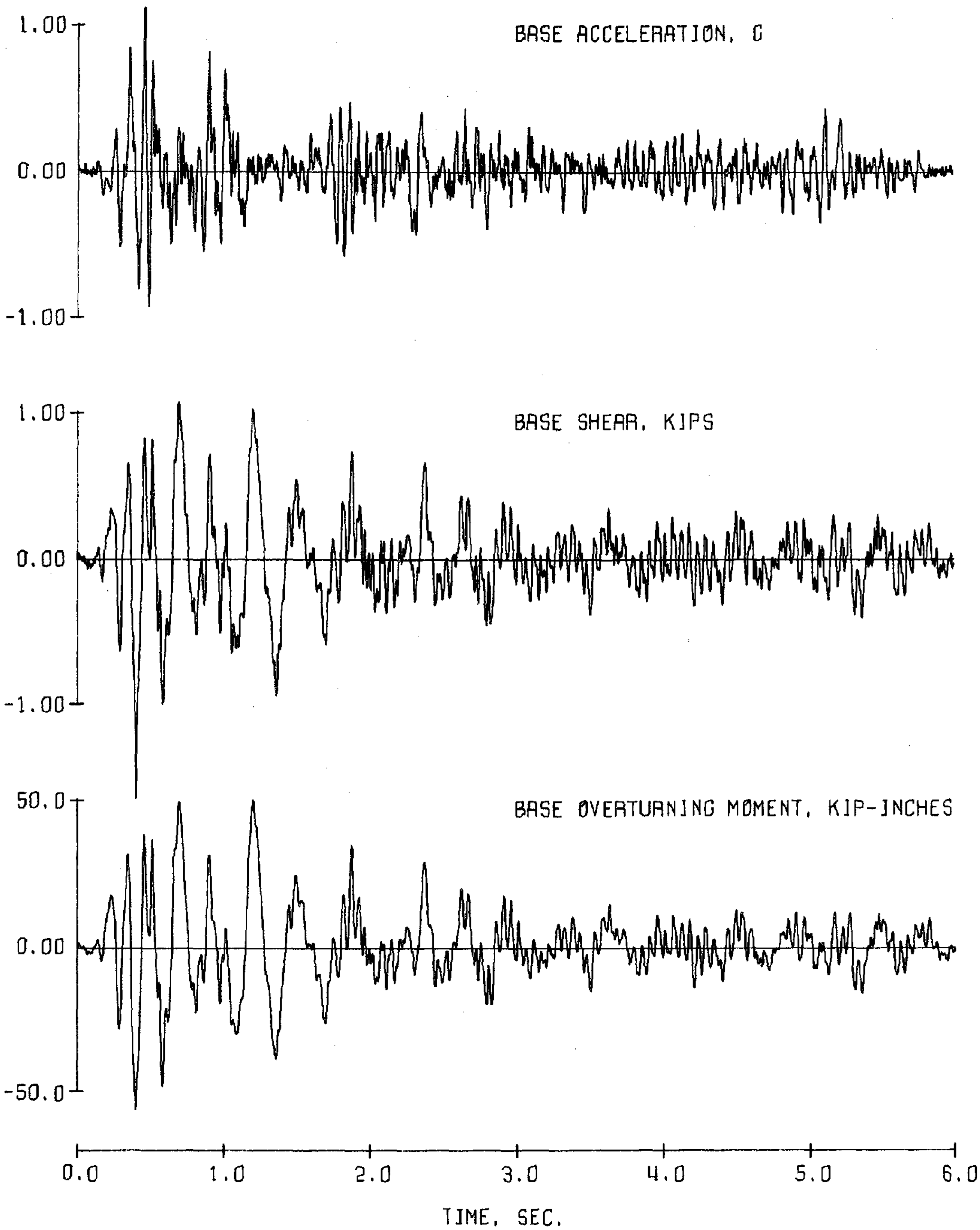
(b) Test Run D4-2. North Wall.

Figure 3.34 (contd.) Test Structure D4. Observed Horizontal Displacements



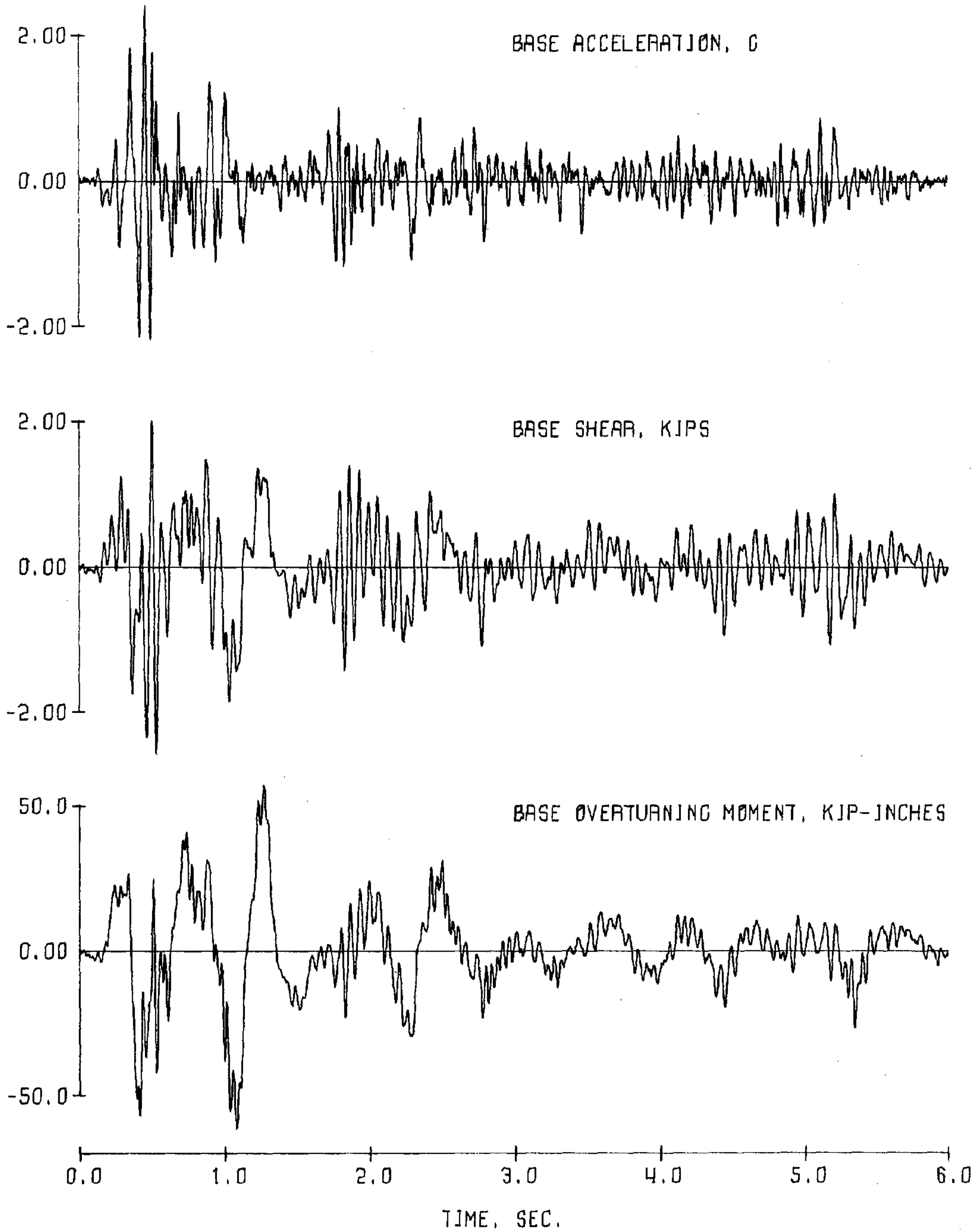
(a) Test D4-1. North Wall.

Figure 3.35 Test Structure D4. Observed Base Functions



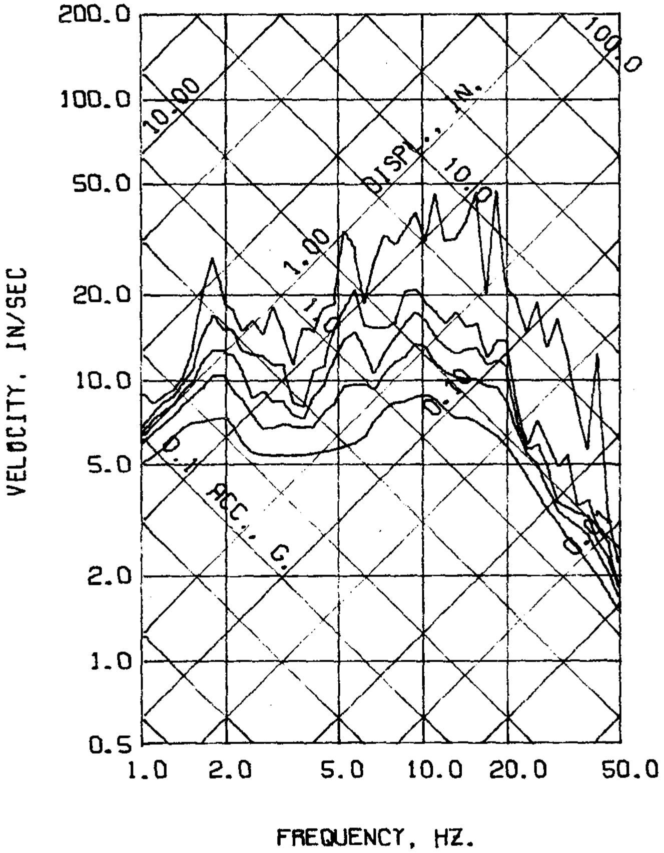
(b) Test Run D4-1. South Wall

Figure 3.35 (contd.) Test Structure D4. Observed Base Functions

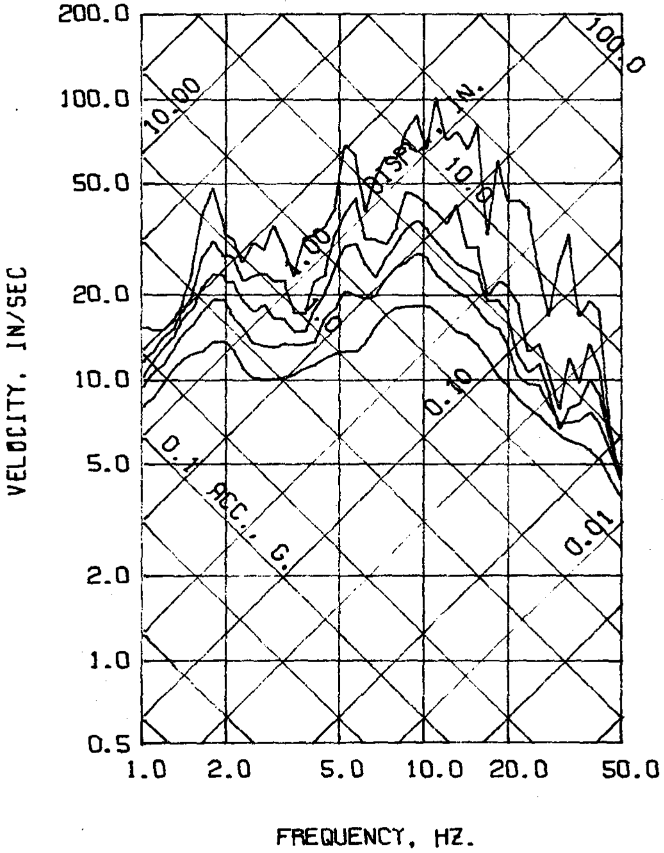


(c) Test Run D4-2. North Wall.

Figure 3.35 (contd.) Test Structure D4. Observed Base Functions

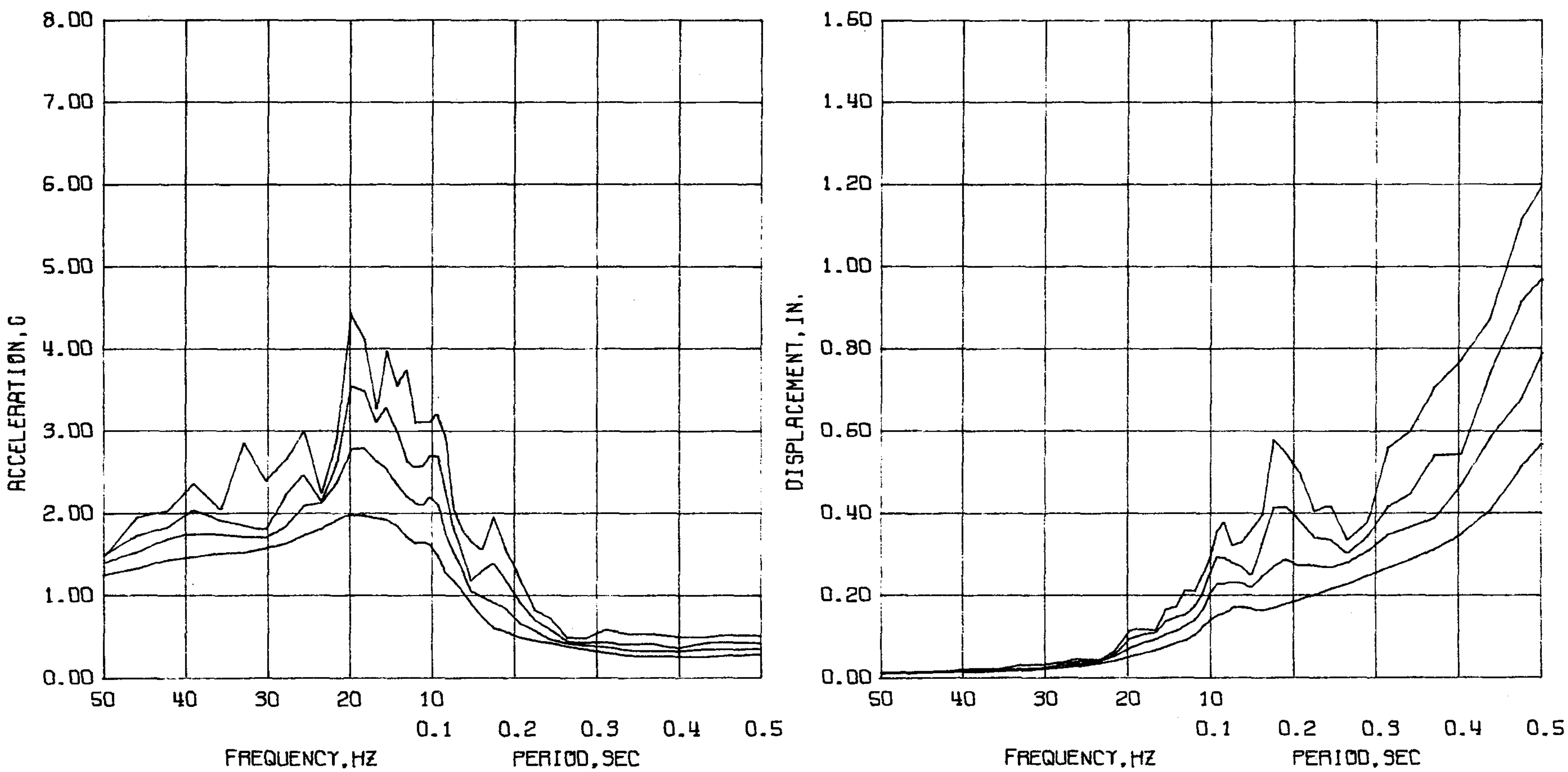


(a) Test Run D5-1



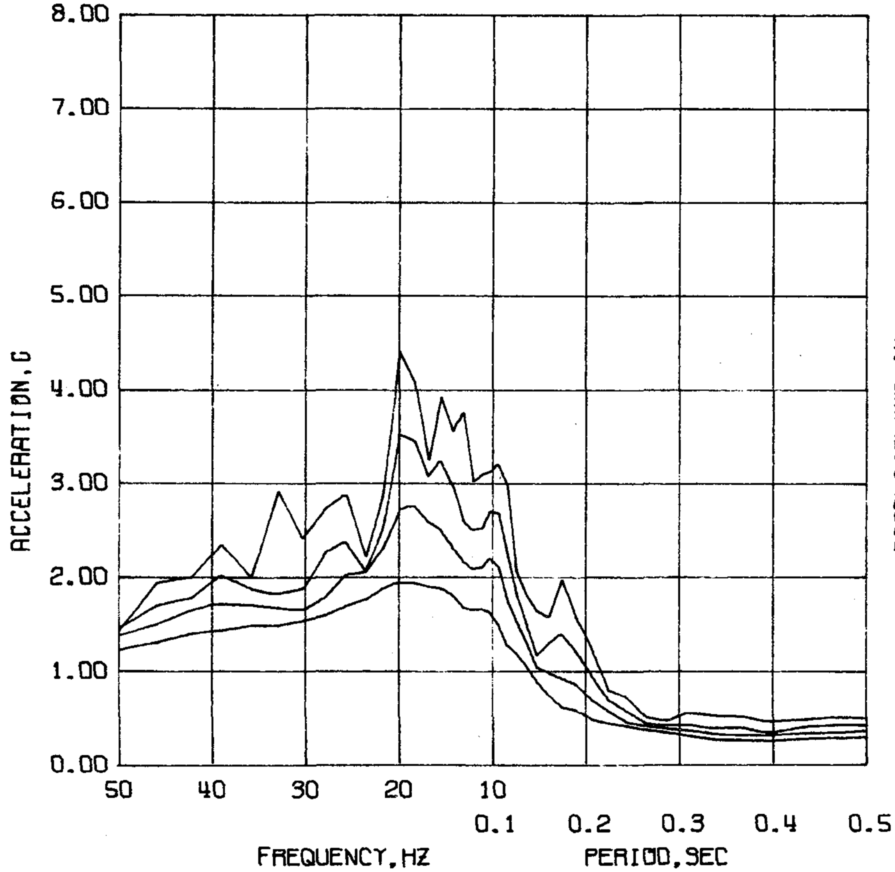
(b) Test Run D5-2

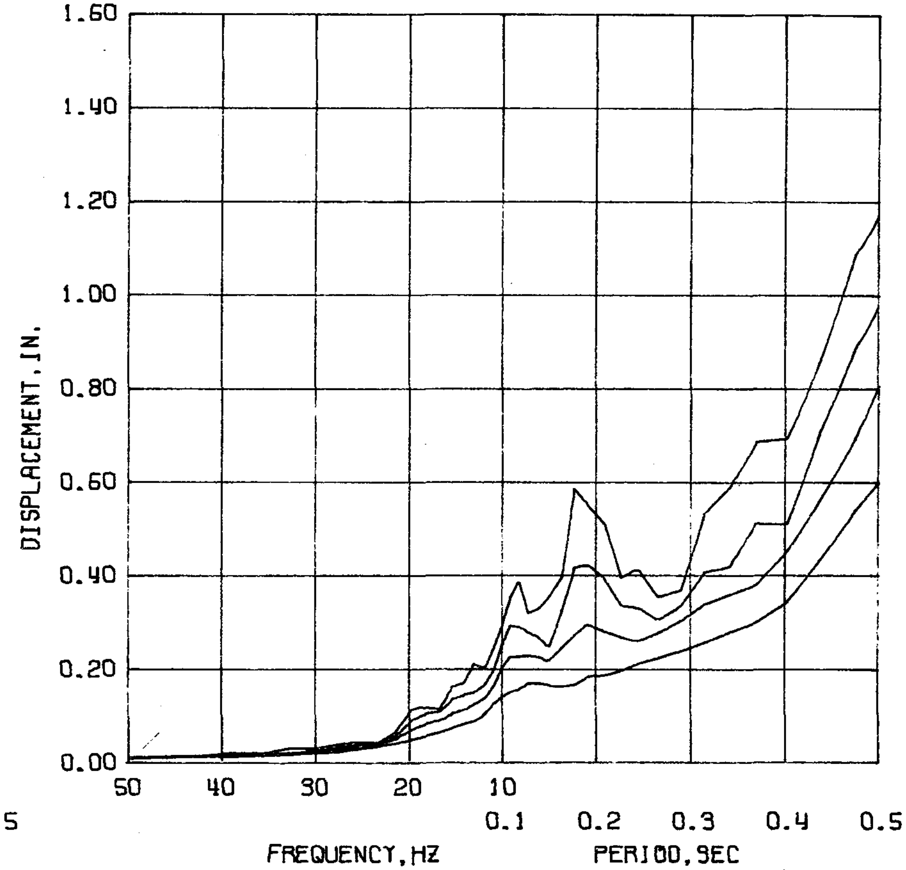
Figure 3.36 Test Structure D5. Linear Response Spectra. Tripartite Format. (β = 0.0, 0.02, 0.05, 0.10, 0.20)



(a) Test Run D5-1. North Wall.

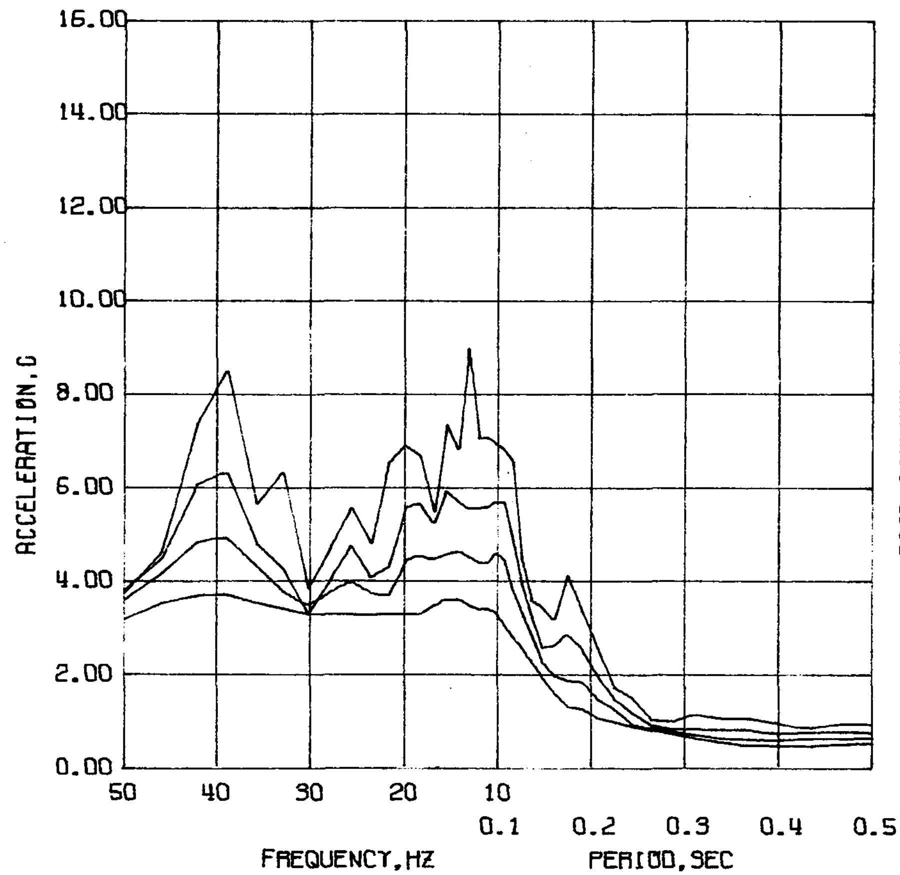
Figure 3.37 Test Structure D5. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)

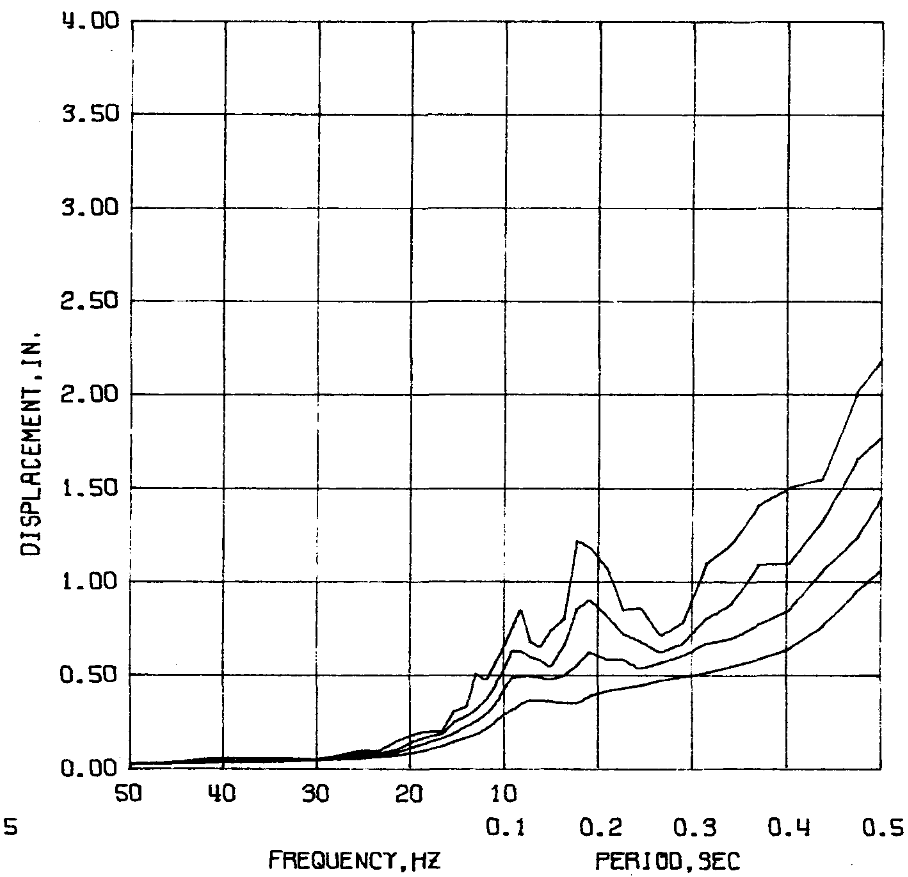




(b) Test Run D5-1. South Wall.

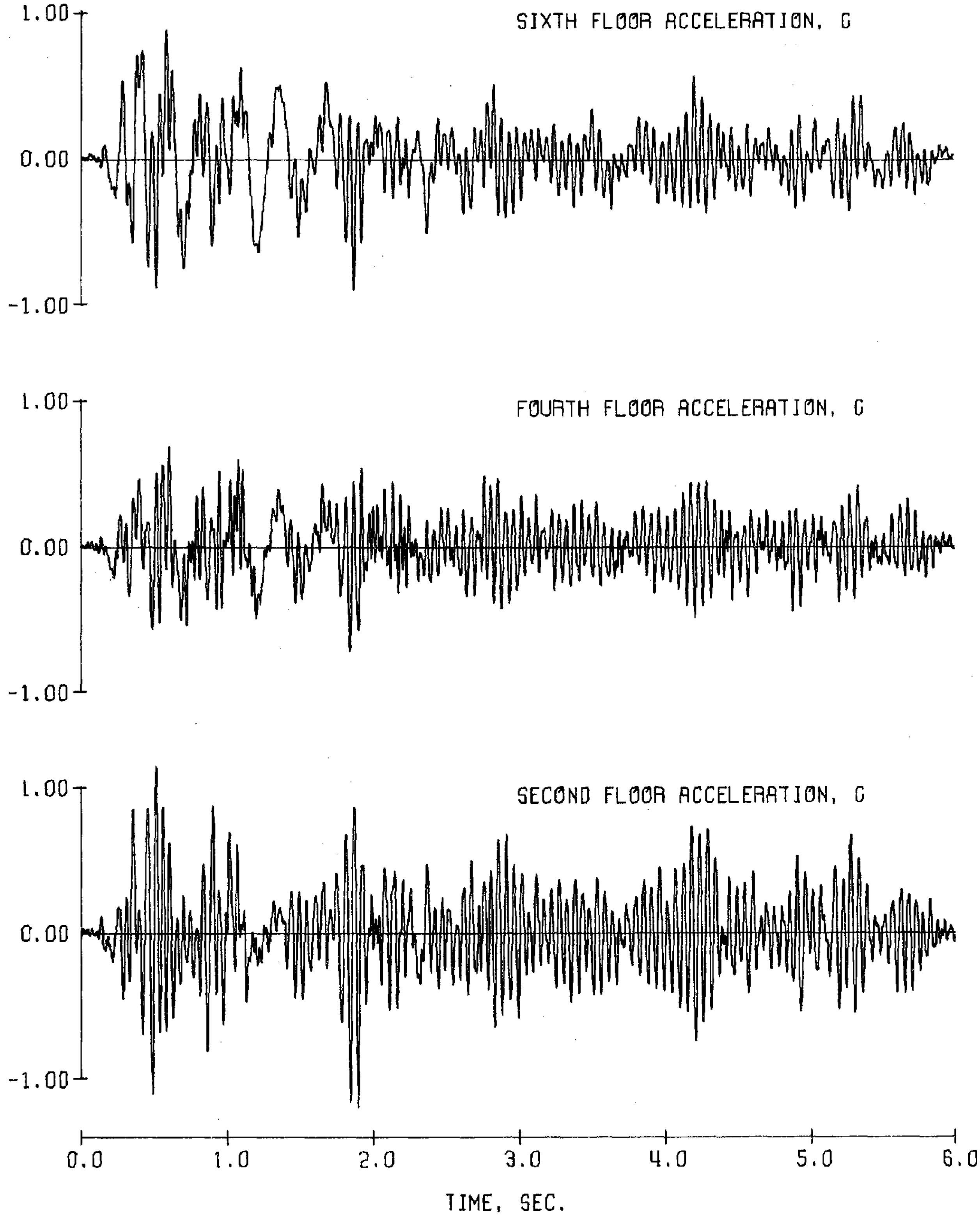
Figure 3.37 (contd.) Test Structure D5. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)





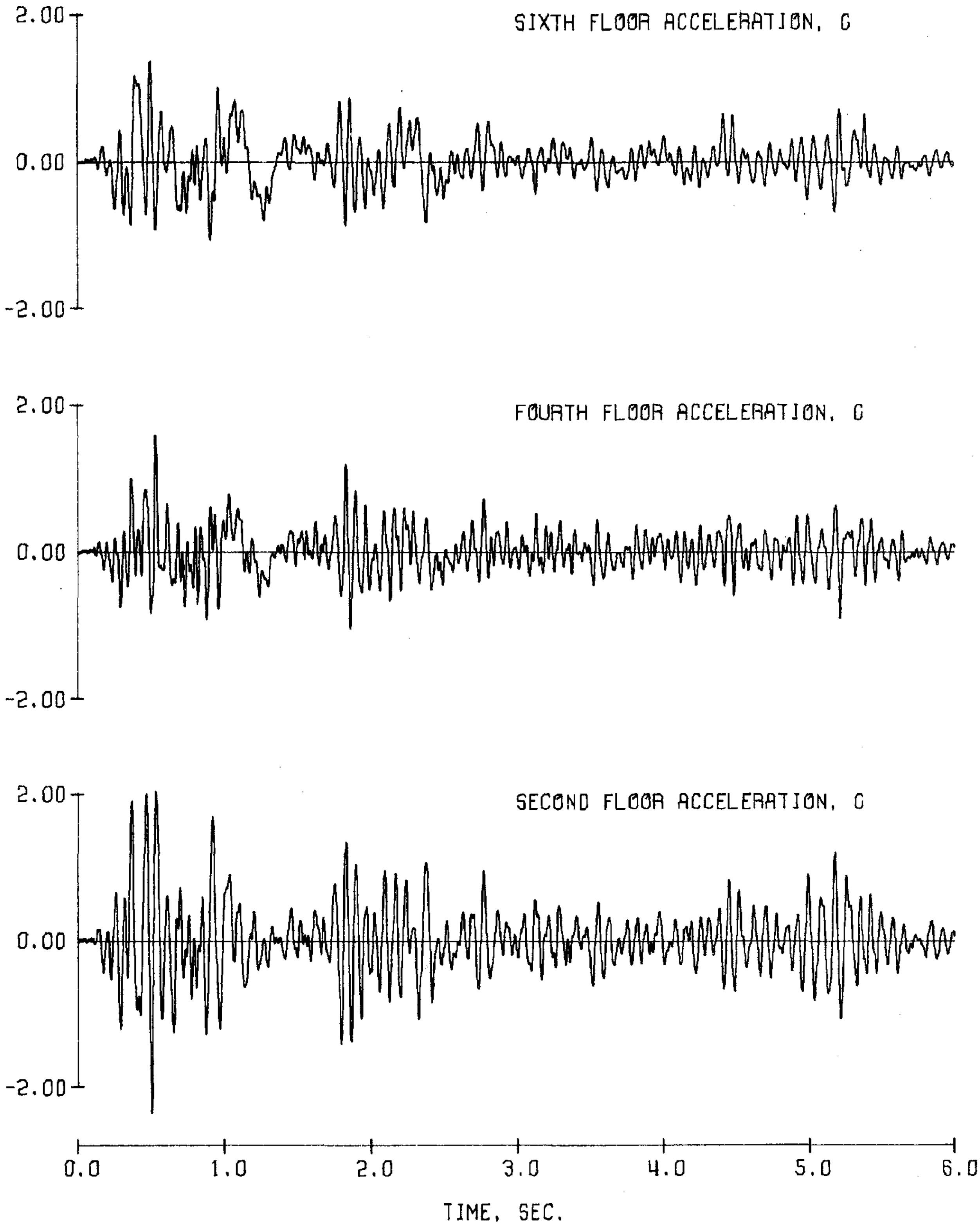
(c) Test Run D5-2. North Wall.

Figure 3.37 (contd.) Test Structure D5. Linear Response Spectra. (β = 0.02, 0.05, 0.10, 0.20)



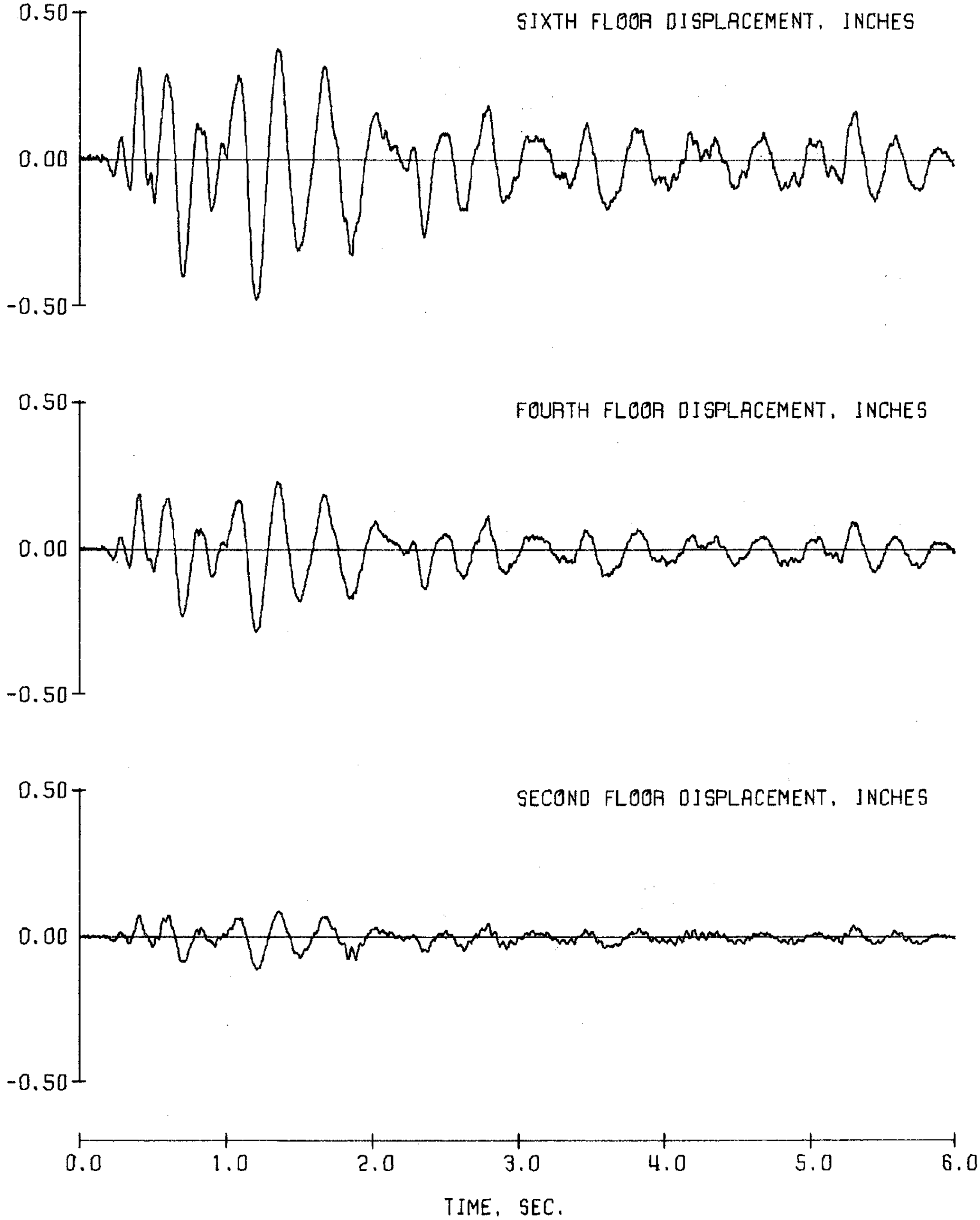
(a) Test Run D5-1. North Wall.

Figure 3.38 Test Structure D5. Observed Horizontal Accelerations



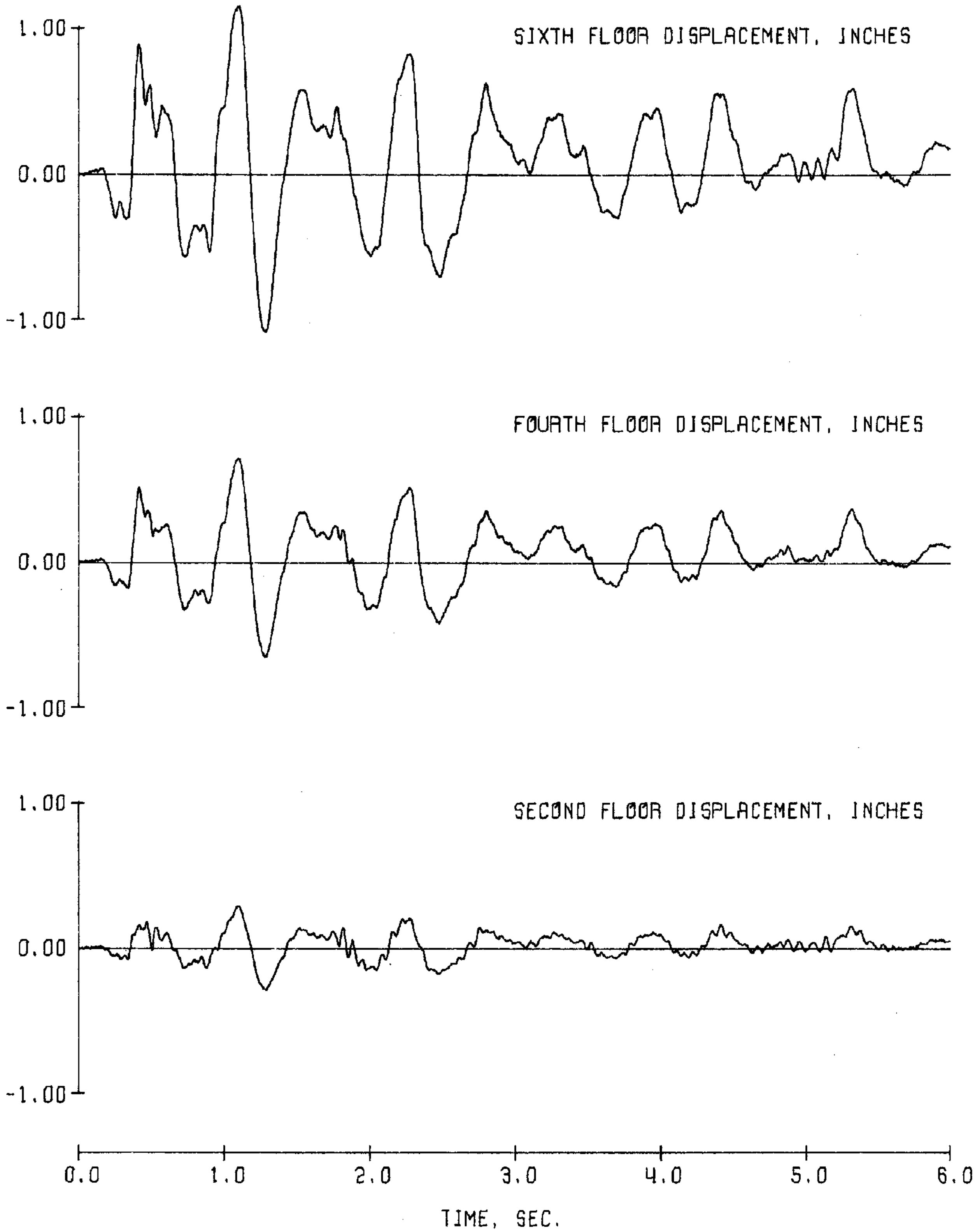
(b) Test Run D5-2. North Wall.

Figure 3.38 (contd.) Test Structure D5. Observed Horizontal Accelerations



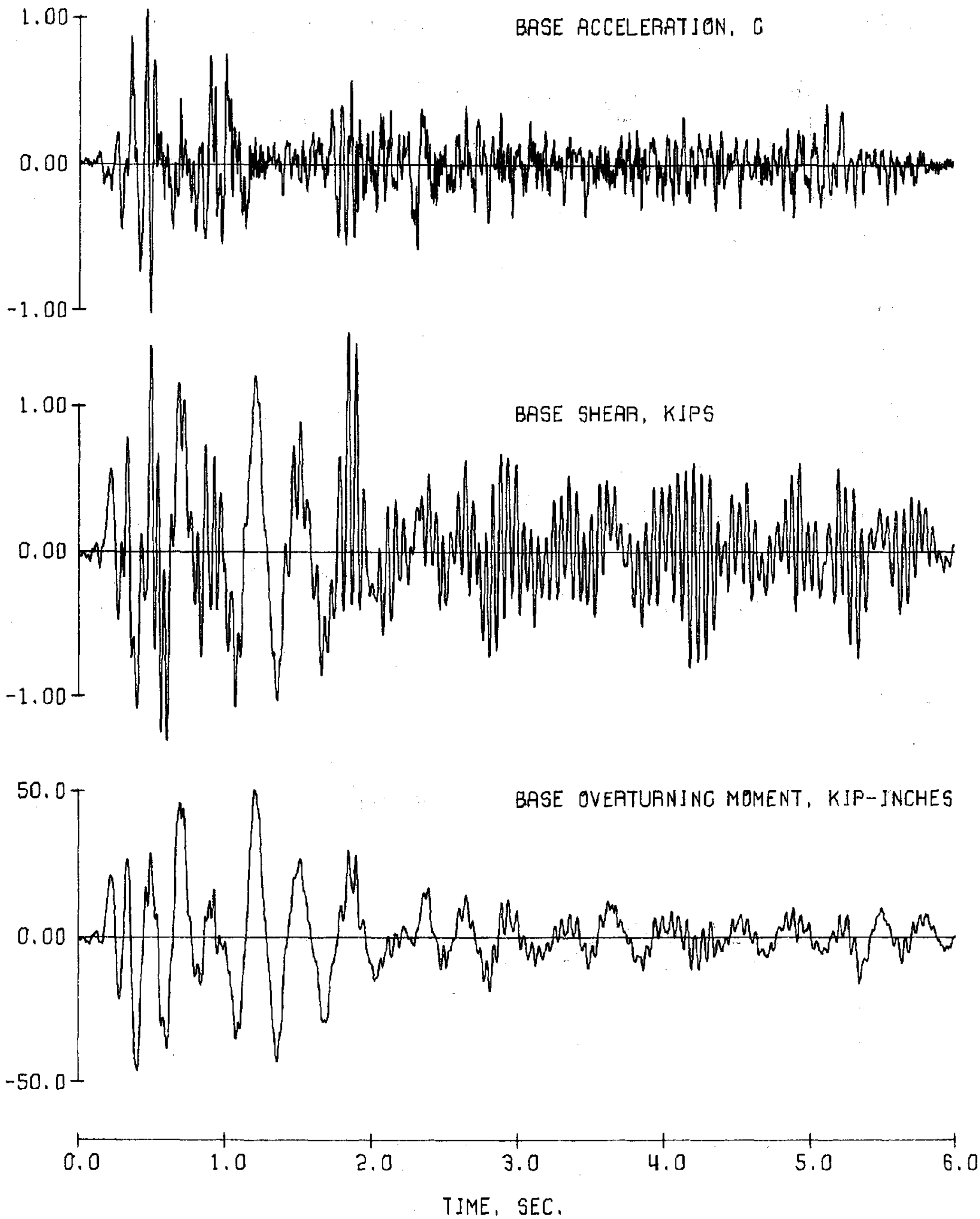
(a) Test Run D5-1. North Wall.

Figure 3.39 Test Structure D5. Observed Horizontal Displacements



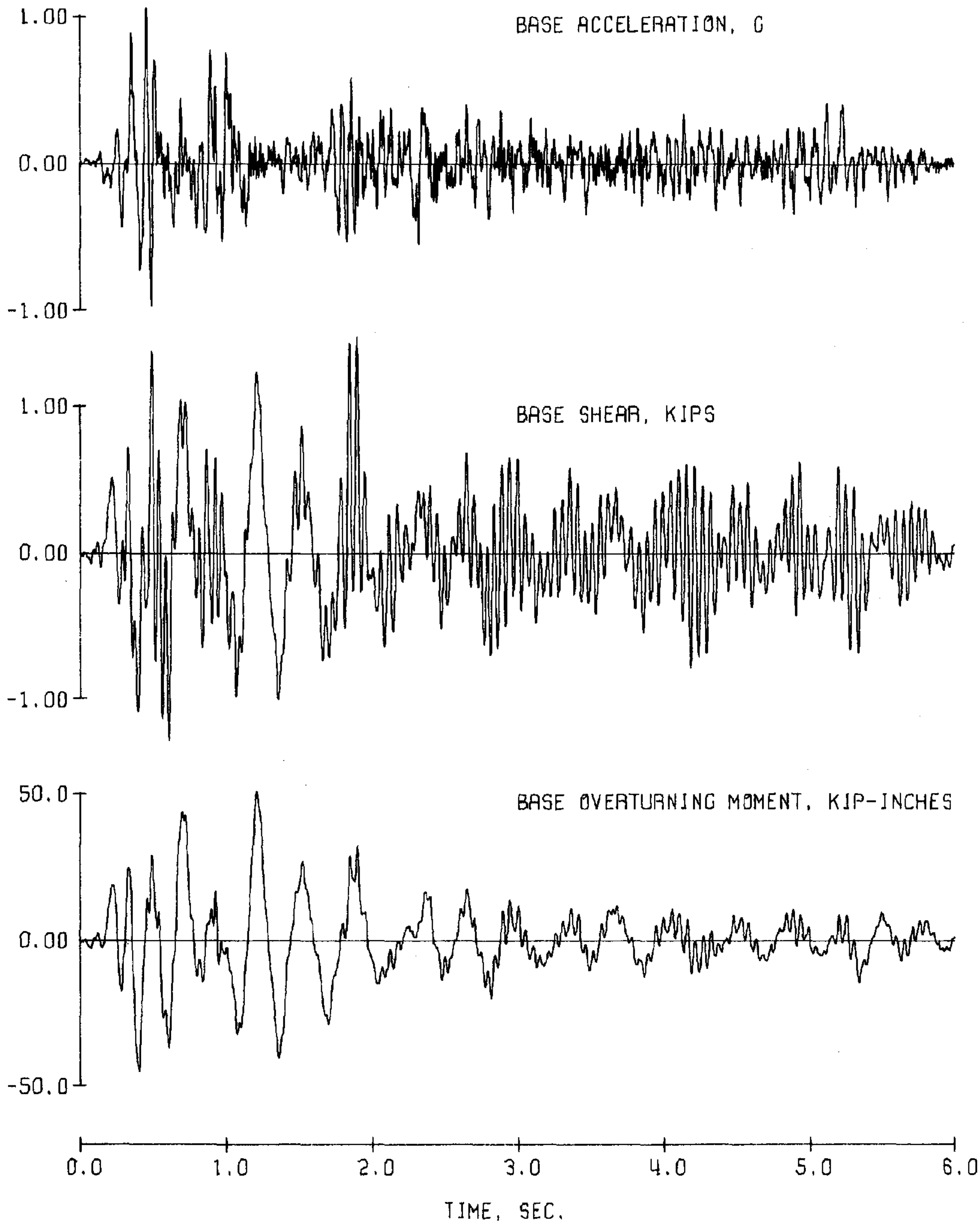
(b) Test Run D5-2. North Wall.

Figure 3.39 (contd.) Test Structure D5. Observed Horizontal Displacements



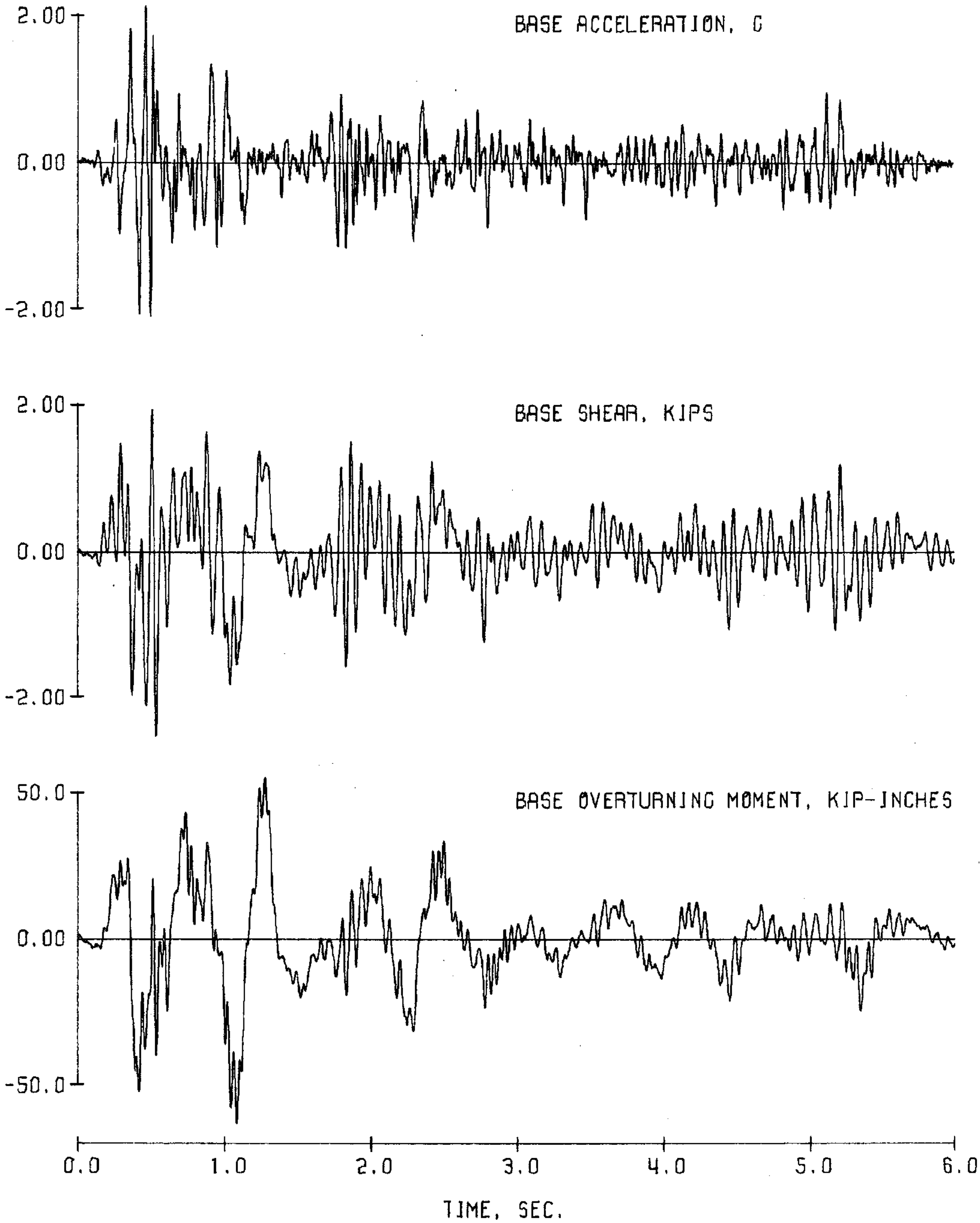
(a) Test Run D5-1. North Wall.

Figure 3.40 Test Structure D5. Observed Base Functions



(b) Test Run D5-1. South Wall.

Figure 3.40 (contd.) Test Structure D5. Observed Base Functions



(c) Test Run D5-2. North Wall.

Figure 3.40 (contd.) Test Structure D5. Observed Base Functions

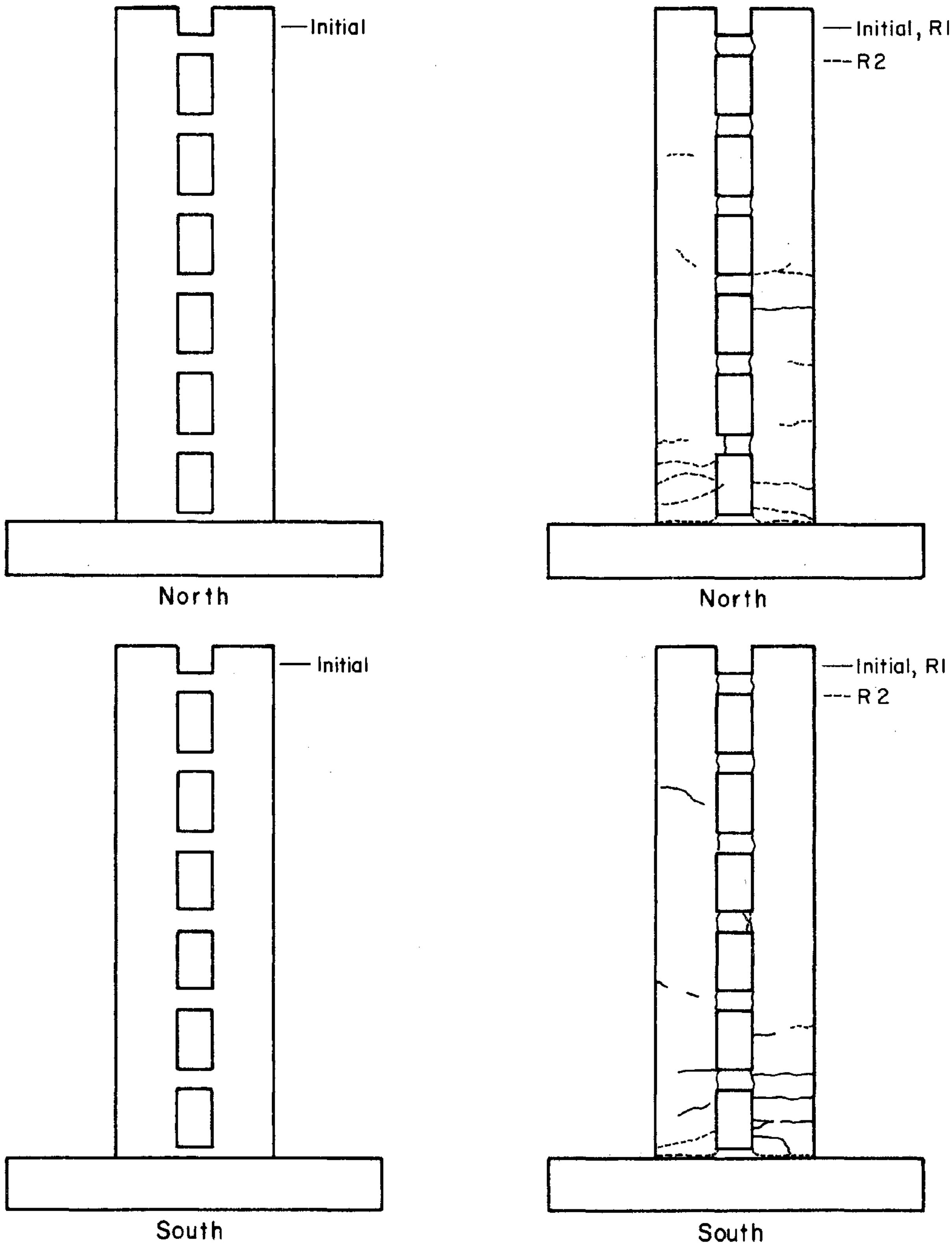


Figure 3.41 Test Structure D4. Observed Crack Patterns.

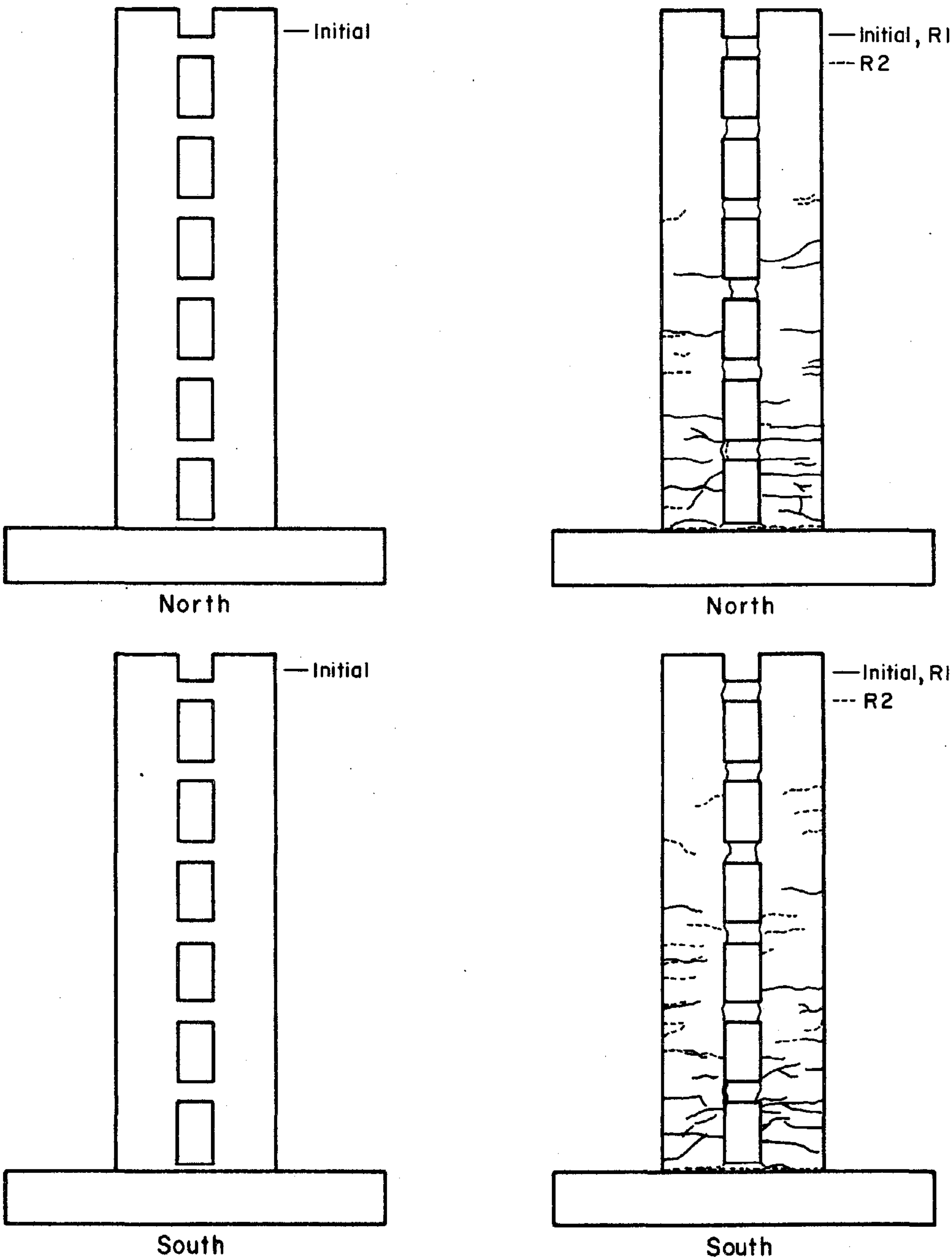


Figure 3.42 Test Structure D5. Observed Crack Patterns

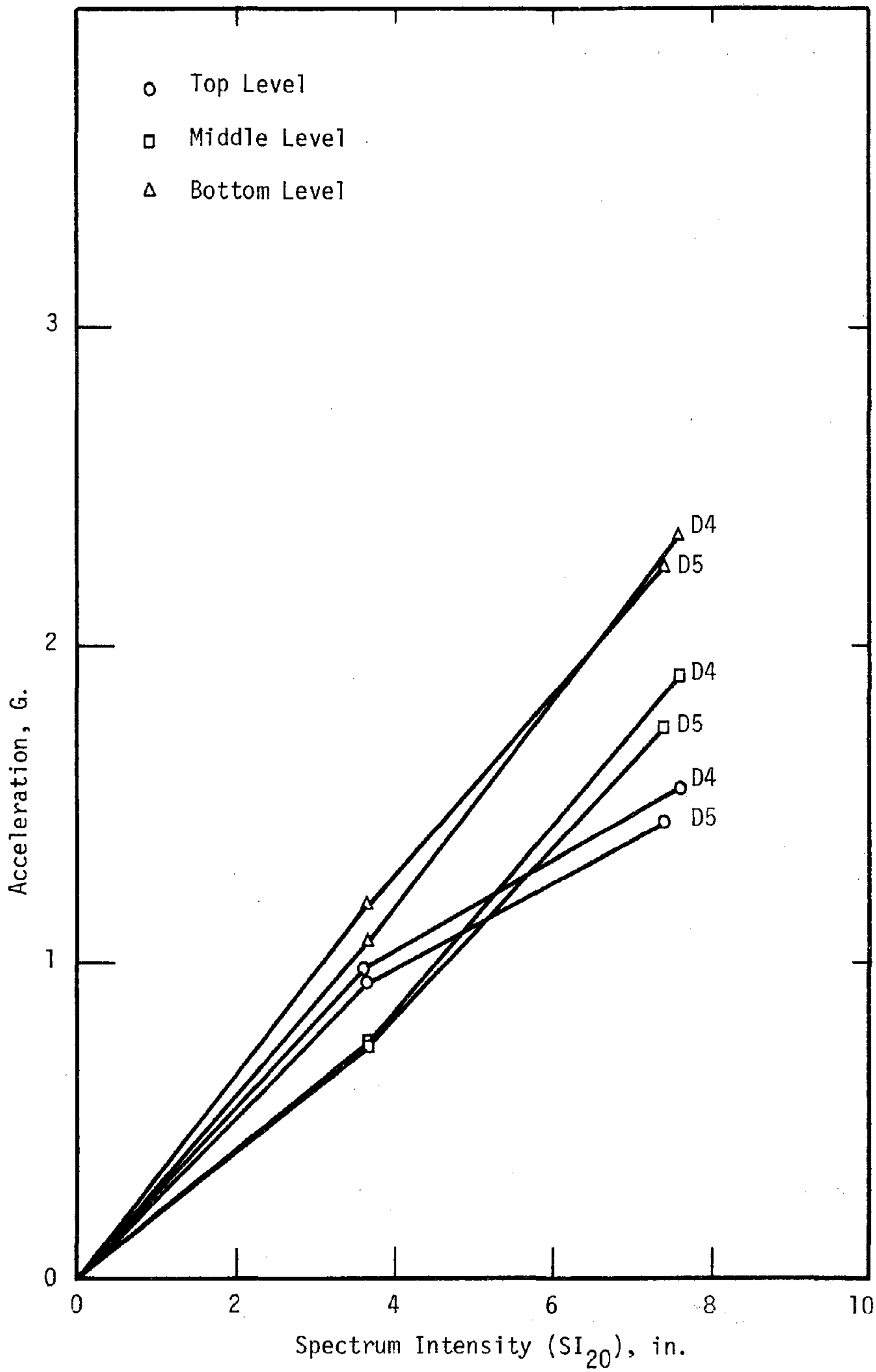


Figure 3.43 Type C Test Structures. Variation of Spectrum Intensity with Horizontal Acceleration

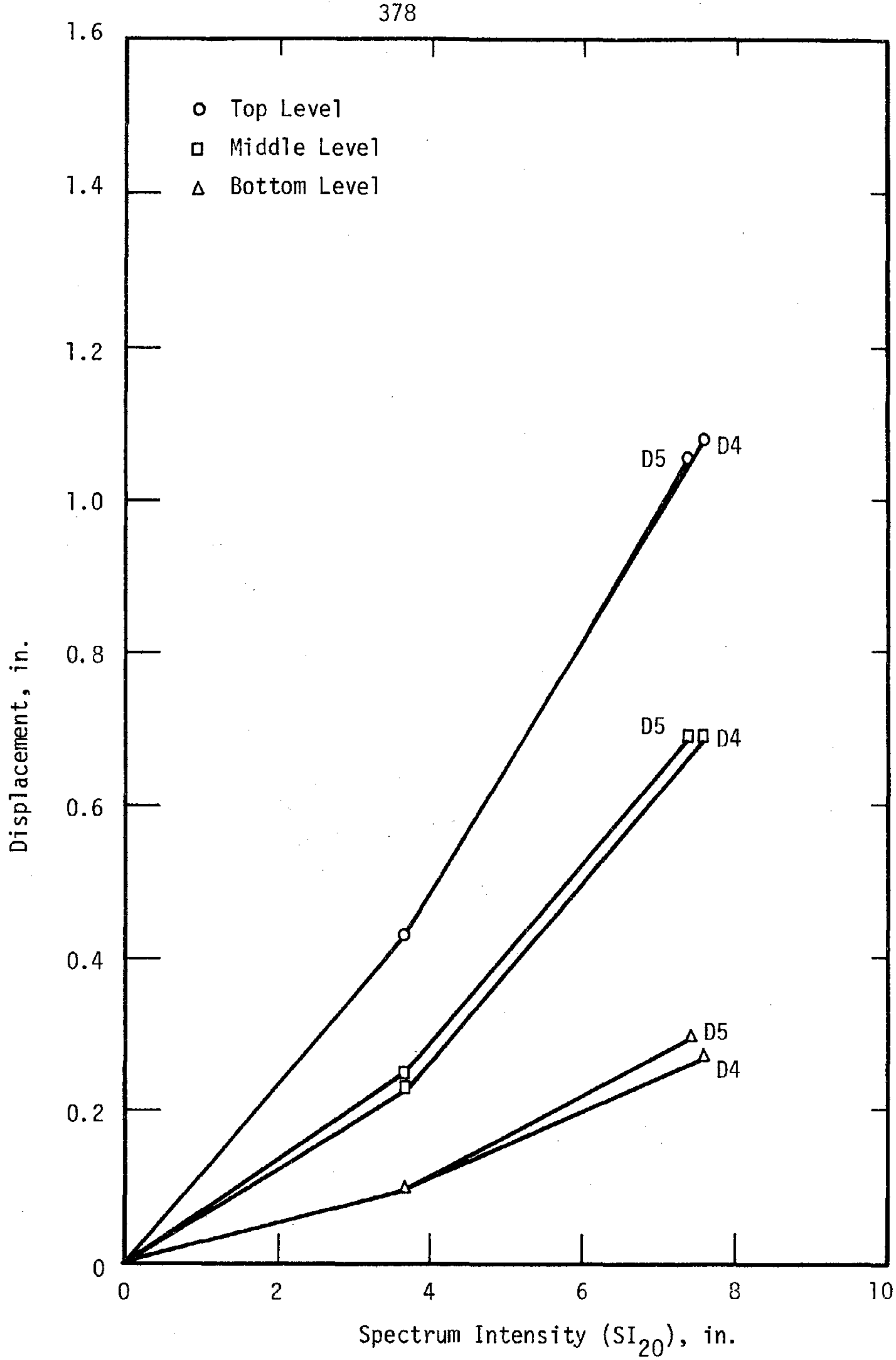


Figure 3.44 Type C Test Structures. Variation of Spectrum Intensity with One-Half of Average Horizontal Double Amplitude Displacement

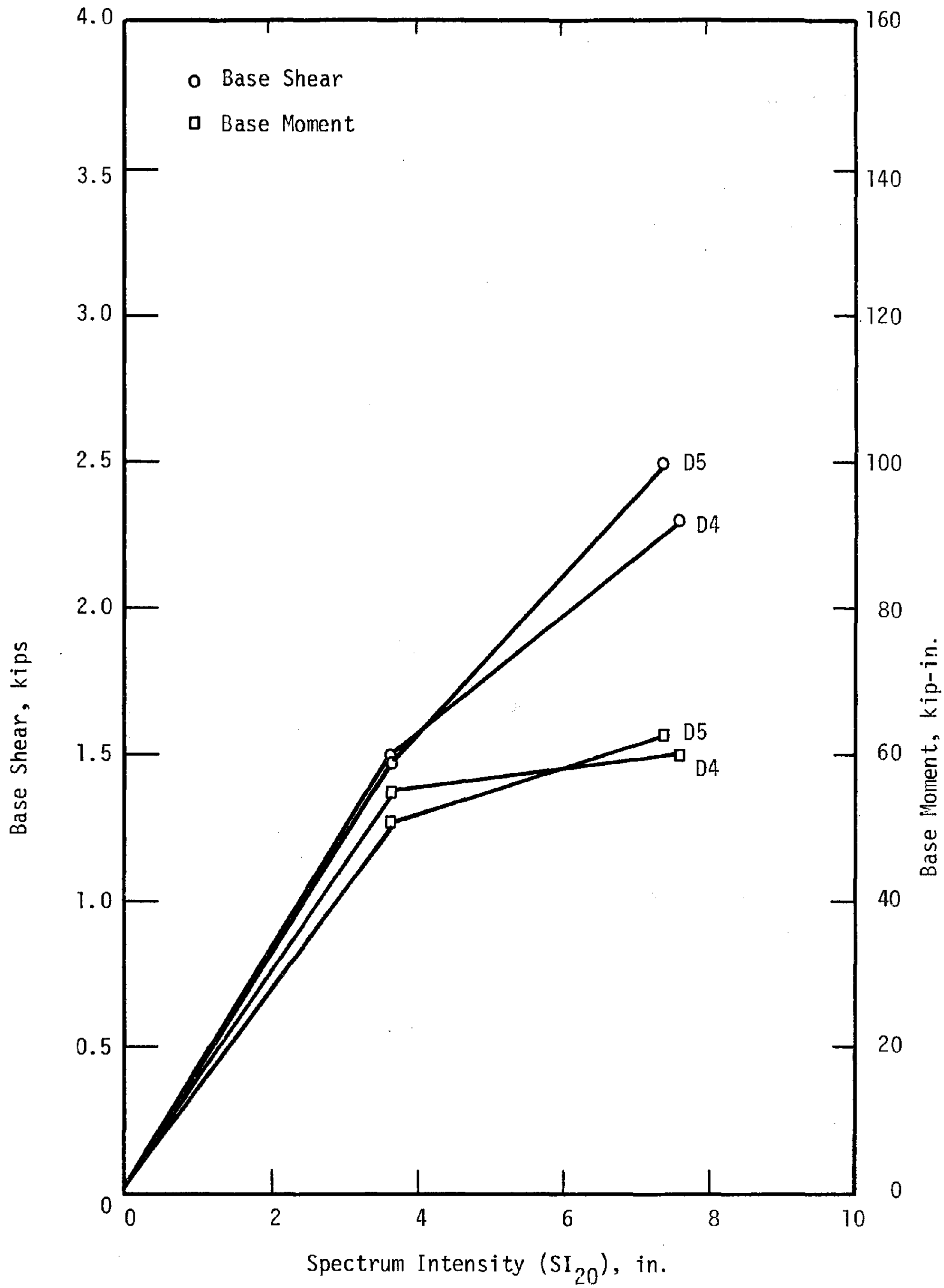


Figure 3.45 Type C Test Structures. Variation of Spectrum Intensity with Average Base Shear and Average Base Moment

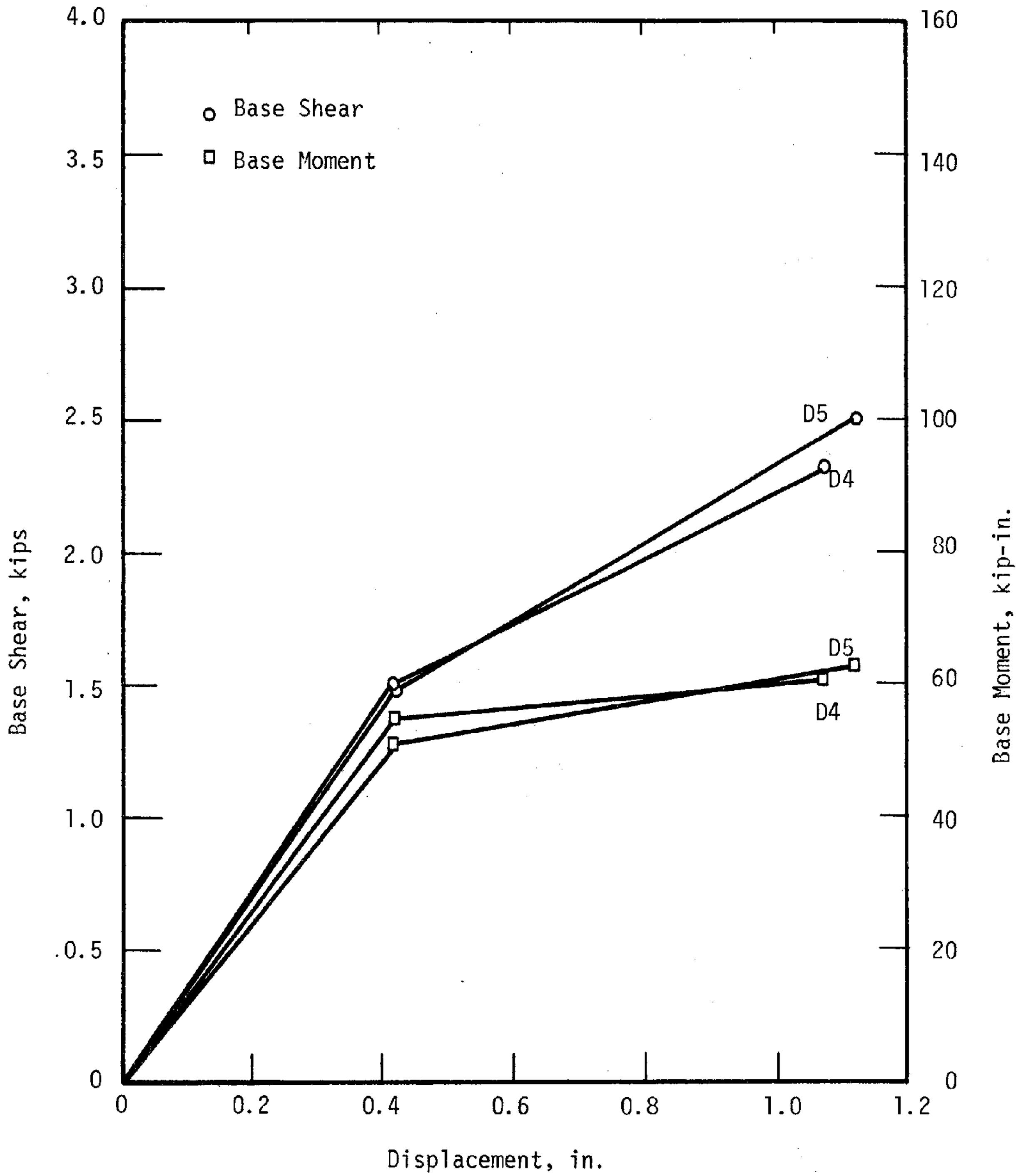
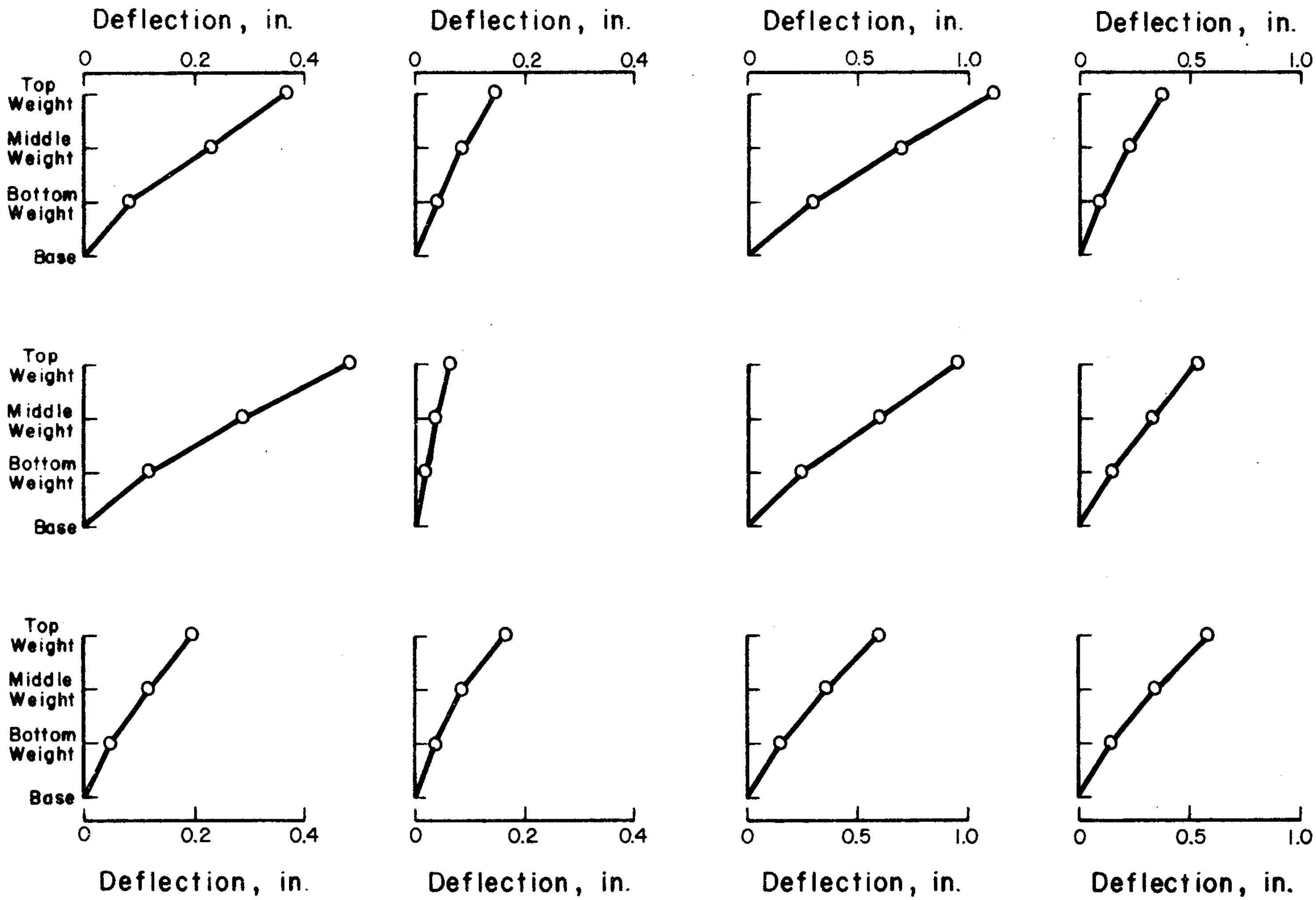


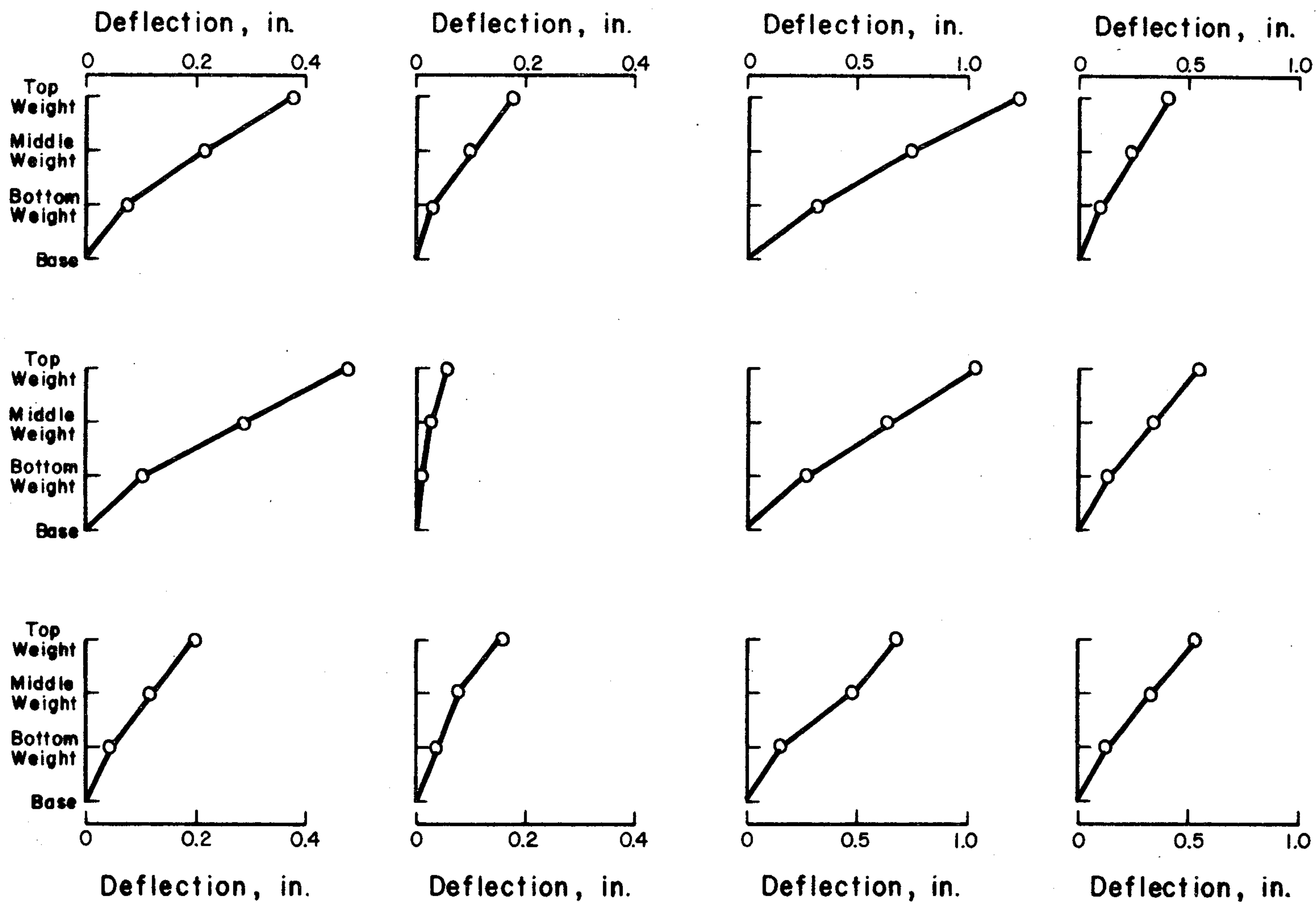
Figure 3.46 Type C Test Structures. Variation of Average Base Moment with One-Half of Average Double Amplitude Top Level Displacement



(a) Test Run D4-1

(b) Test Run D4-2

Figure 3.47 Type C Test Structures. Variation of Observed Deflection with Height at Several Times. Structure D4. South Wall



(a) Test Run D5-1

(b) Test Run D5-2

Figure 3.48 Type C Test Structures. Variation of Observed Deflection with Height at Several Times. Structure D5. South Wall

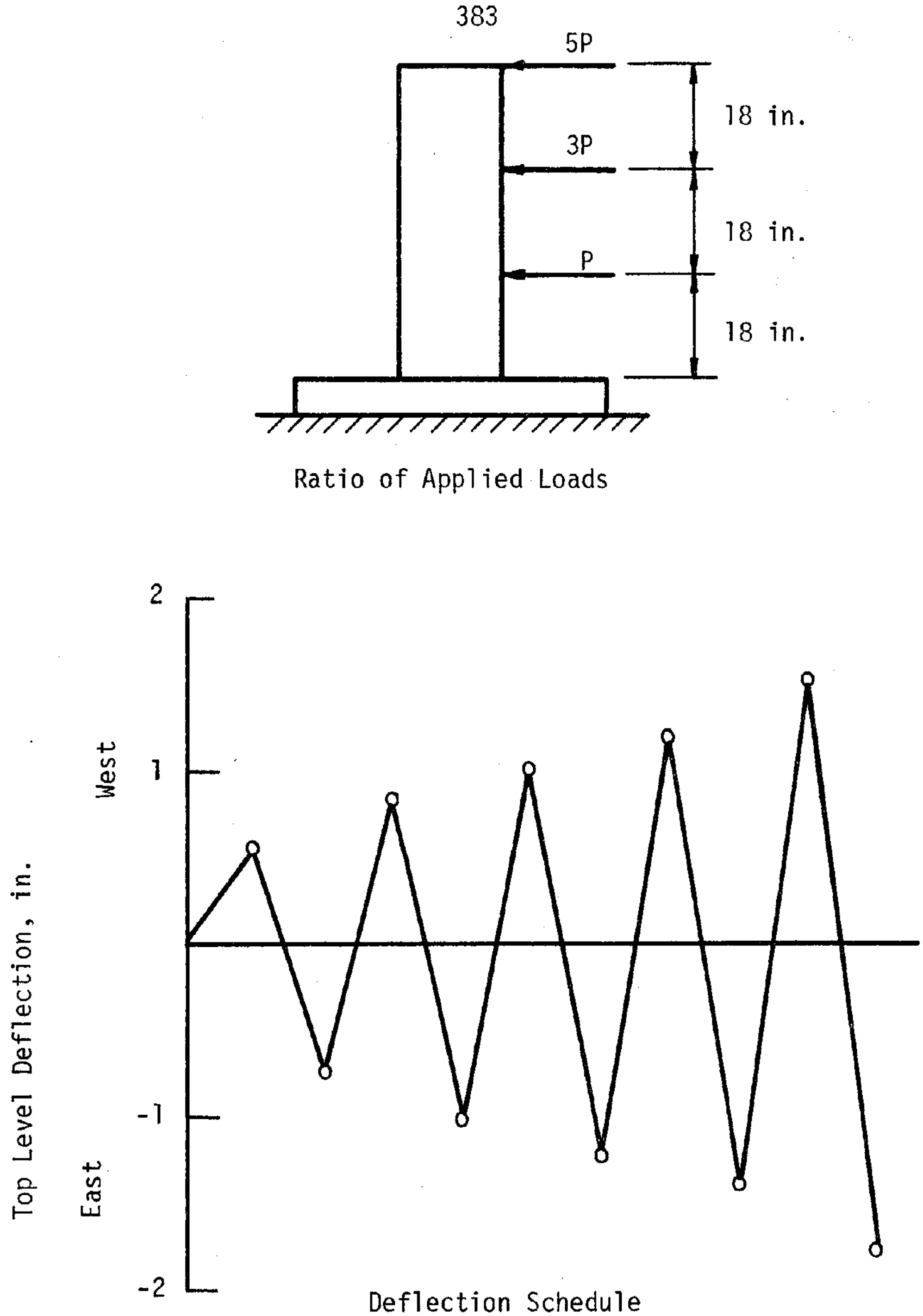


Figure 3.49 Static Test. Loading Information

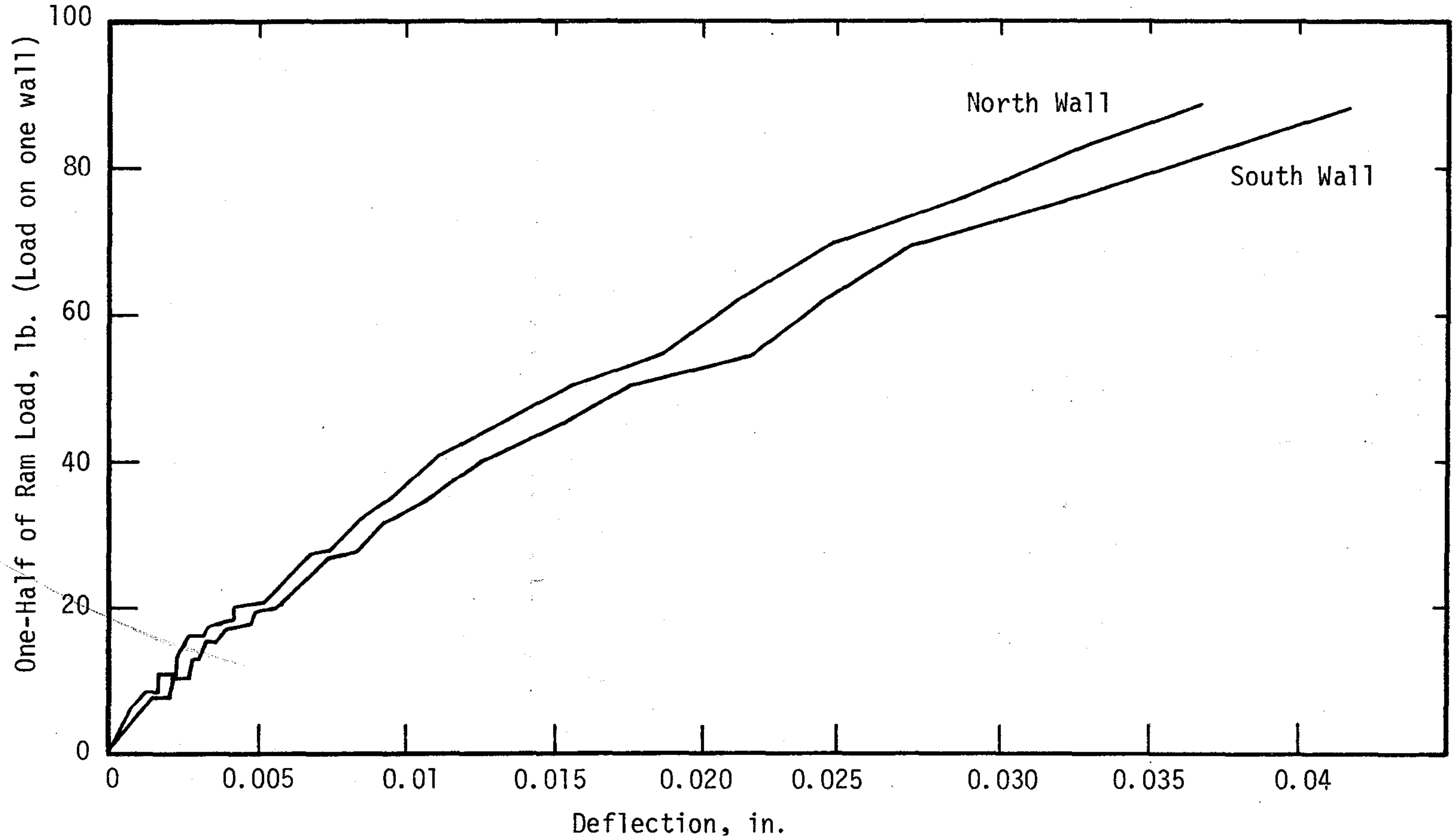


Figure 3.50 Static Test. Observed Variation of Lower Level Lateral Load with Lower Level Lateral Deflection. No Base Displacement Correction

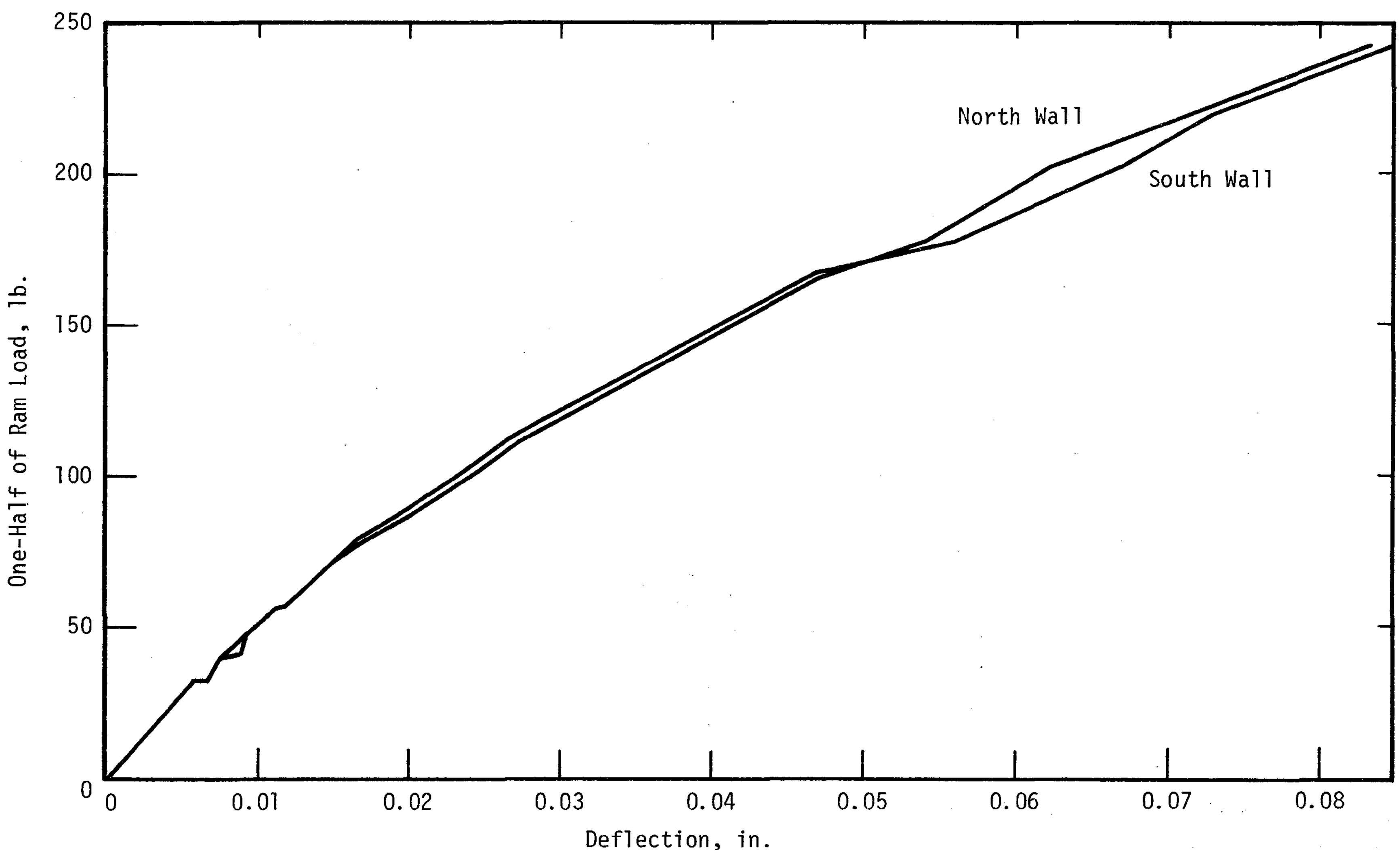


Figure 3.50 (contd.) Static Test. Observed Variation of Middle Level Lateral Load with Middle Level Lateral Deflection. No Base Displacement Correction

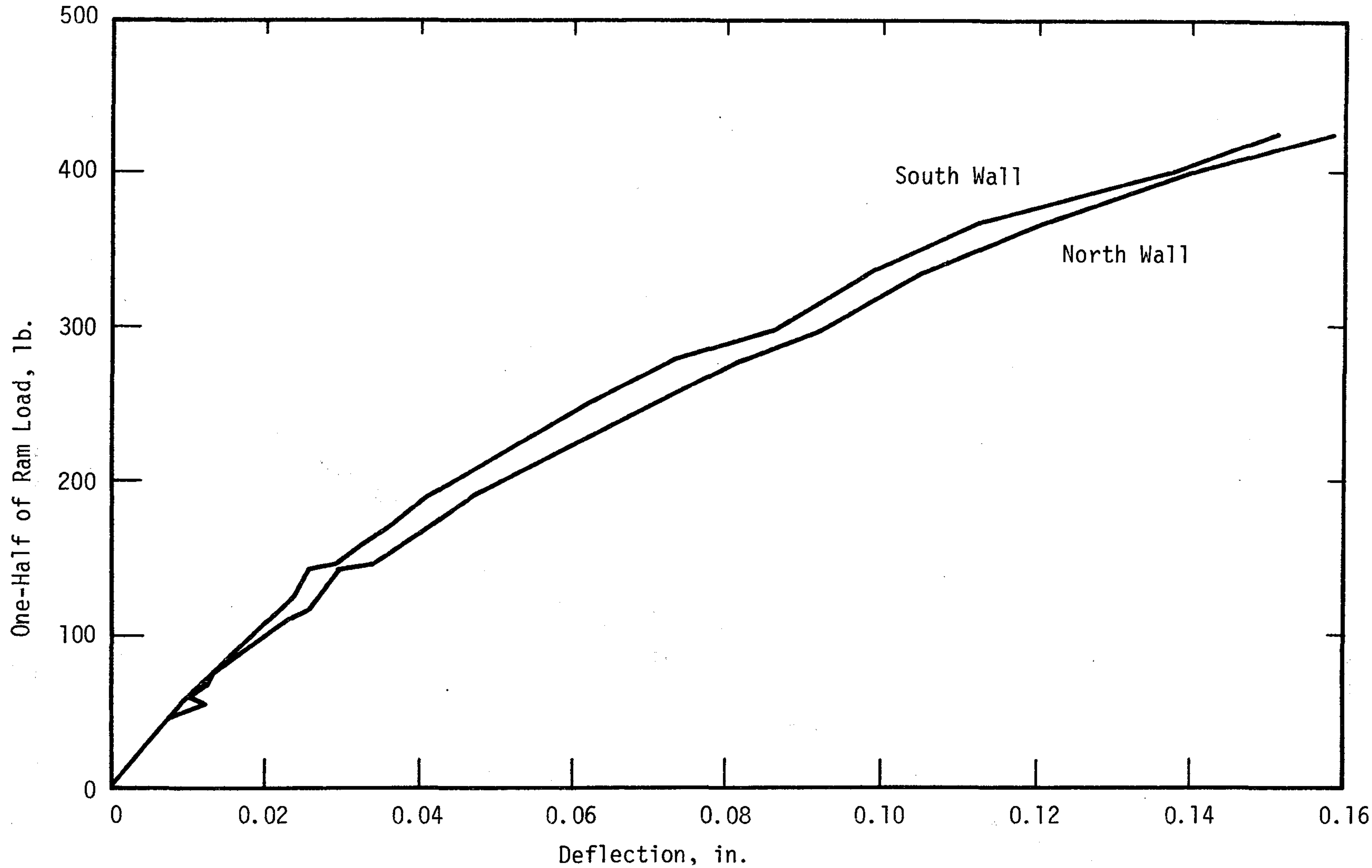


Figure 3.50 (contd.) Static Test. Observed Variation of Top Level Lateral Load with Top Level Lateral Deflection. No Base Displacement Correction

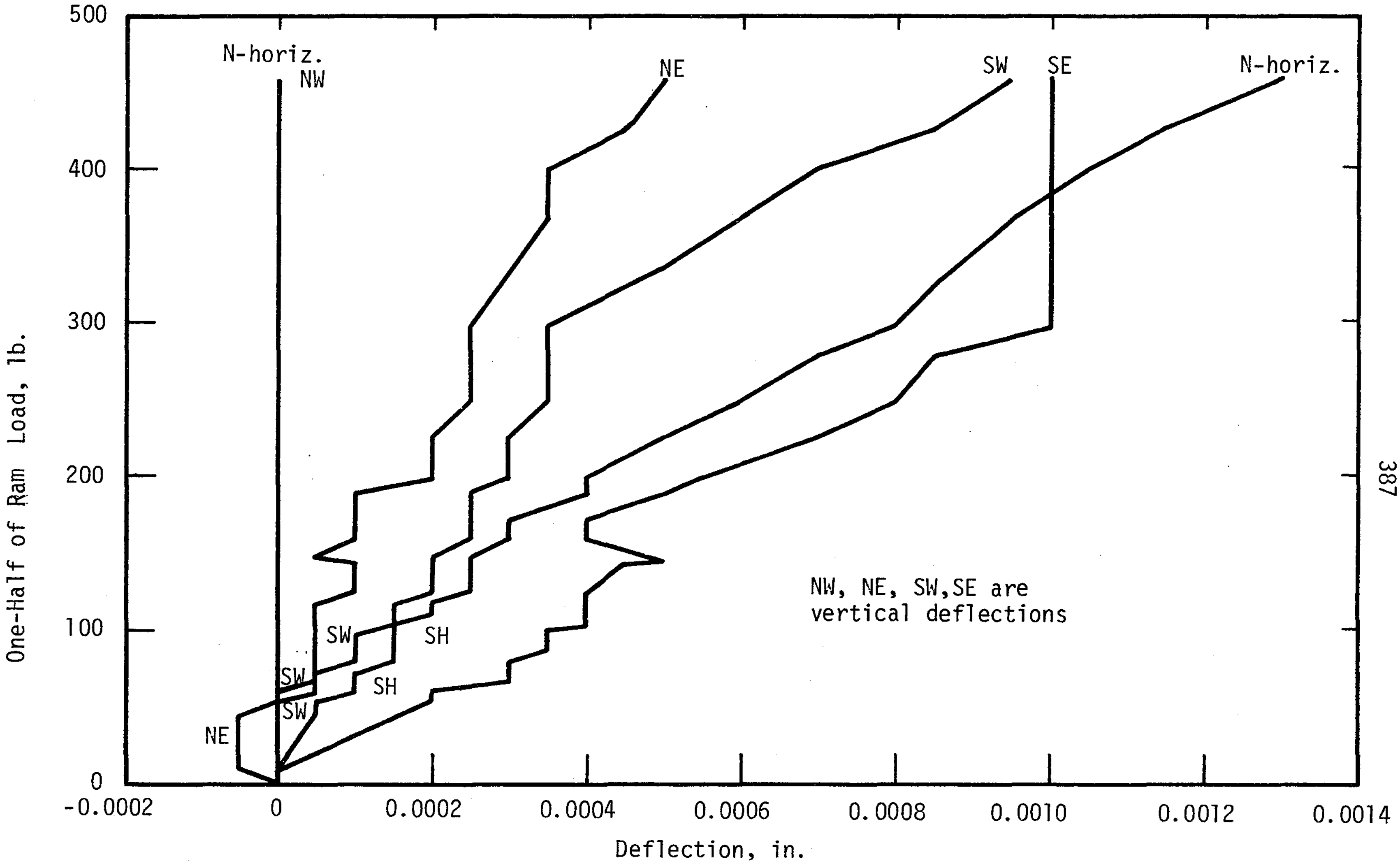
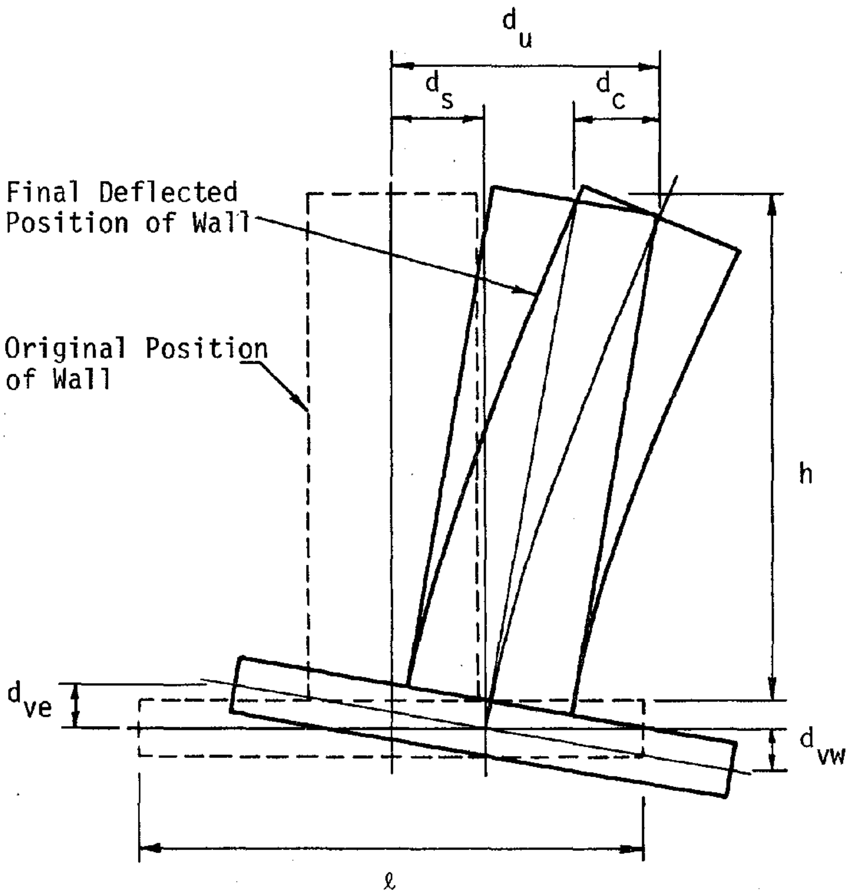


Figure 3.51 Static Test. Observed Variation of Vertical and Horizontal Deflections of the Base with Top Level Load



d_{ve} = Vertical Deflection at East End of Base.

d_{vw} = Vertical Deflection at West End of Base.

d_s = Horizontal Deflection of Base.

d_u = Horizontal Deflection of Wall Uncorrected for Base Deflection.

d_c = Horizontal Deflection of Wall Corrected for Base Deflection

h = Height of Deflection Observation above Base

ℓ = Distance between East and West Vertical Deflection Observations on Base.

$$d_c = d_u - d_s - \left[\frac{d_{ve}+d_{vw}}{\ell}\right] h$$

Figure 3.52 Static Test. Correction of Observed Wall Deflections for Observed Base Deflections

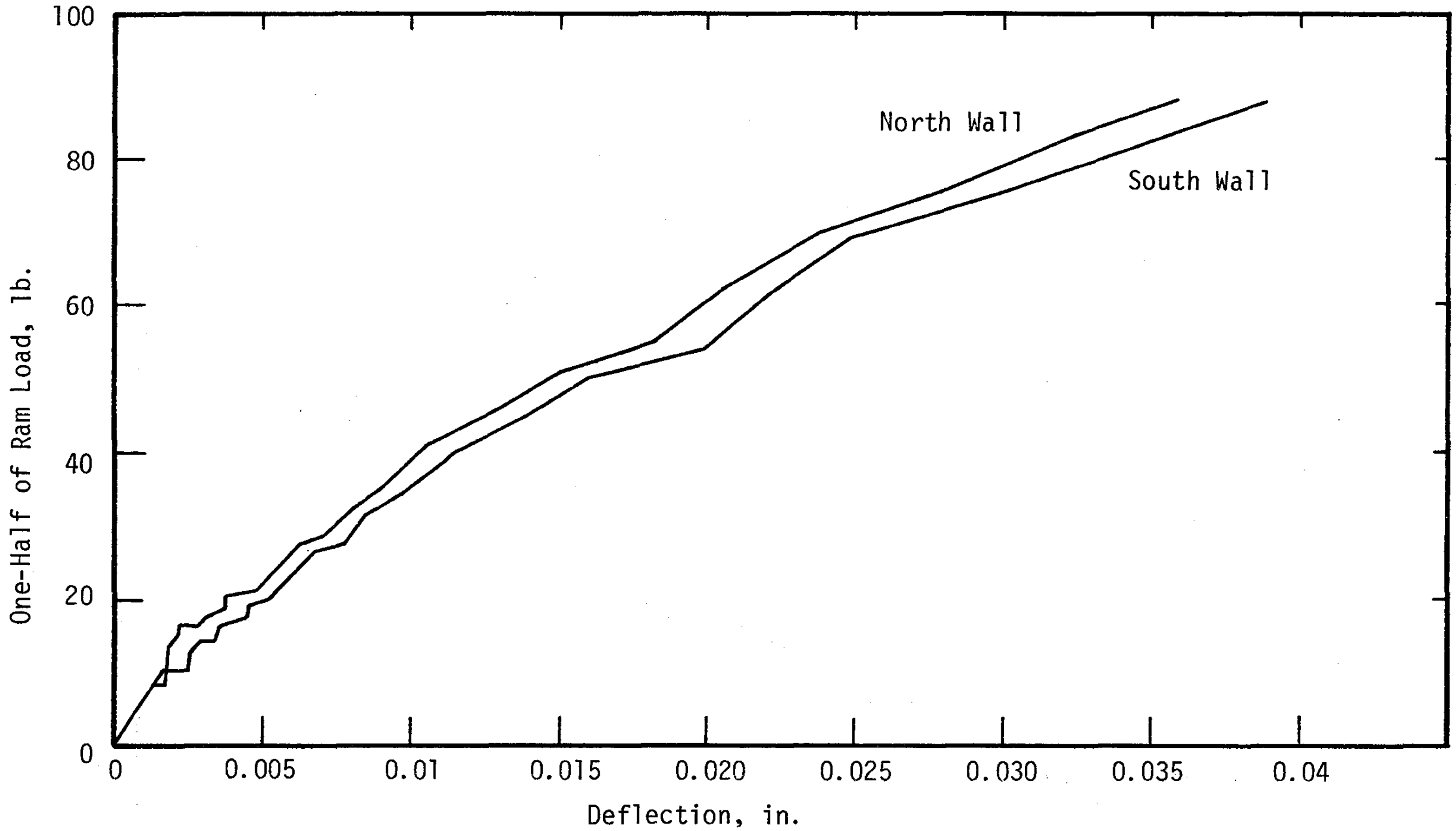


Figure 3.53 Static Test. Observed Variation of Lower Level Lateral Load with Lower Level Lateral Deflection. Corrected for Base Displacement

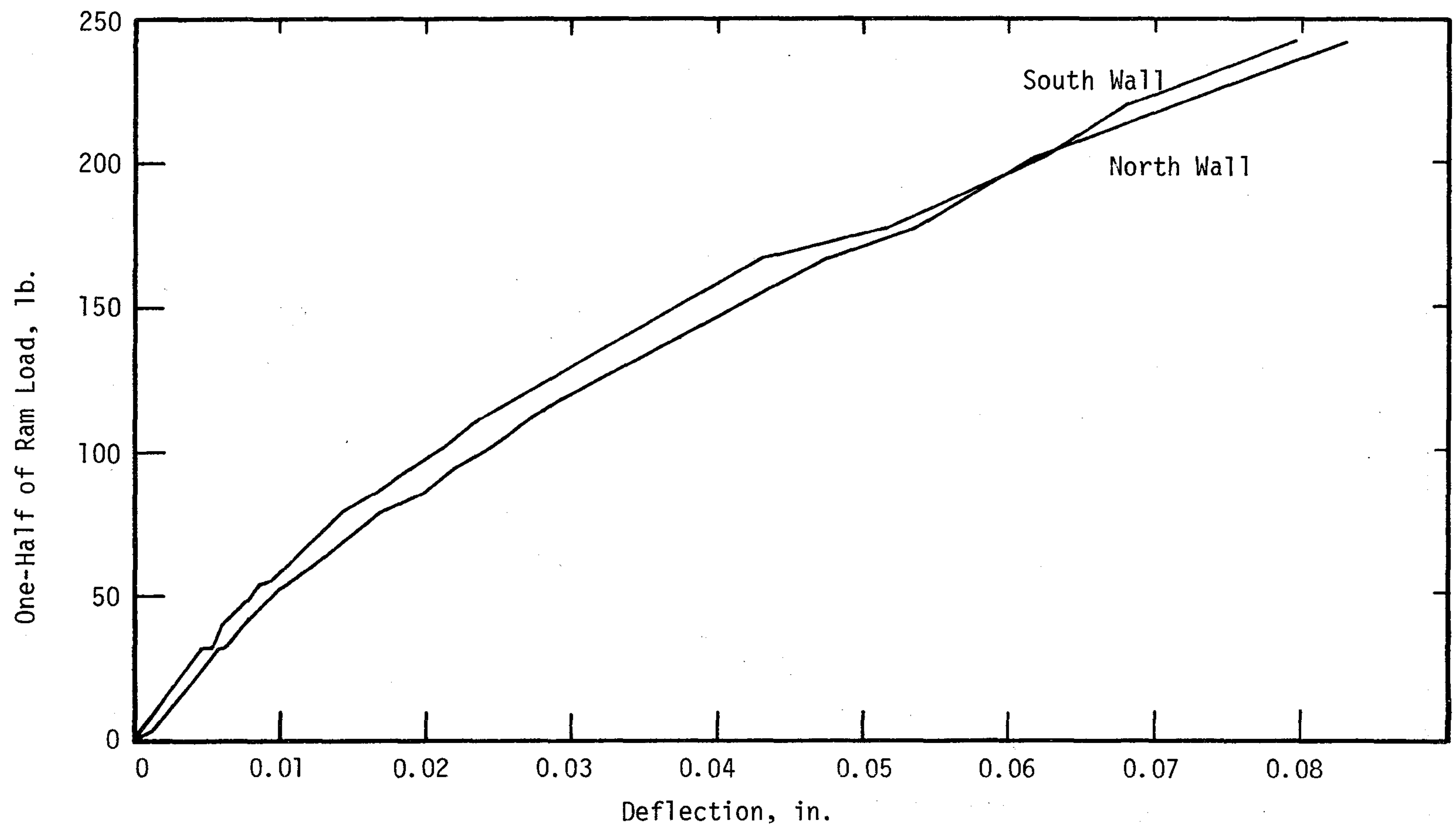


Figure 3.53 (contd.) Static Test. Observed Variation of Middle Level Lateral Load with Middle Level Lateral Deflection. Corrected for Base Displacement

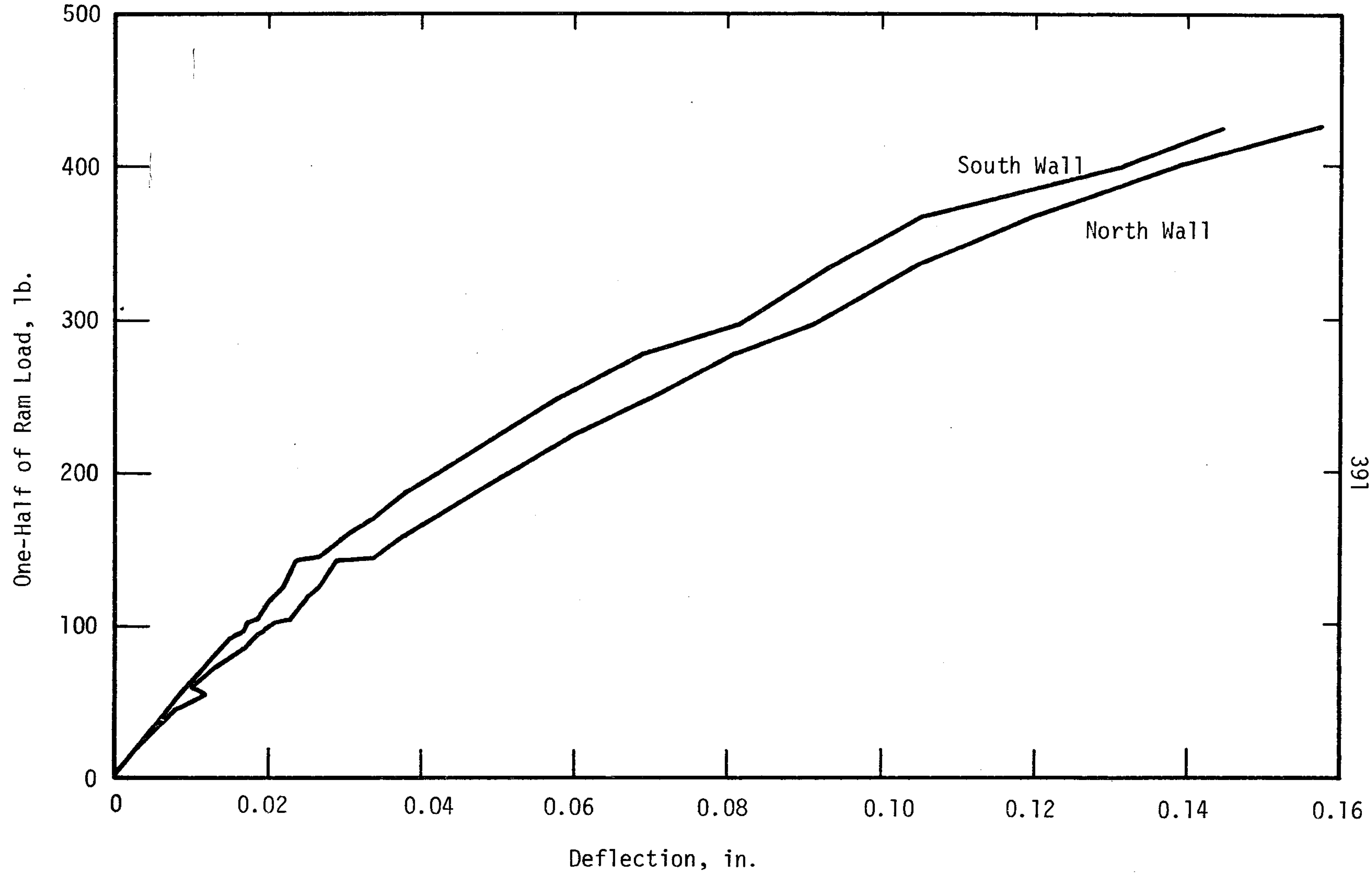


Figure 3.53 (contd.) Static Test. Observed Variation of Top Level Lateral Load with Top Level Lateral Deflection. Corrected for Base Displacement

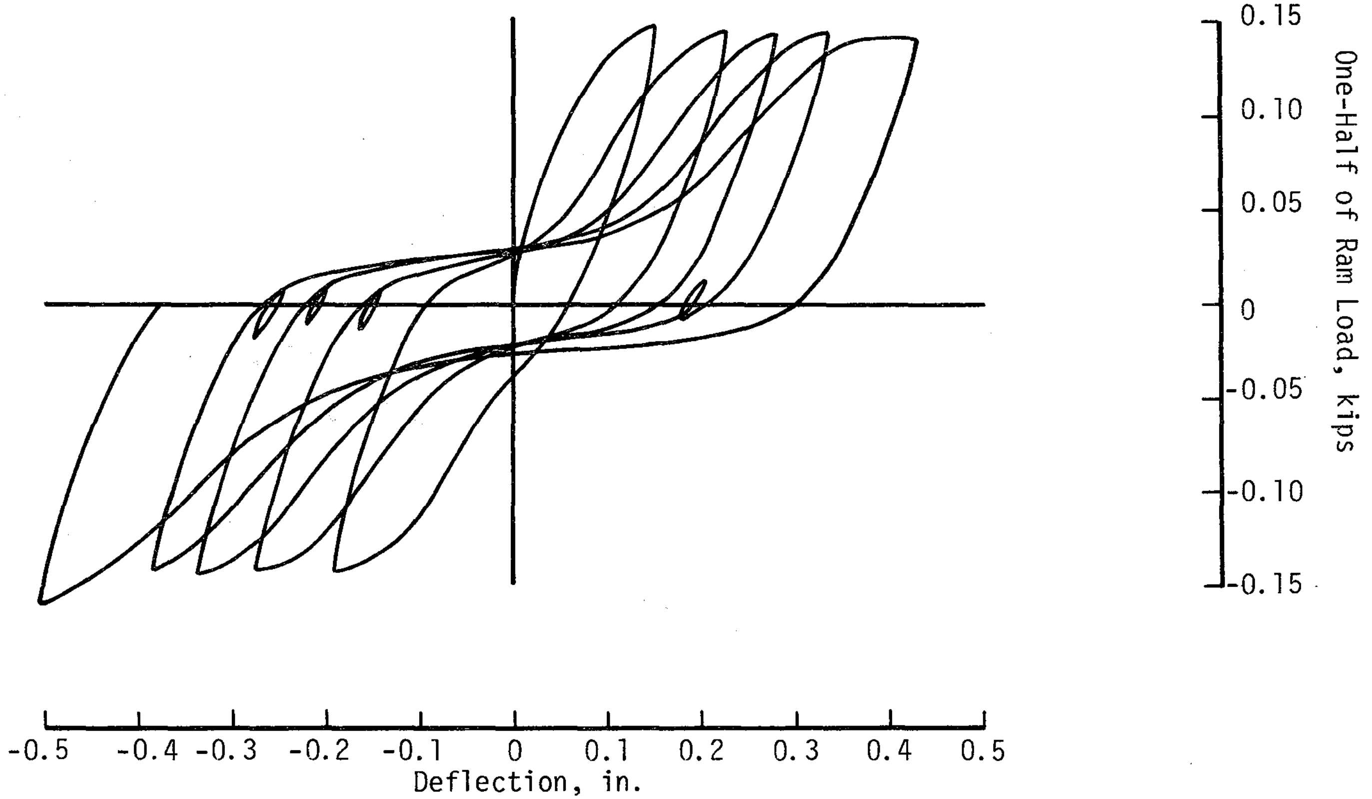


Figure 3.54 Static Test. Observed Variation of Lower Level Ram Load with Lower Level Lateral Deflection

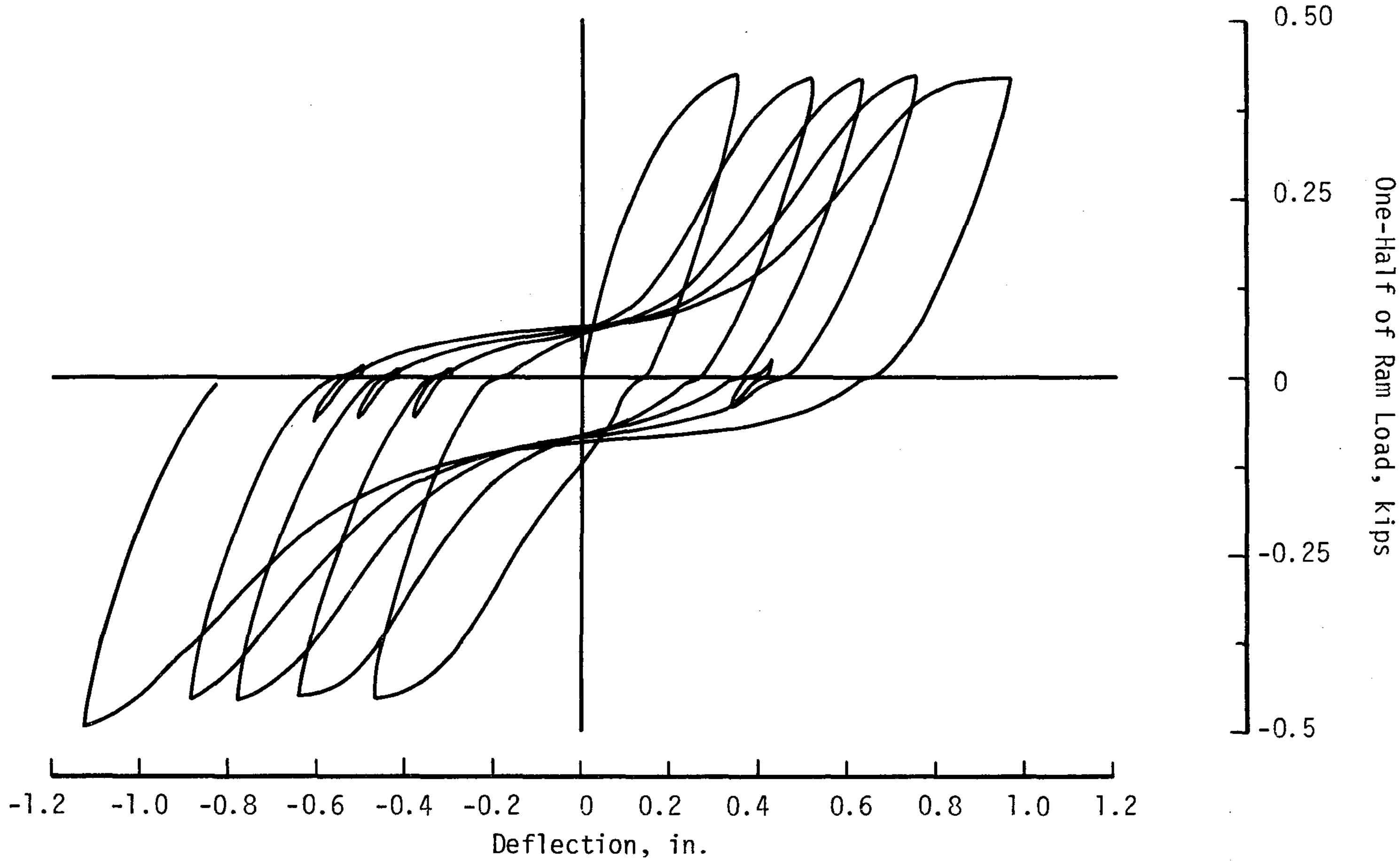


Figure 3.54 (contd) Static test. Observed Variation of Middle Level Ram Load with Middle Level Lateral Deflection

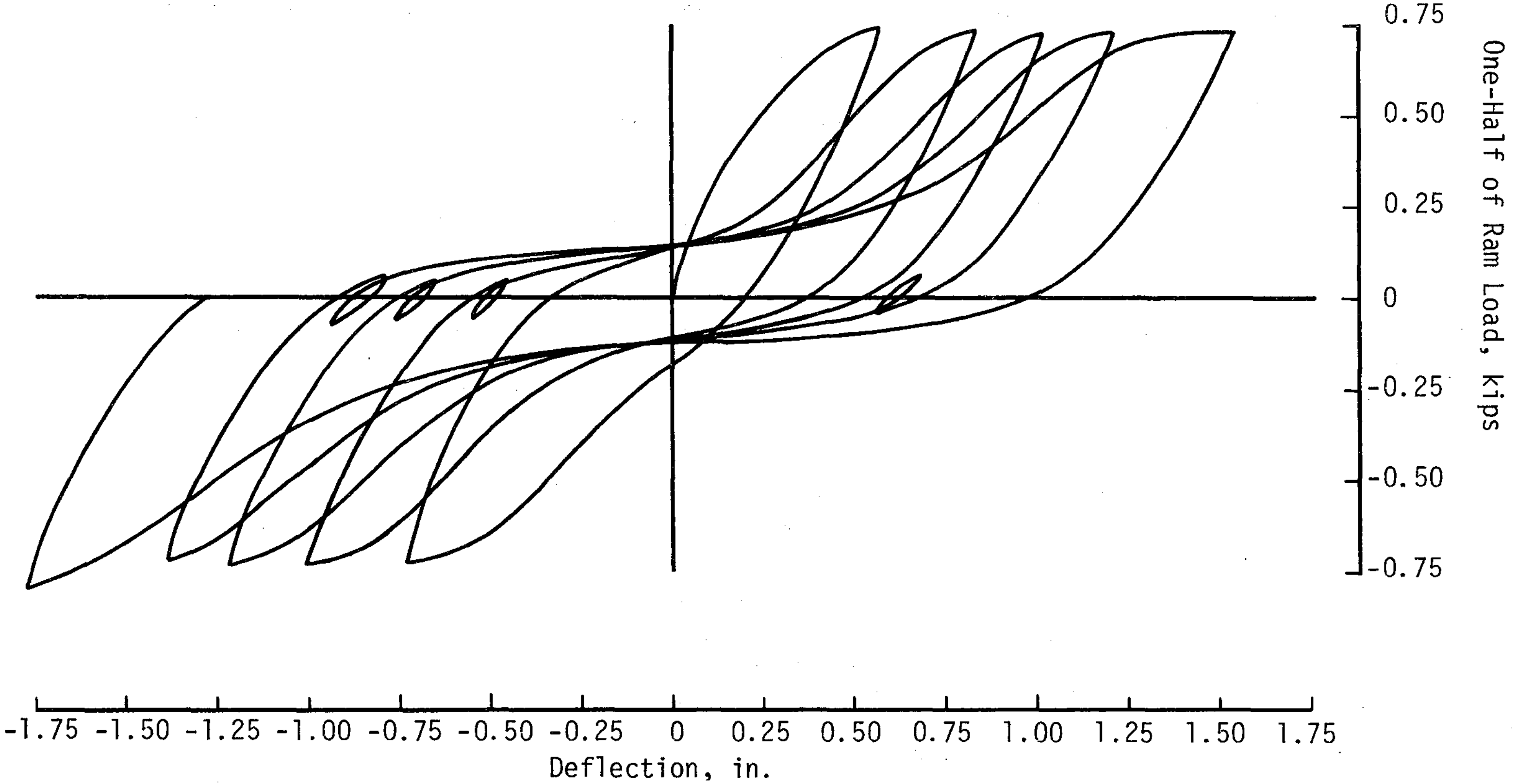


Figure 3.54 (contd.) Static Test. Observed Variation of Top Level Ram Load with Top Level Lateral Deflection

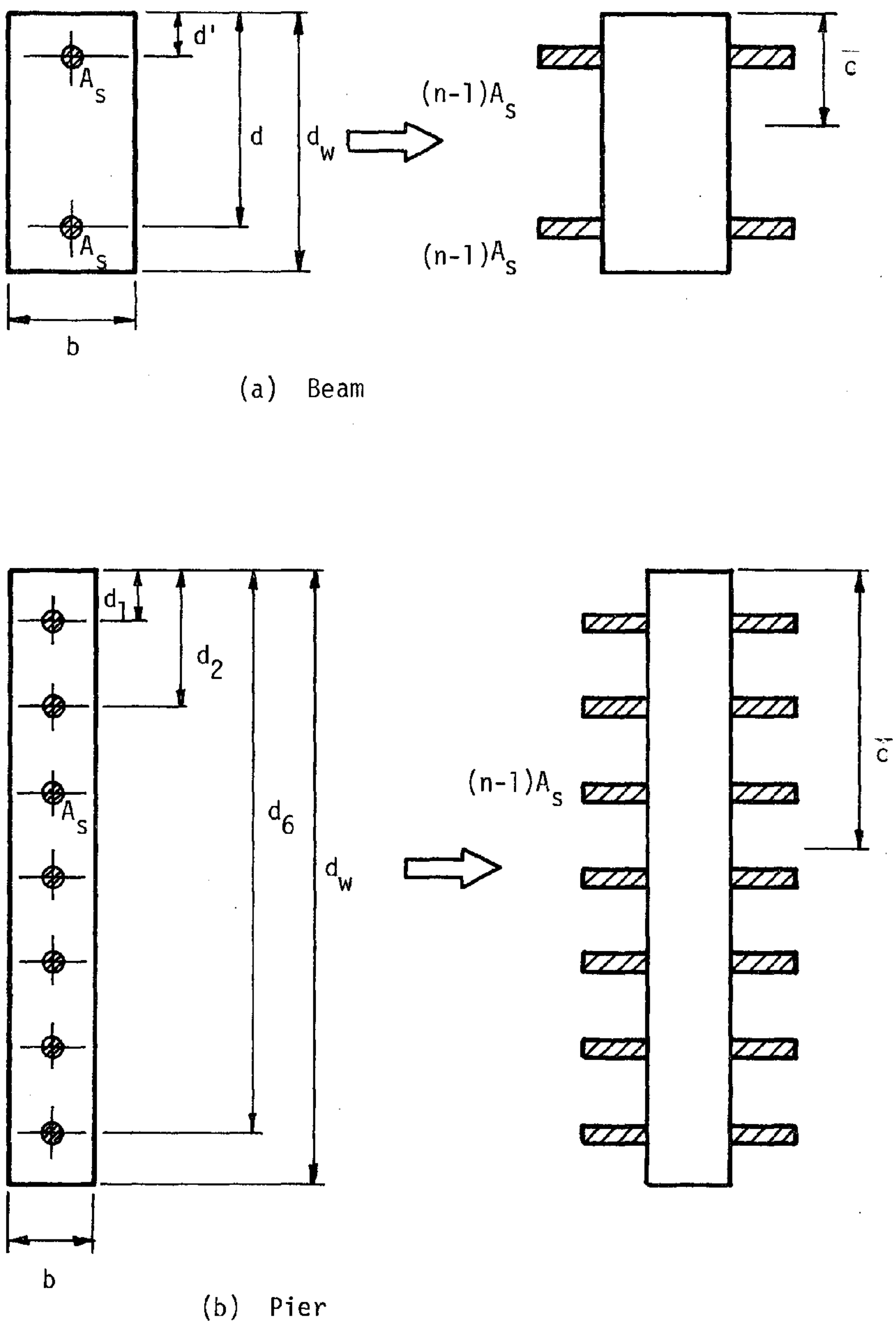


Figure 4.1 Uncracked Transformed Sections

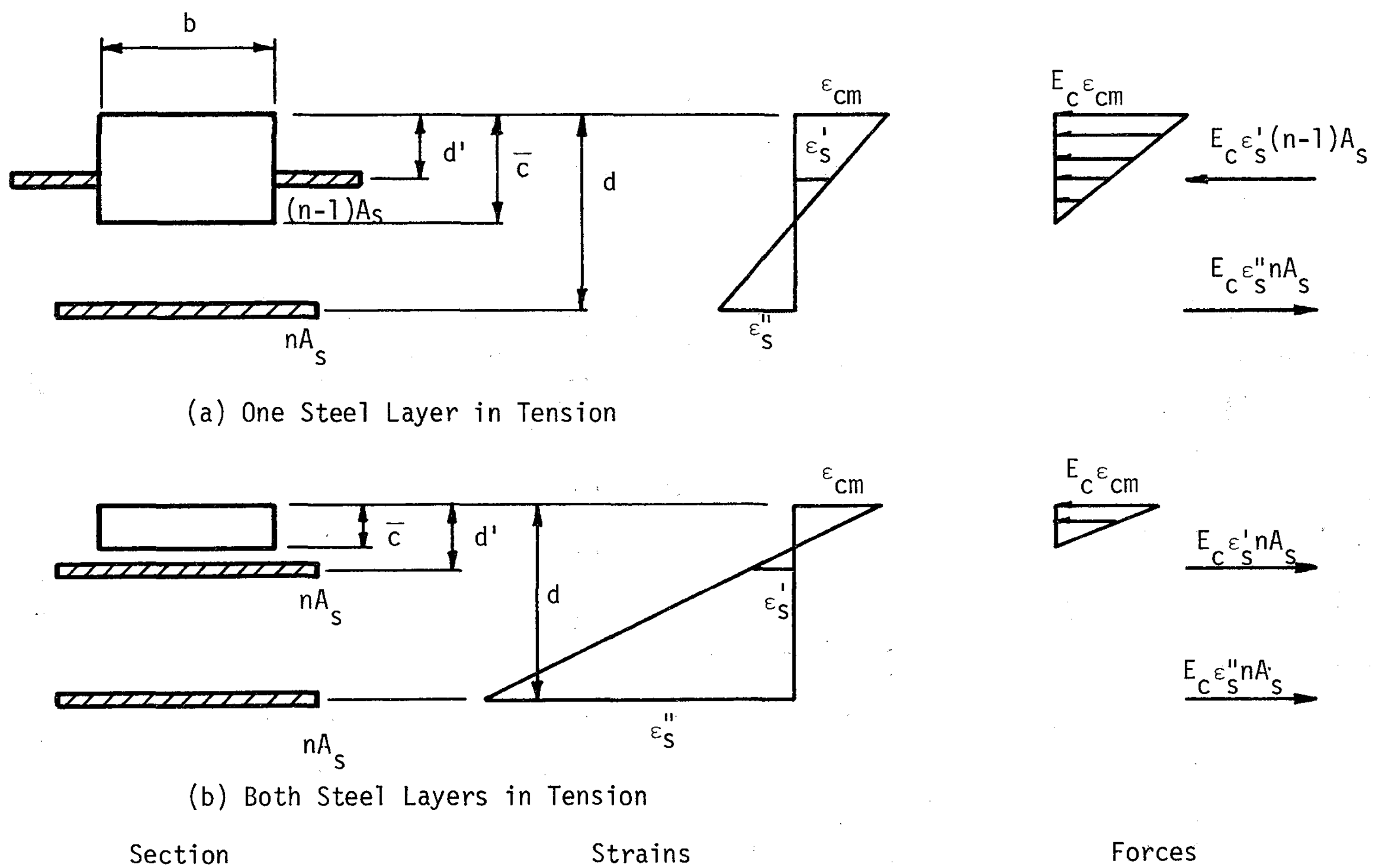


Figure 4.2 Cracked Transformed Beam Section

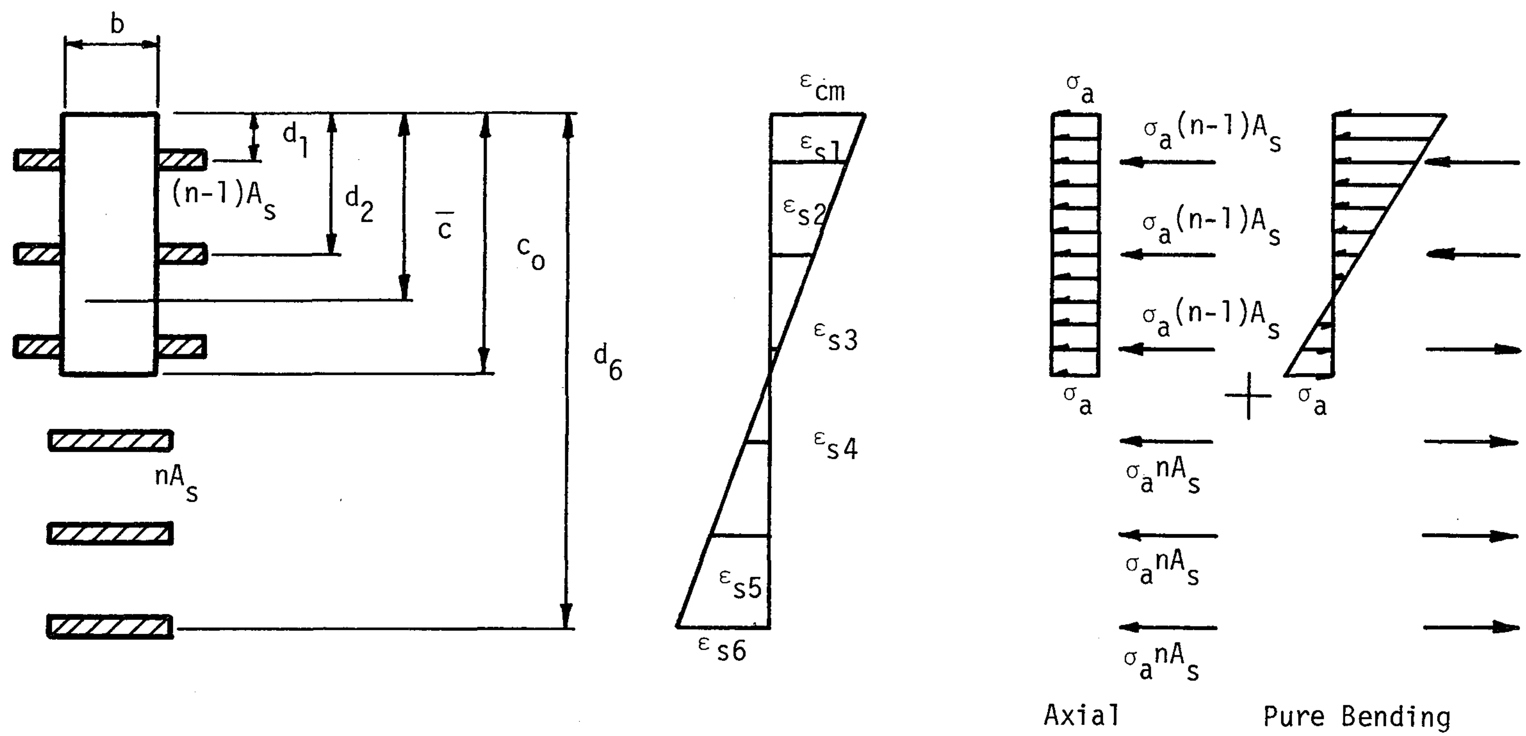


Figure 4.3 Cracked Transformed Pier Section

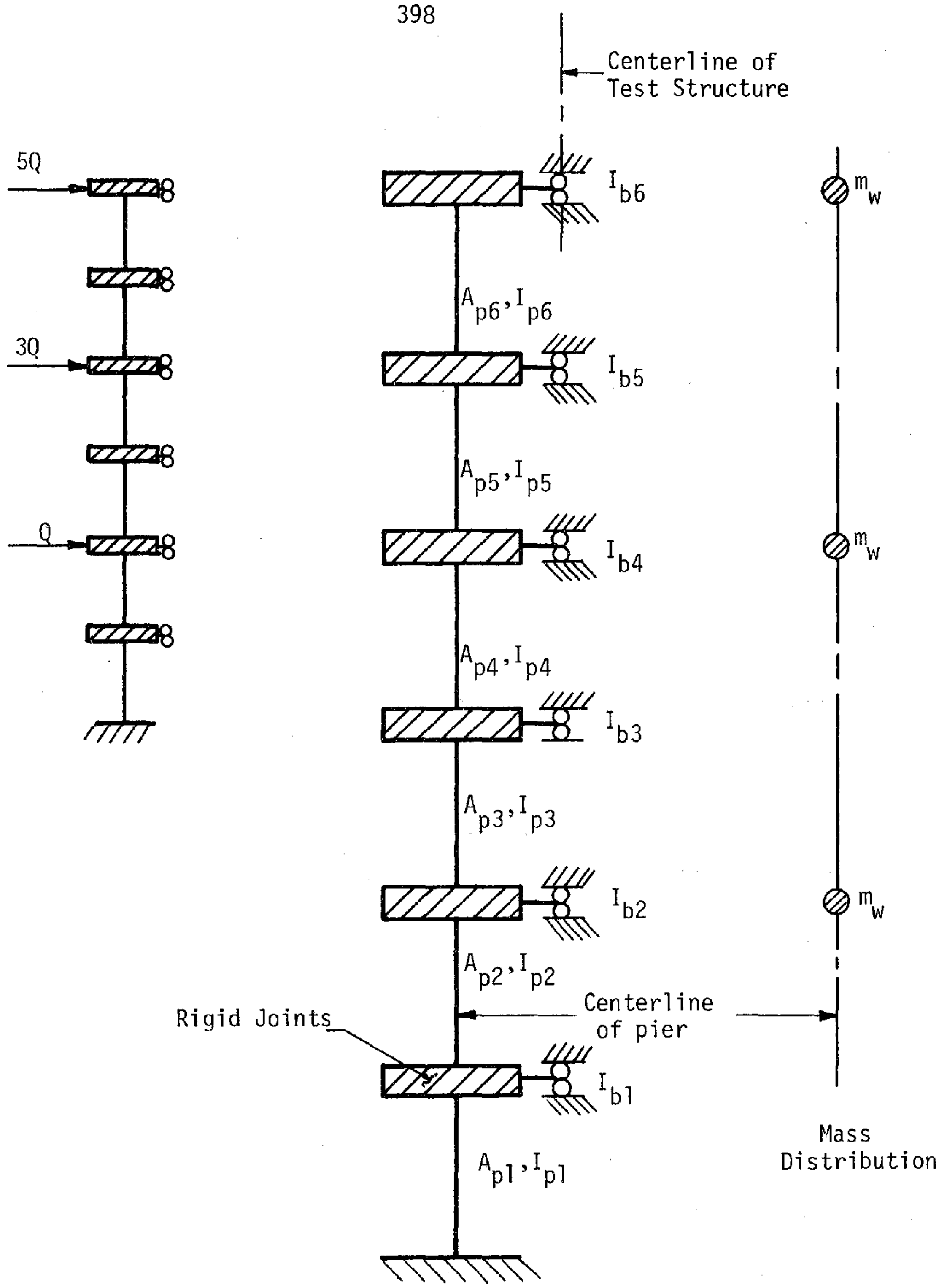
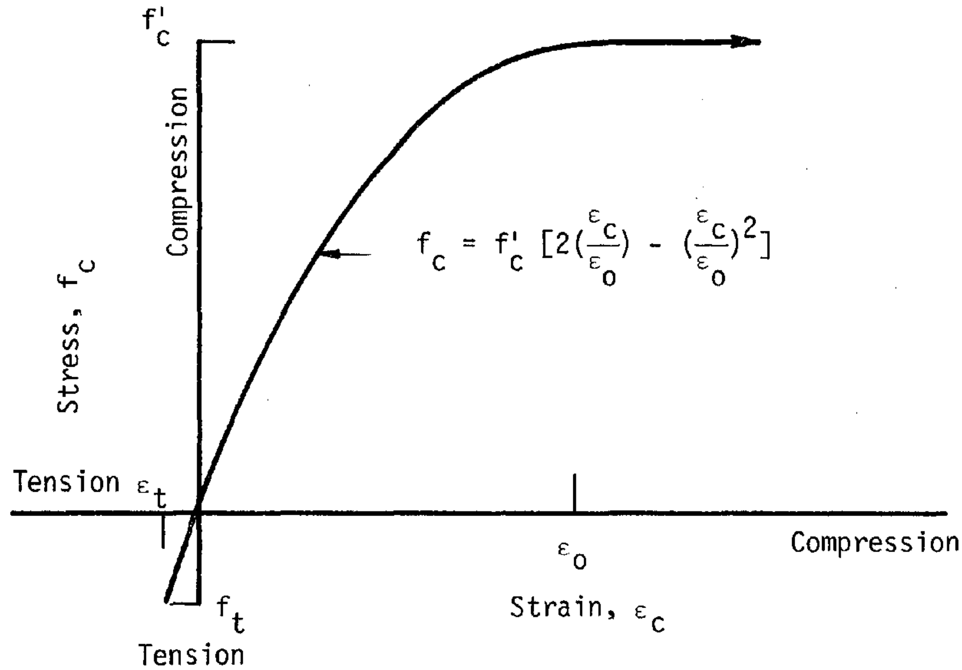
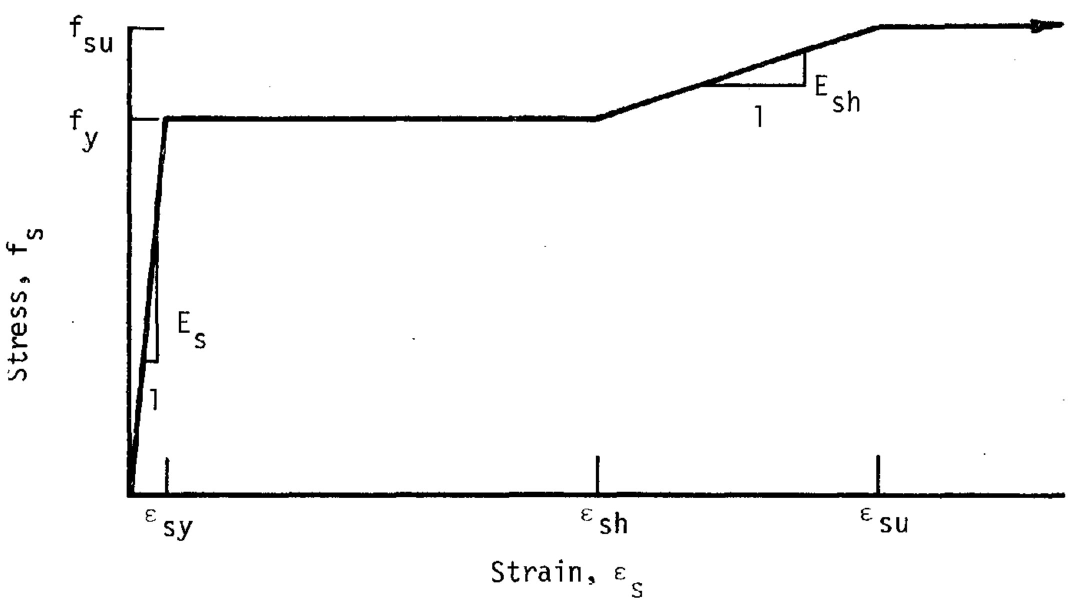


Figure 4.4 Structure Idealization for Modal Analysis and Initial Stiffness Calculation



(a) Concrete



(b) Steel

Figure 4.5 Idealized Stress-Strain Relations for Concrete and Steel

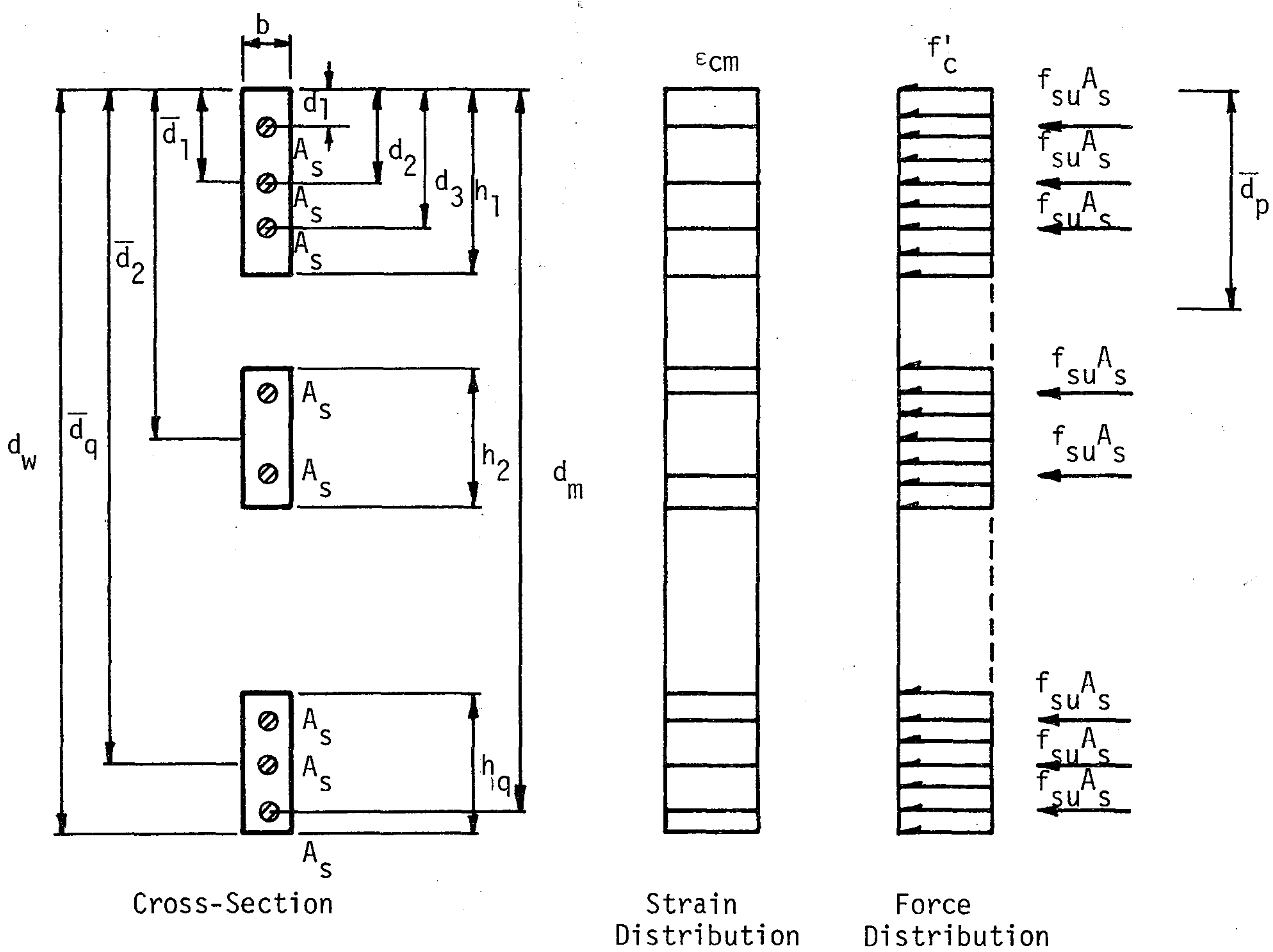


Figure 4.6 Calculation of Plastic Centroid for Cross-Section

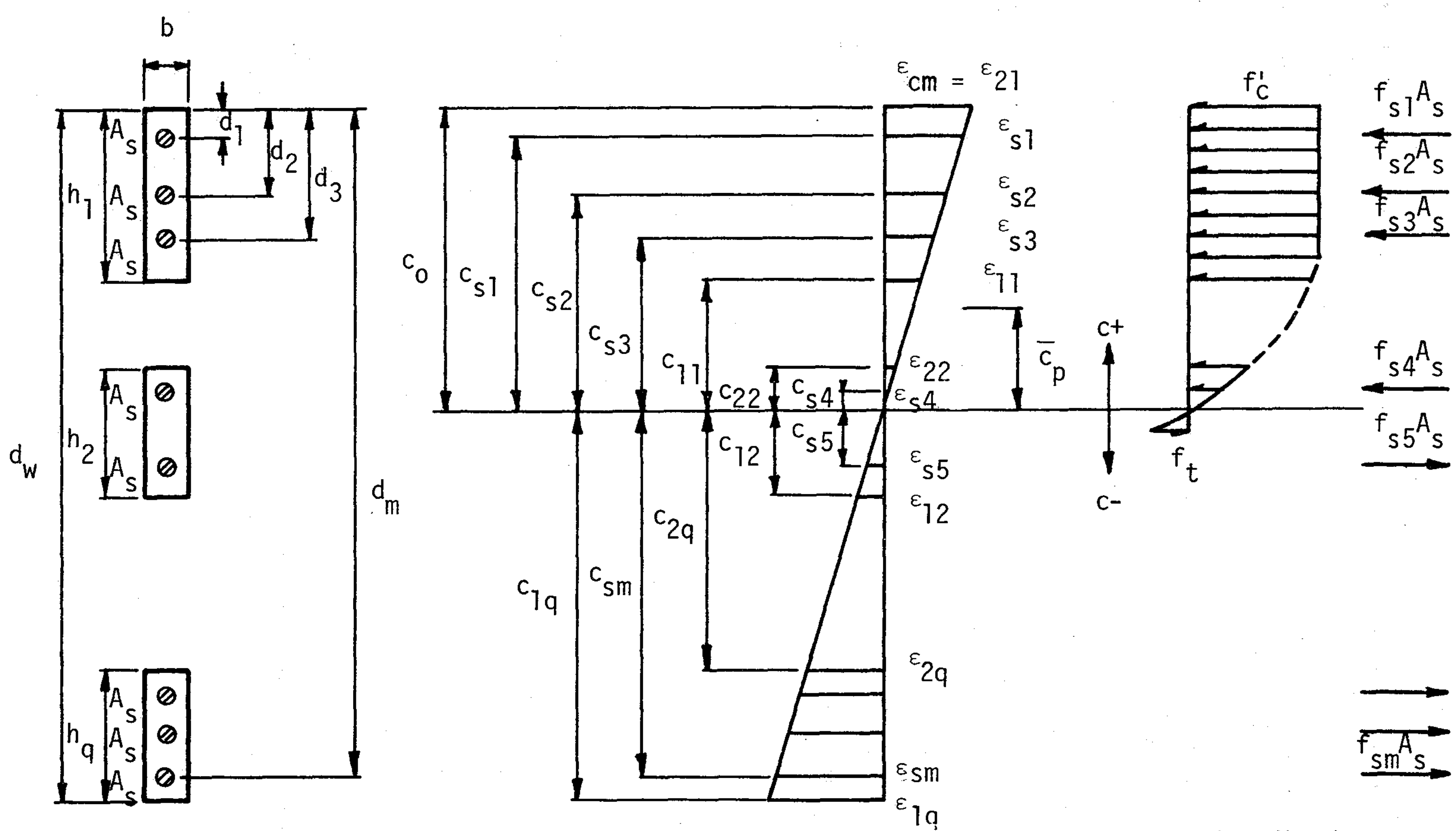


Figure 4.7 Calculation of Moment-Axial Load Interaction and Moment-Curvature Relations

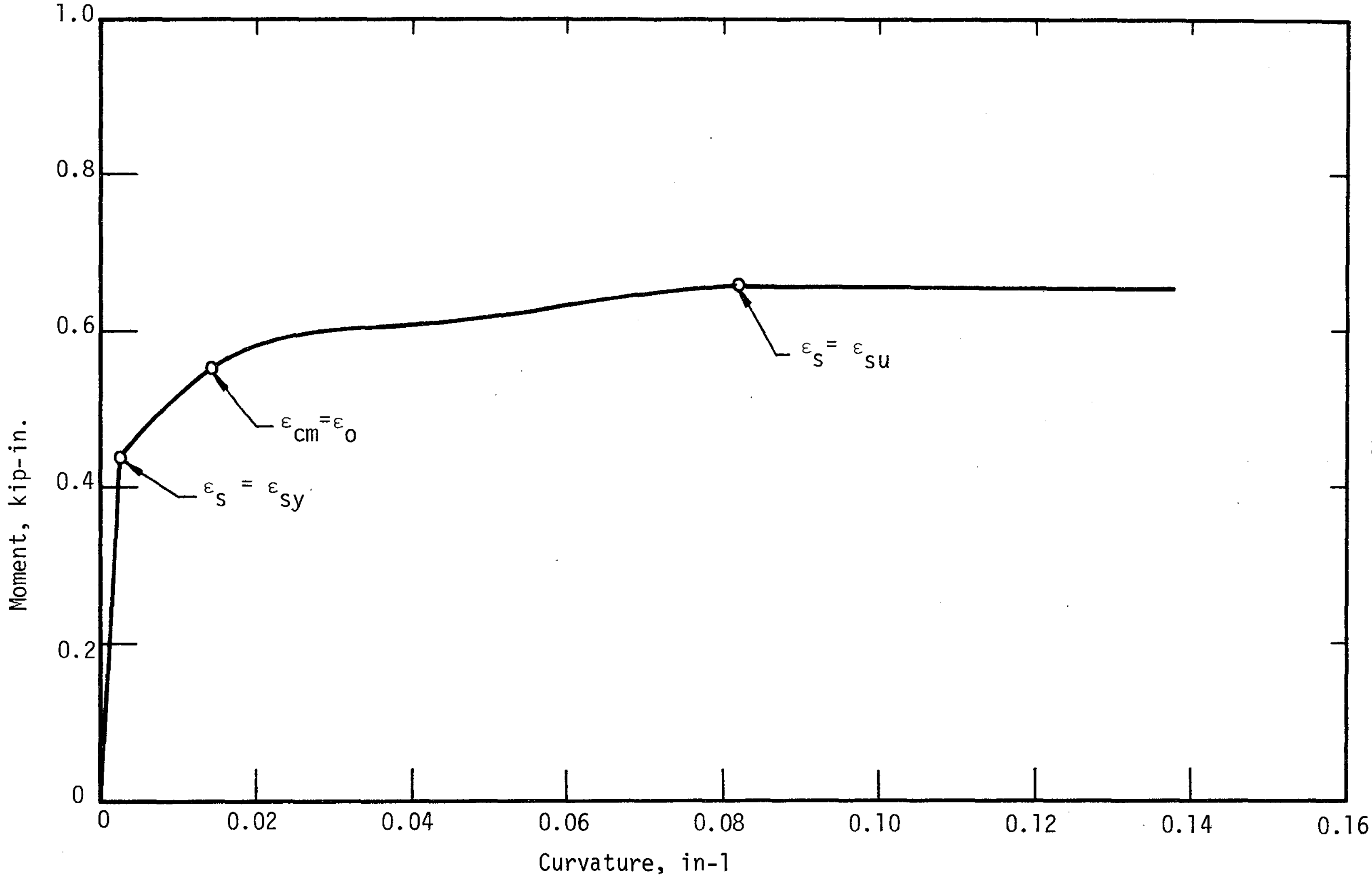


Figure 4.8 Sample Moment-Curvature Relation for Beam Section Computed from Measured Dimensions. Static Test Structure

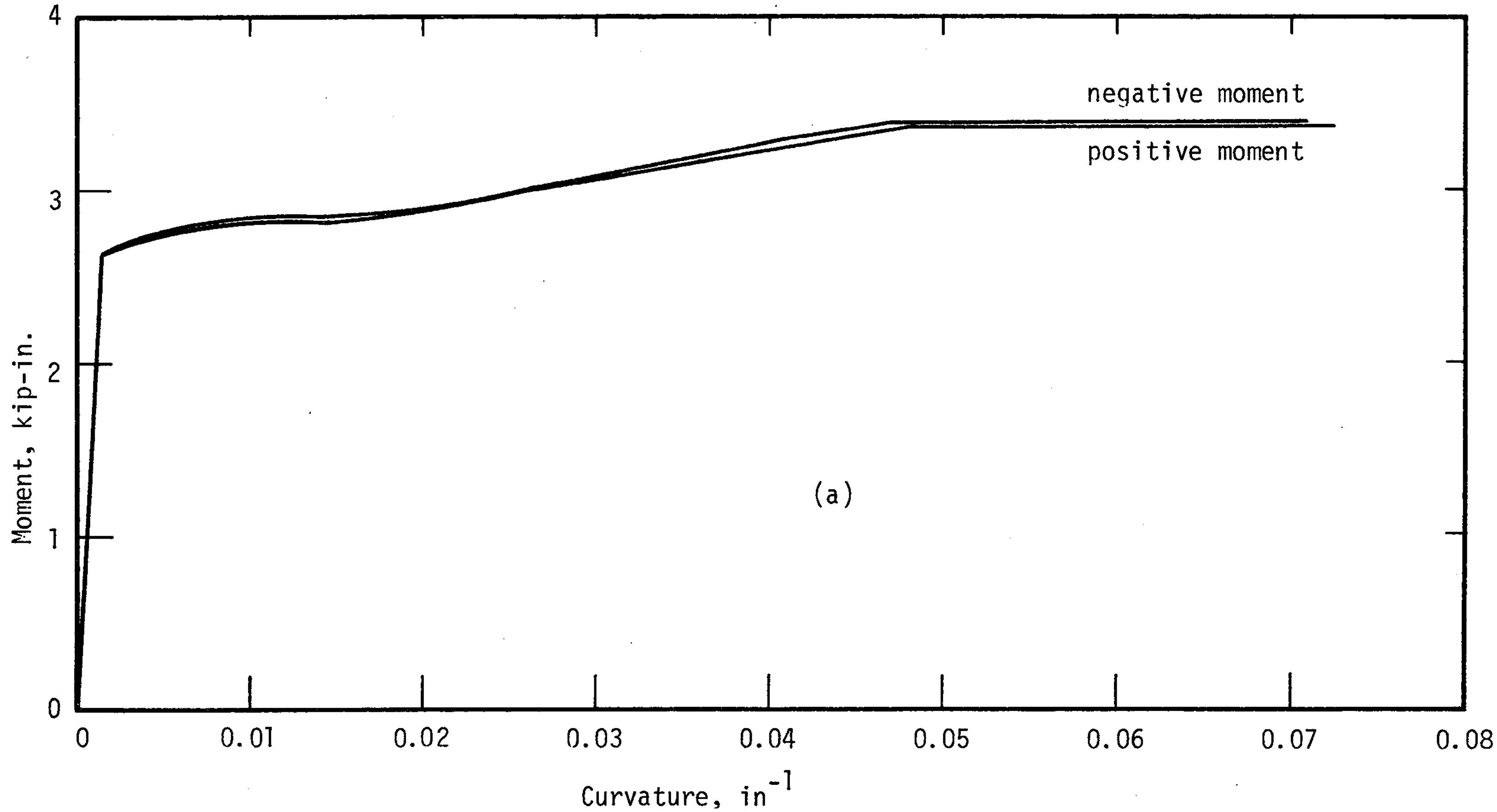


Figure 4.9 Moment-Curvature Relation for Beam Section Computed from Measured Dimensions, Type A Test Structure

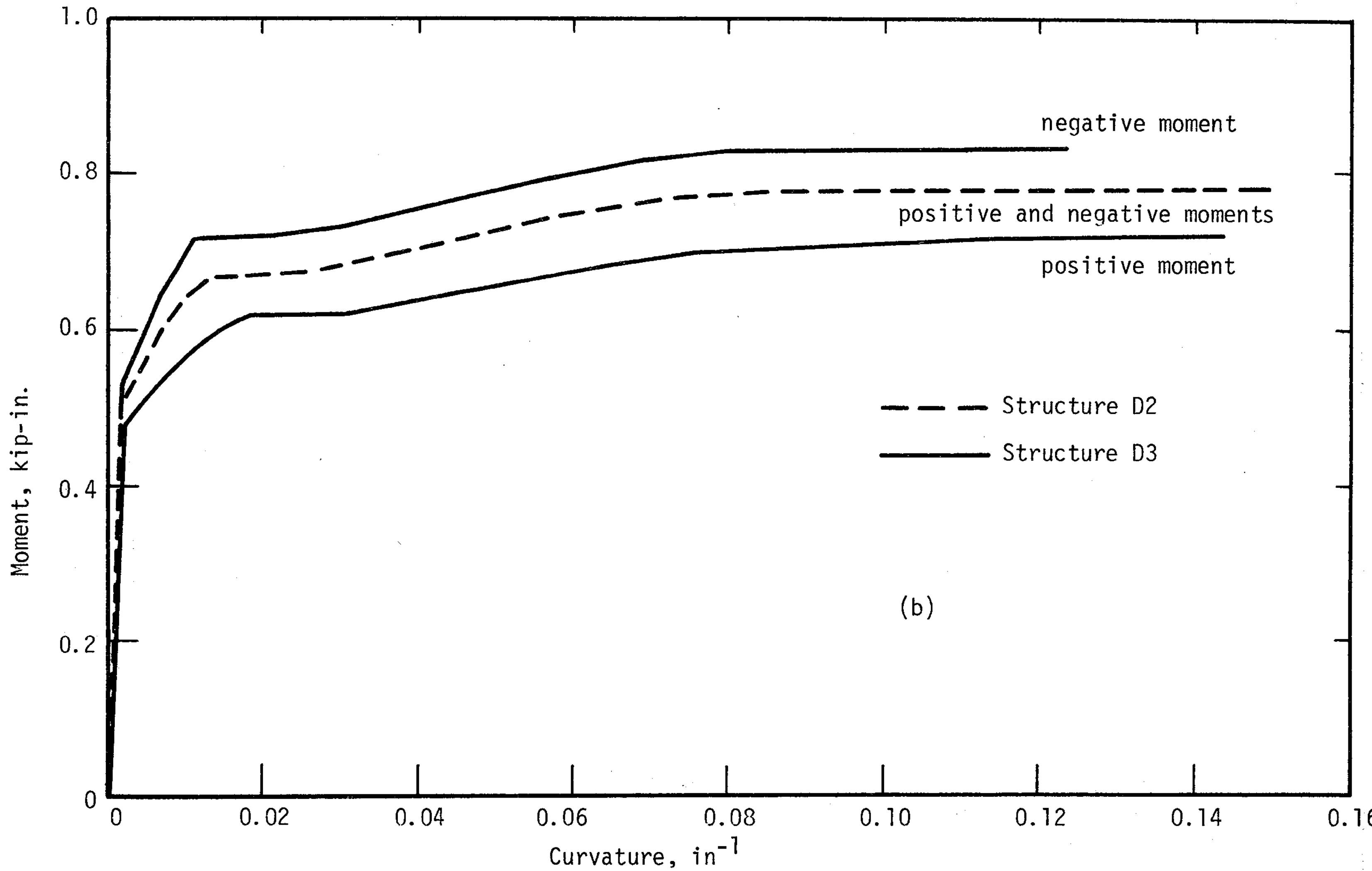


Figure 4.9 (contd.) Moment-Curvature Relation for Beam Section Computed from Measured Dimensions. Type B Test Structure

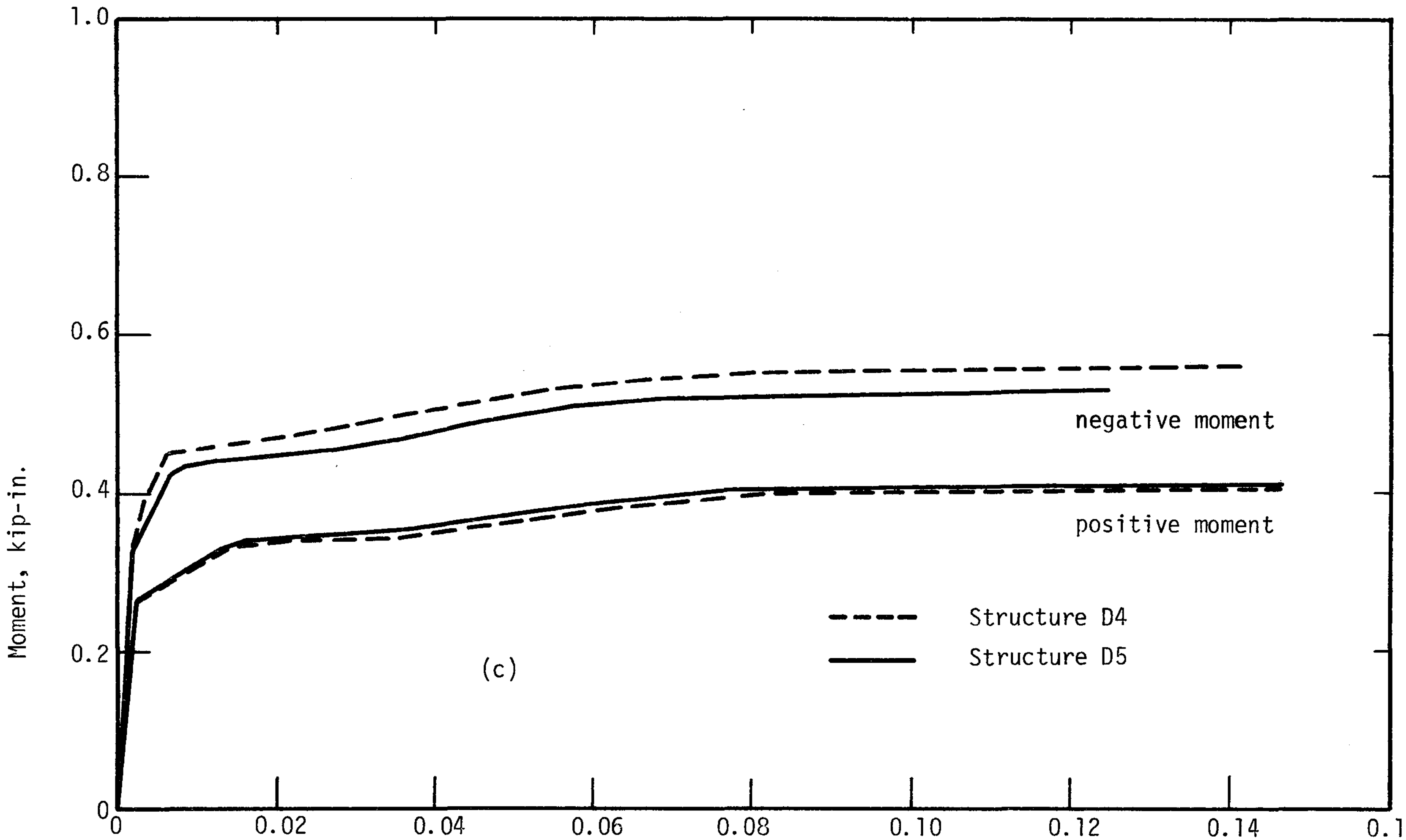


Figure 4.9 (contd.) Moment-Curvature Relation for Beam Section Computed from Measured Dimensions. Type C Test Structure

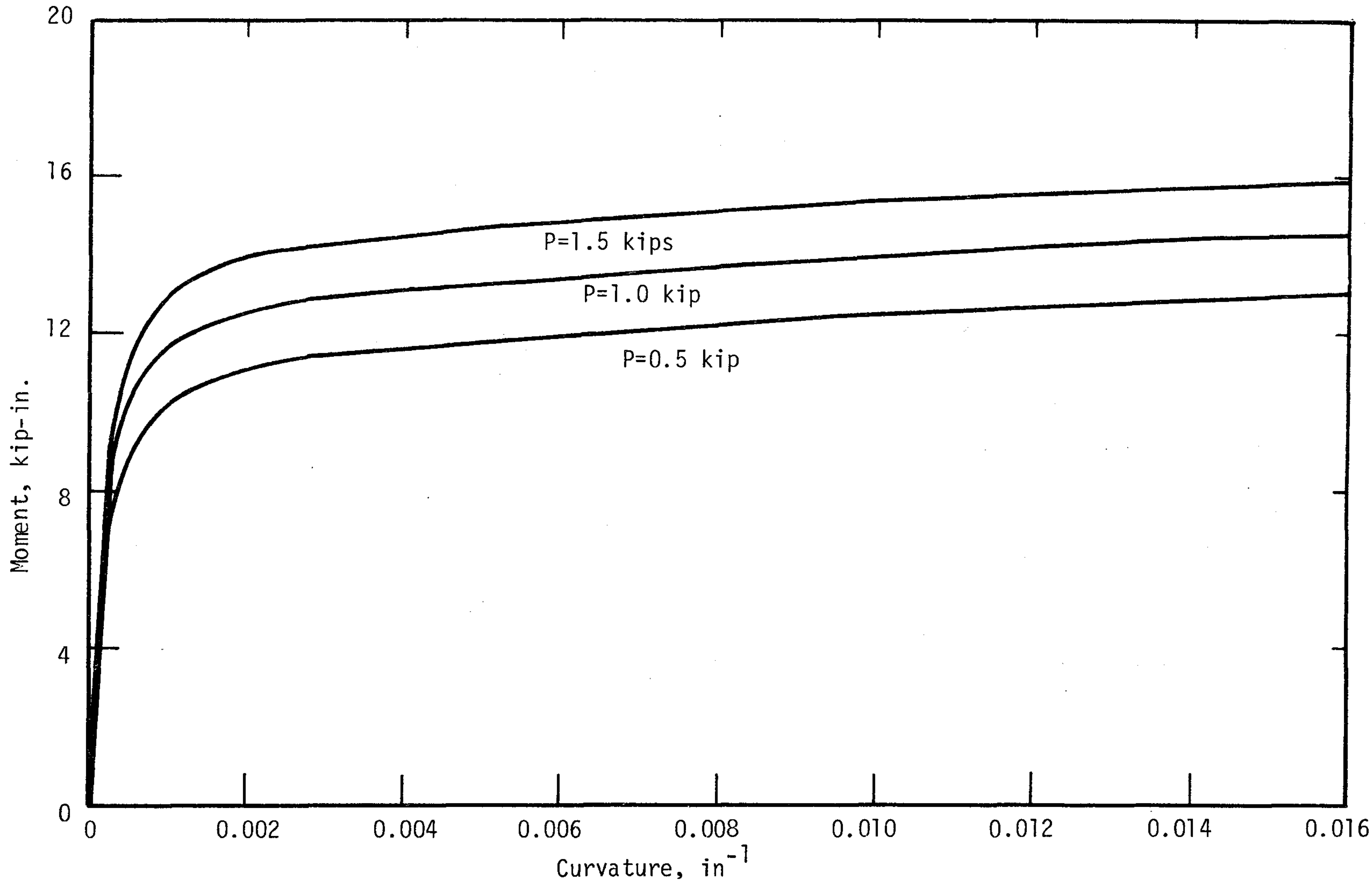


Figure 4.10 Moment-Curvature Relations for Pier Section Computed from Measured Dimensions - Test Structure S1

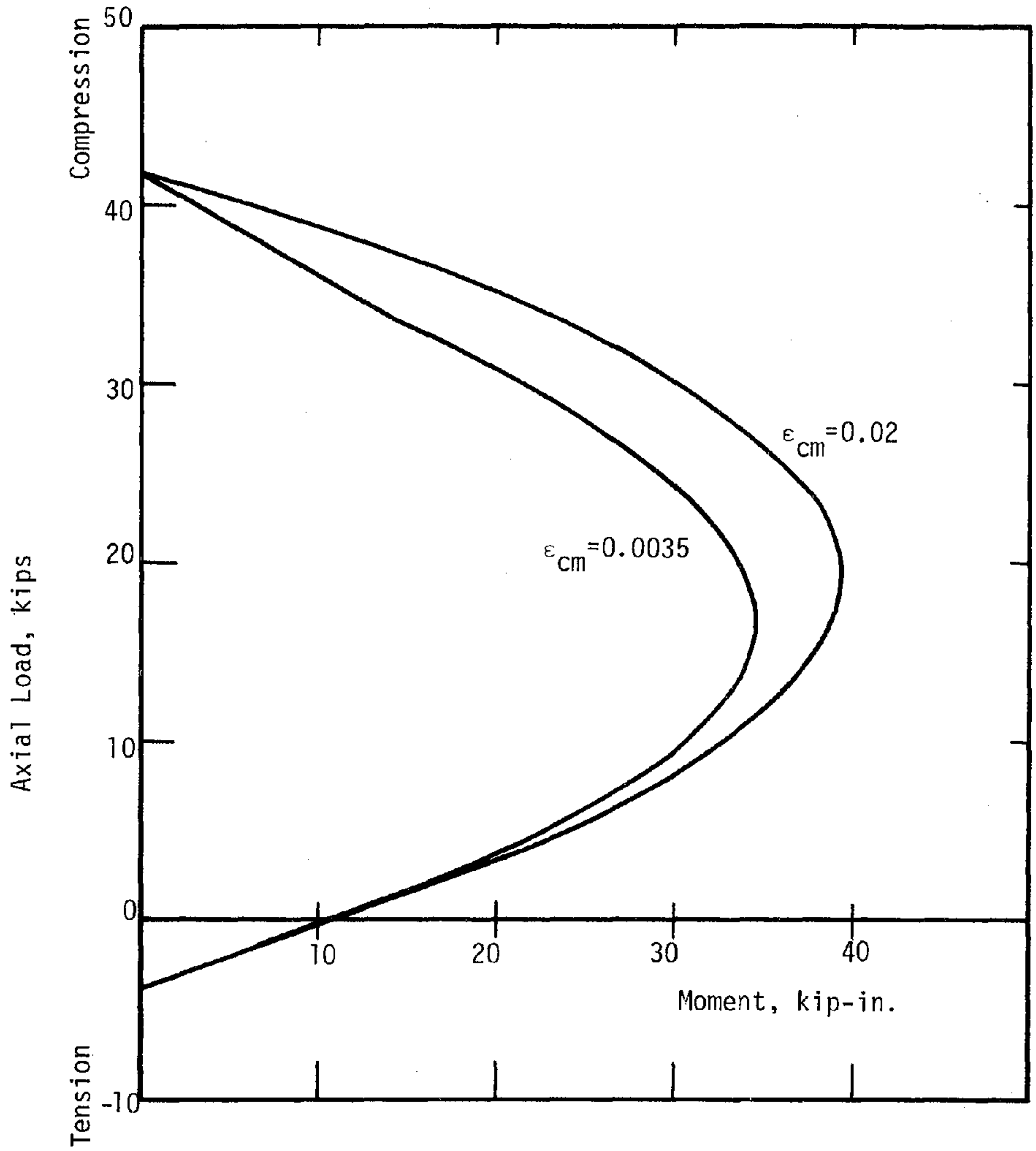


Figure 4.11 Moment-Axial Load Interaction Relation for Pier Section Computed from Measured Dimensions. Test Structure S1

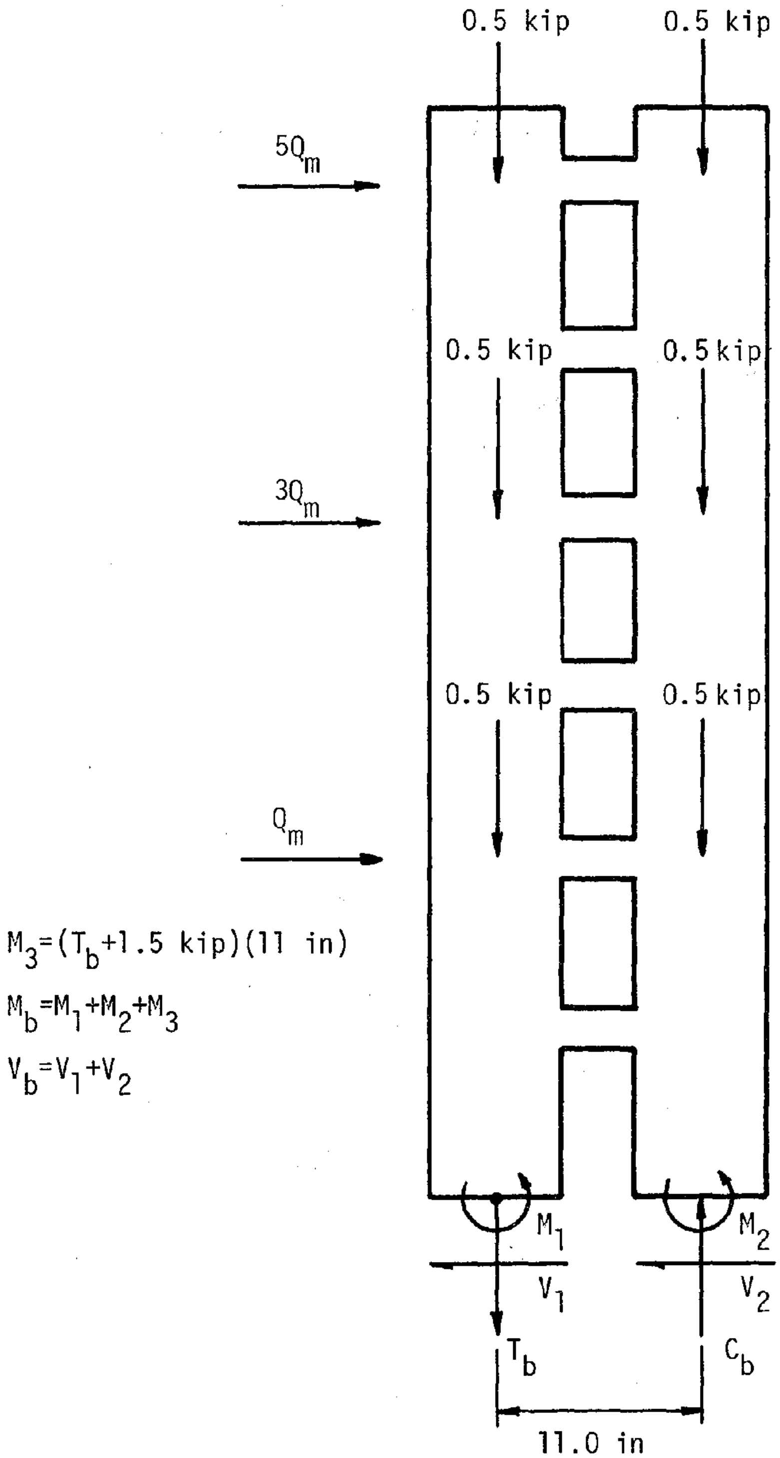


Figure 4.12 Loading and Definition of Reactions for Computed Failure Mechanisms

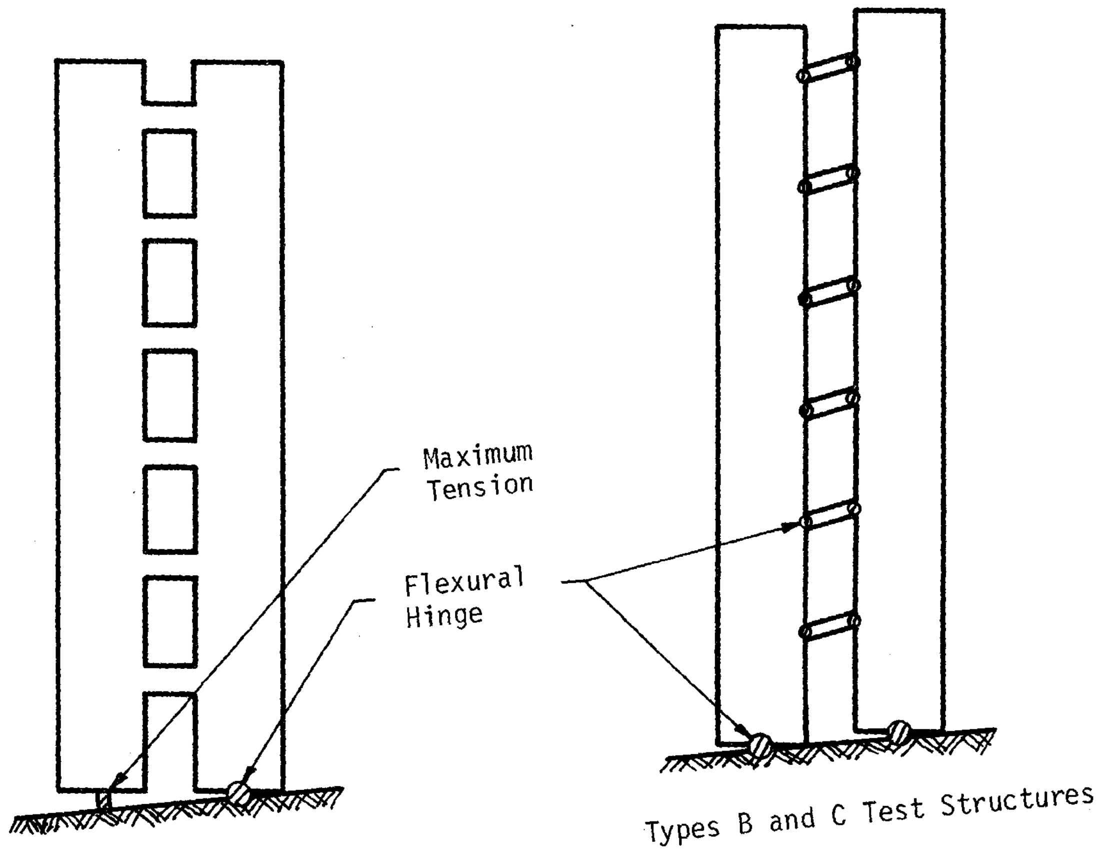


Figure 4.13 Computed Failure Mechanisms for Test Structures

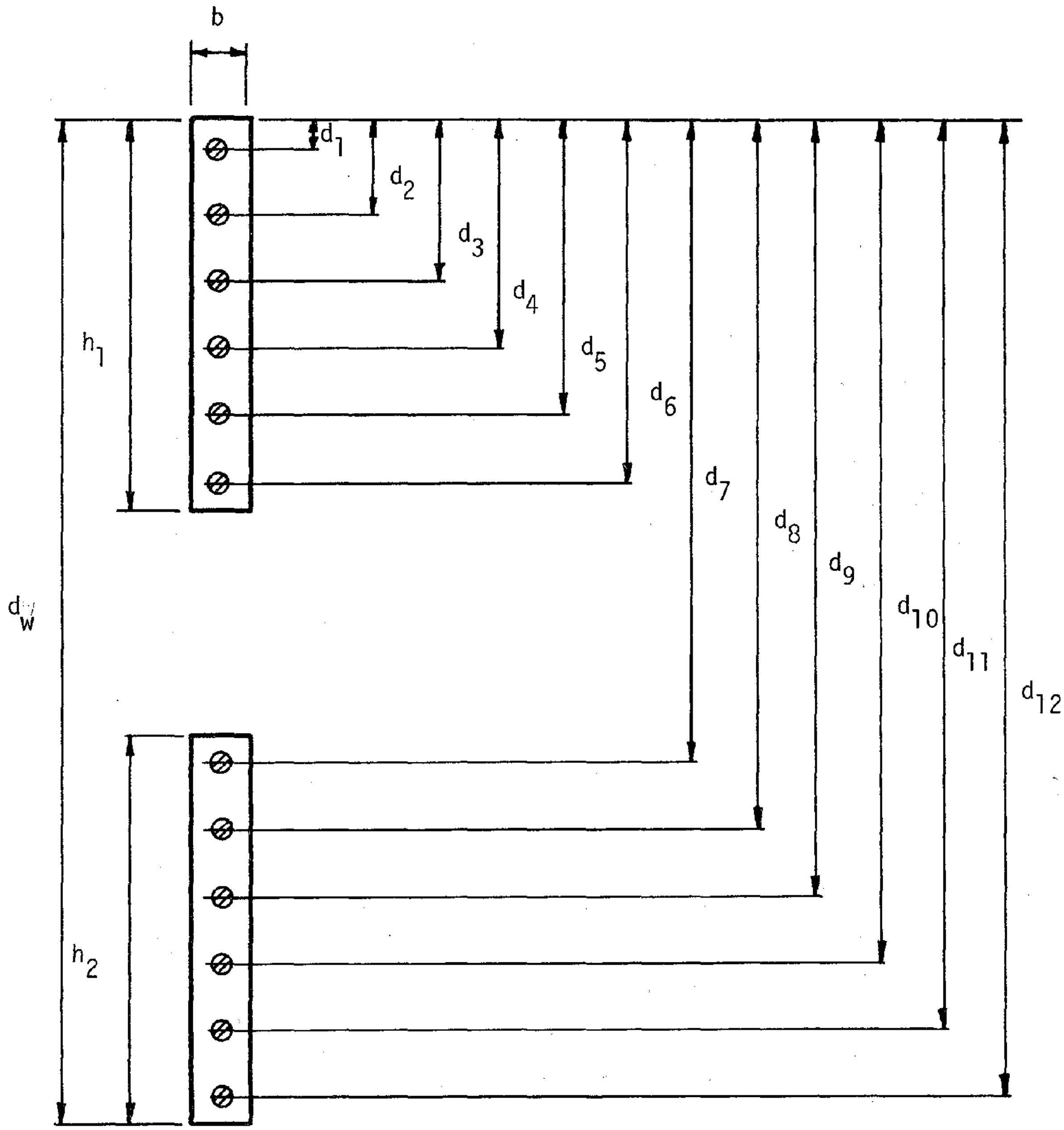


Figure 4.14 Section Used to Calculate Maximum Base Moment of One Wall as a Cantilever

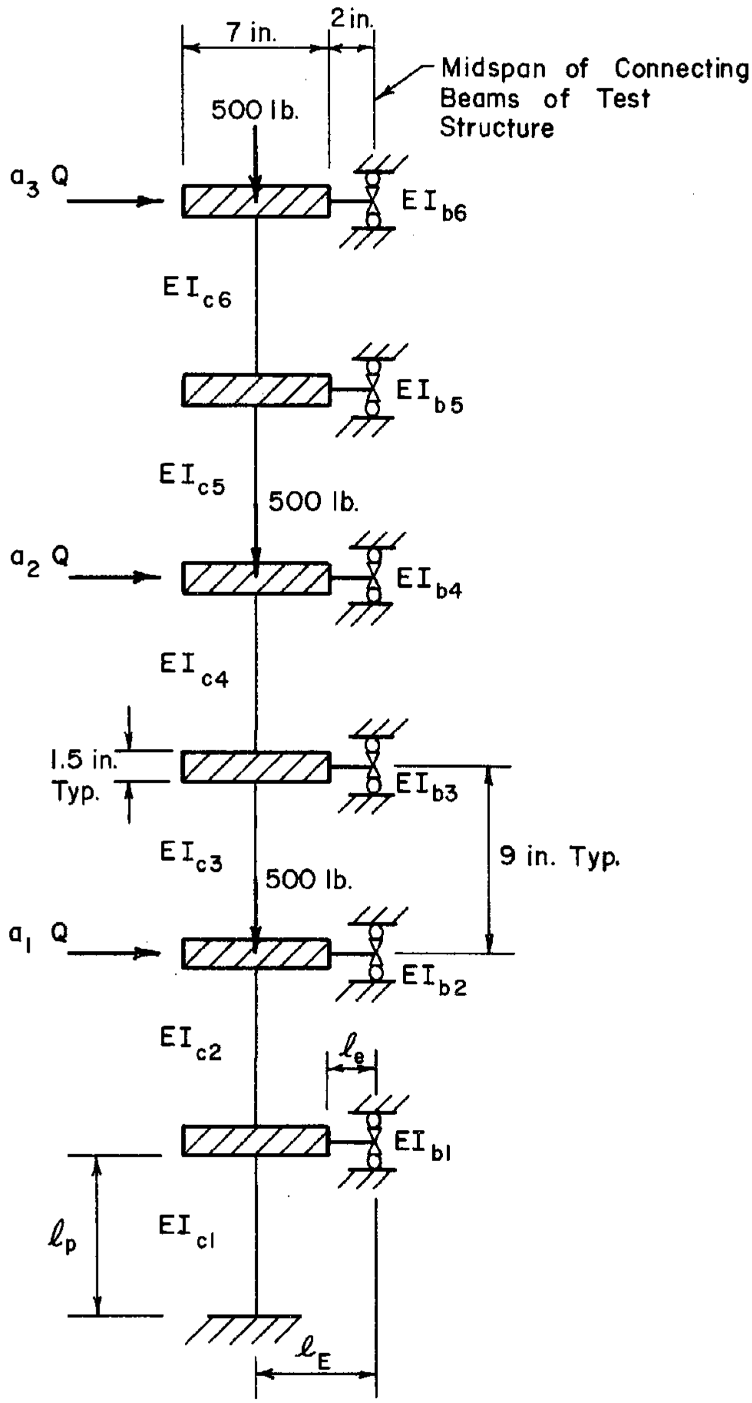


Figure 5.1 Analytical Model for Static Loading

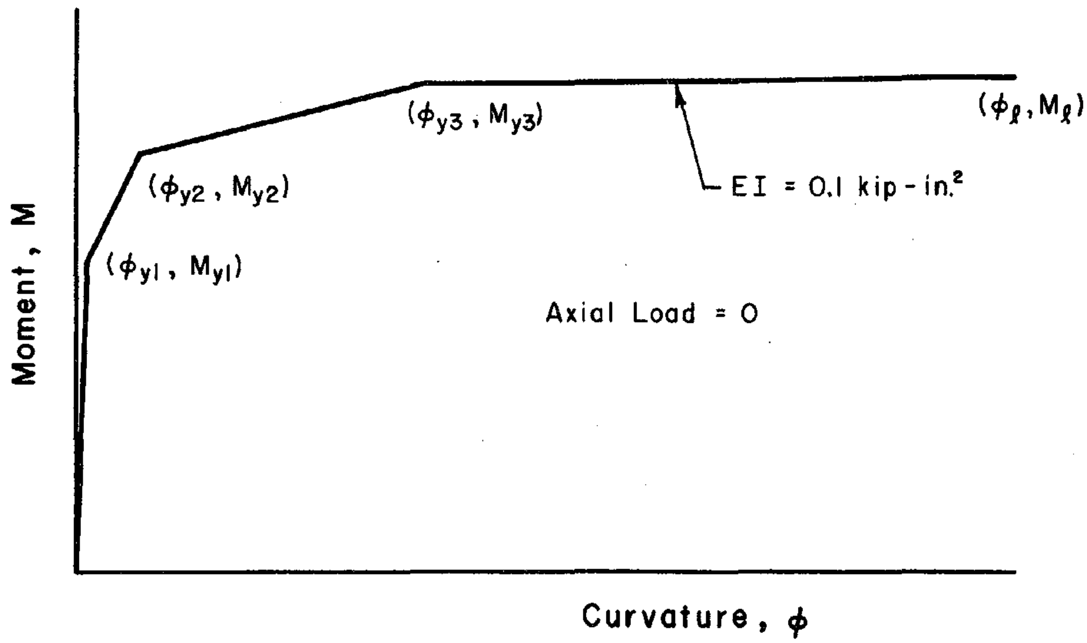


Figure 5.2 Idealized Moment-Curvature Relation for Beam Section

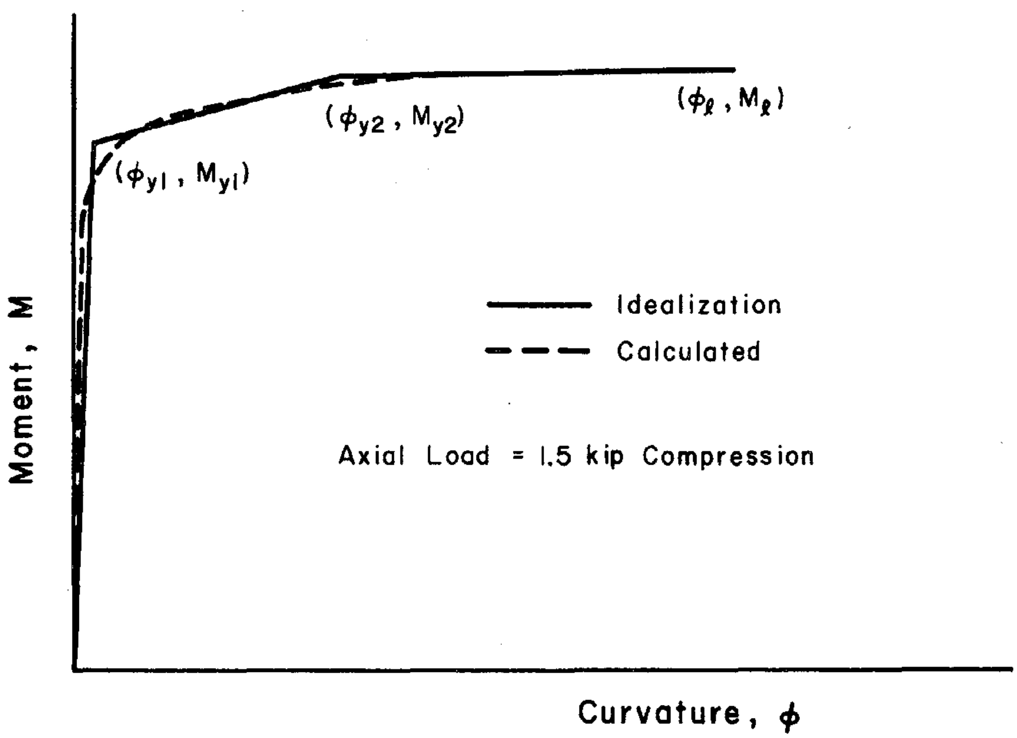


Figure 5.3 Idealized Moment-Curvature Relation for Pier Section

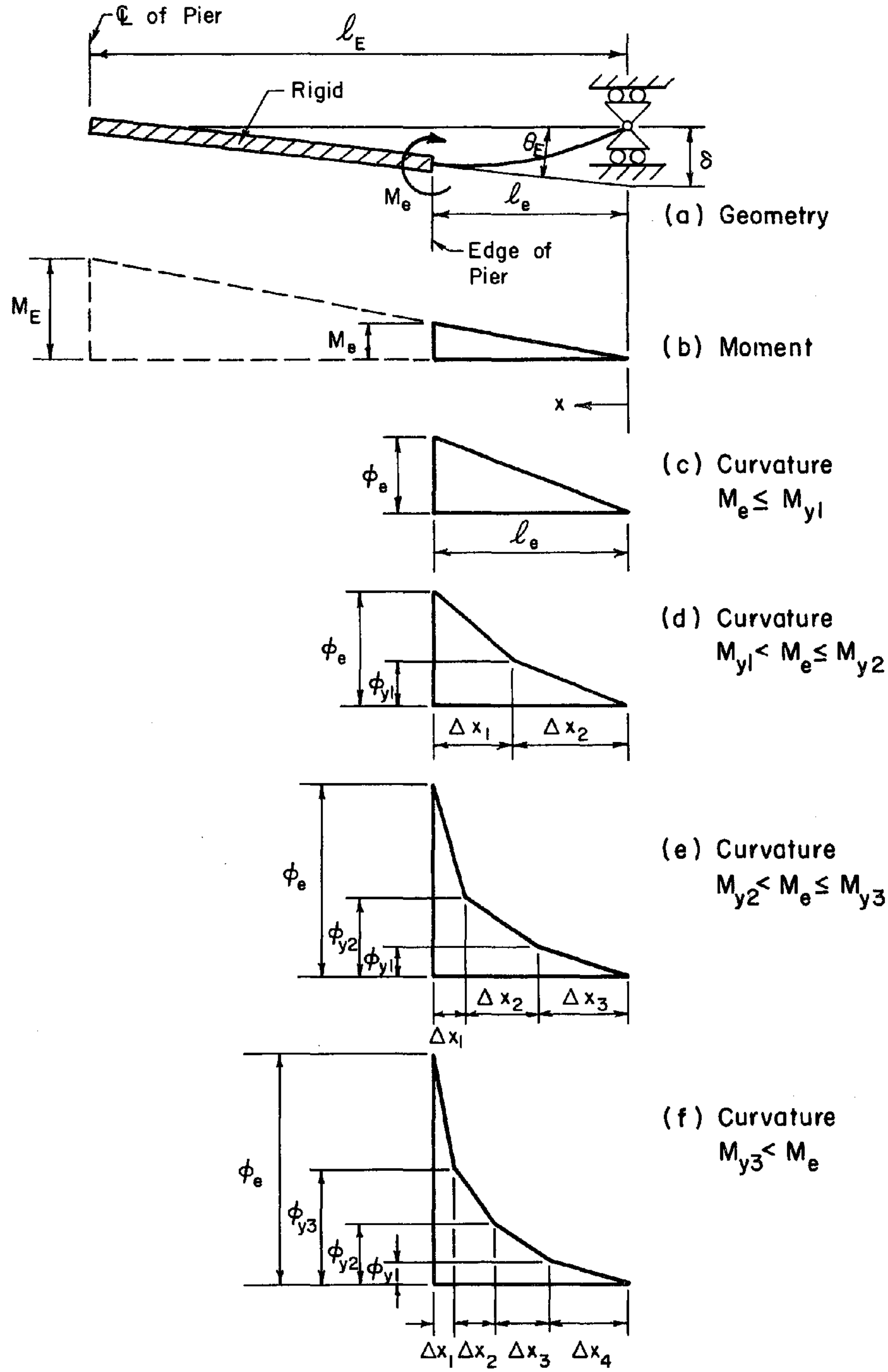


Figure 5.4 Calculation of Moment-Rotation Relation for Connecting Beams

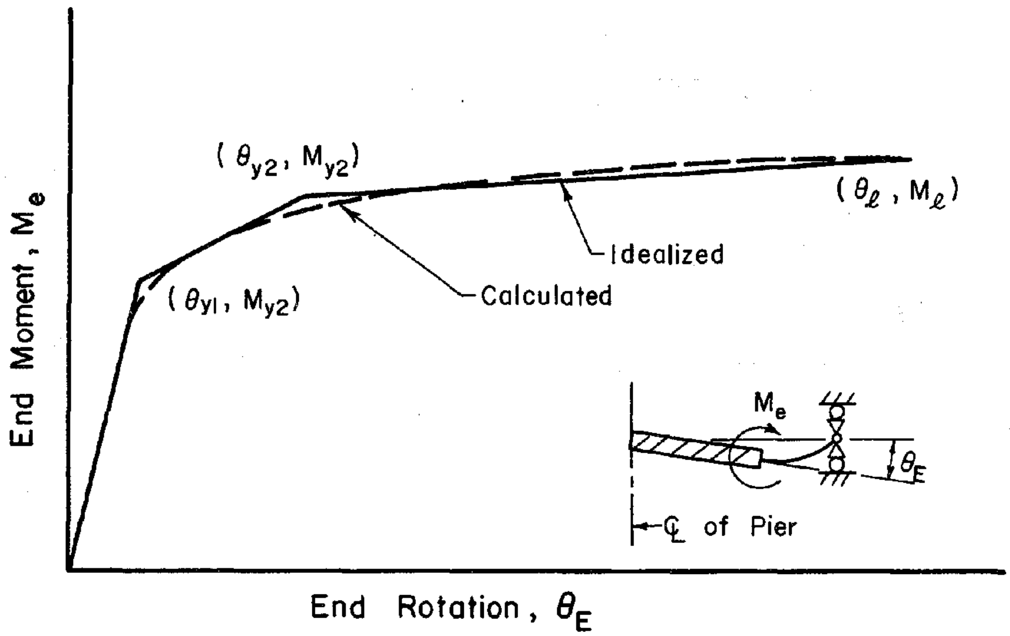


Figure 5.5 Moment-Rotation Relation for Beams

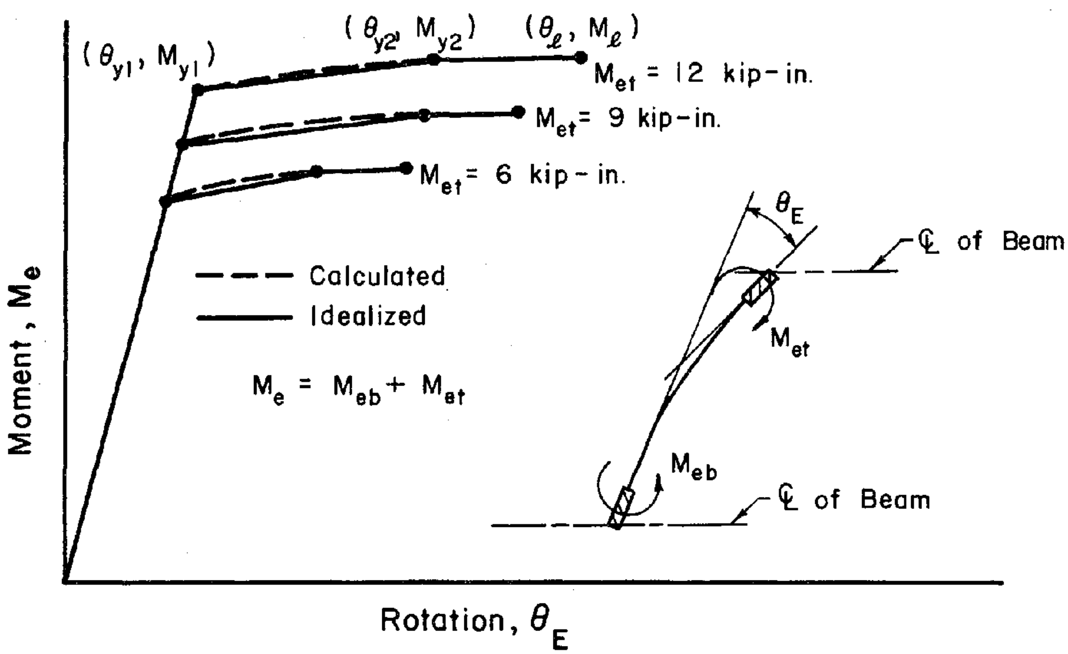


Figure 5.6 Moment-Rotation Relation for Lower Story Pier

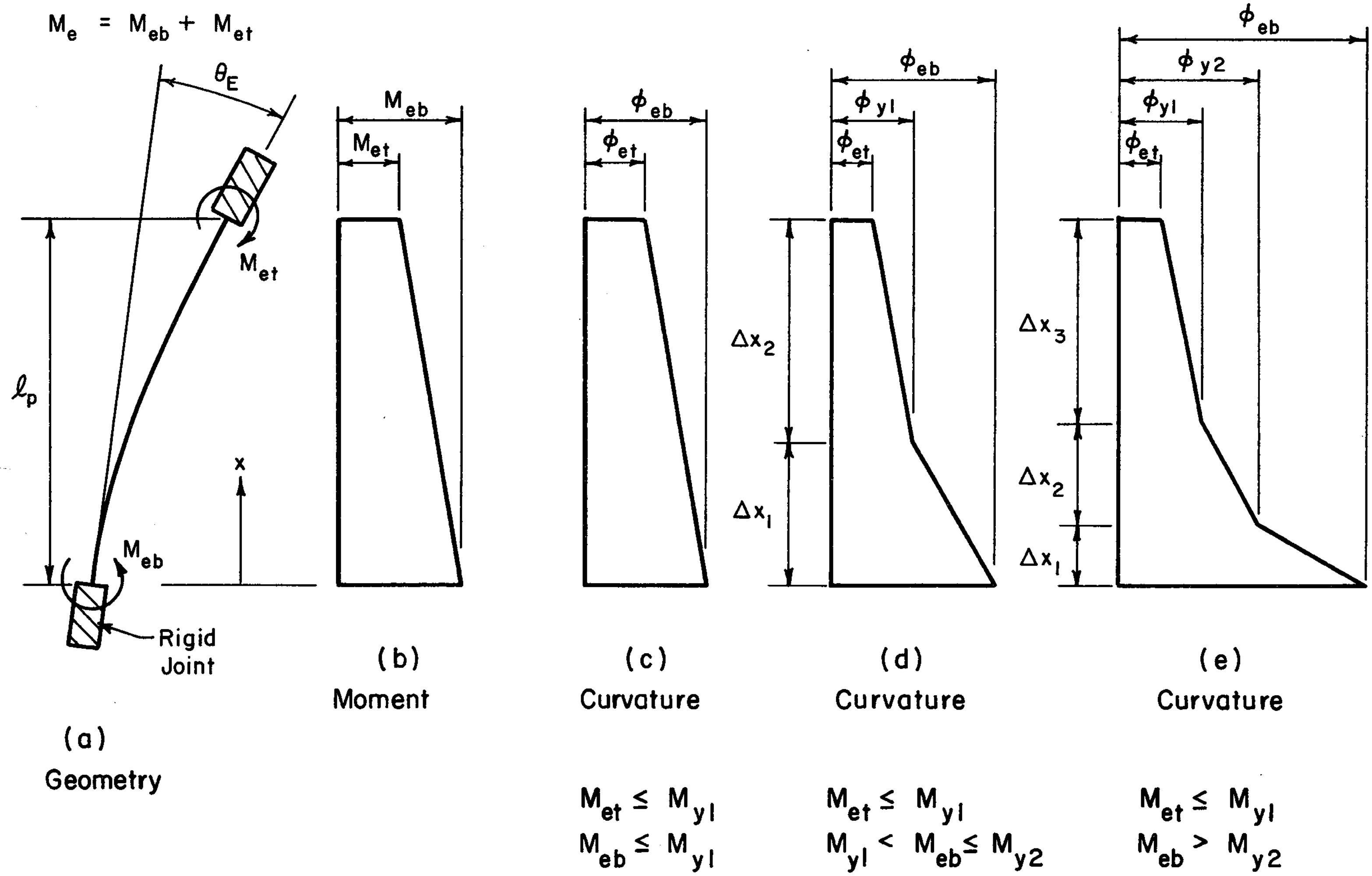


Figure 5.7 Calculation of Moment-Rotation Relation for Piers

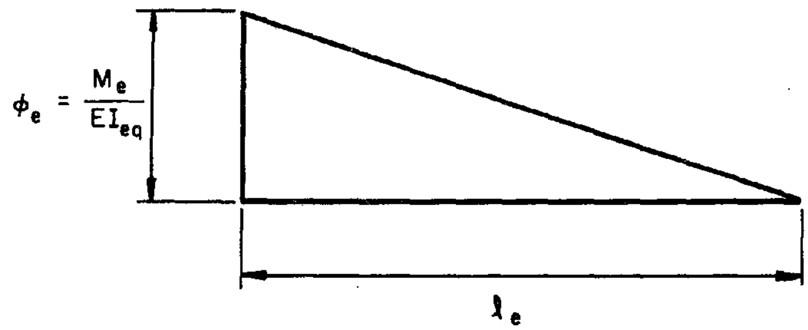


Figure 5.8 Curvature Distribution for Equivalent Uniform Beam Member

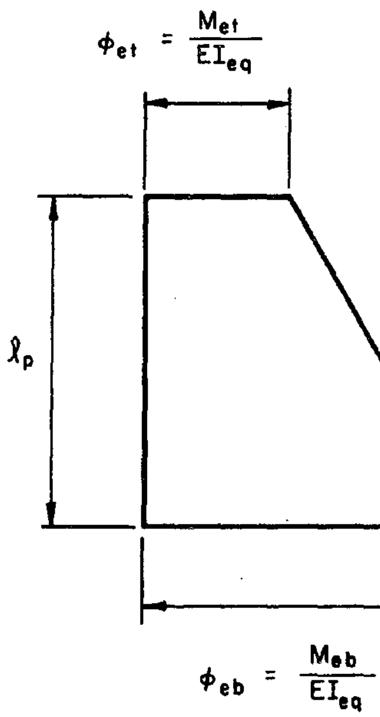


Figure 5.9 Curvature Distribution for Equivalent Uniform Pier Member

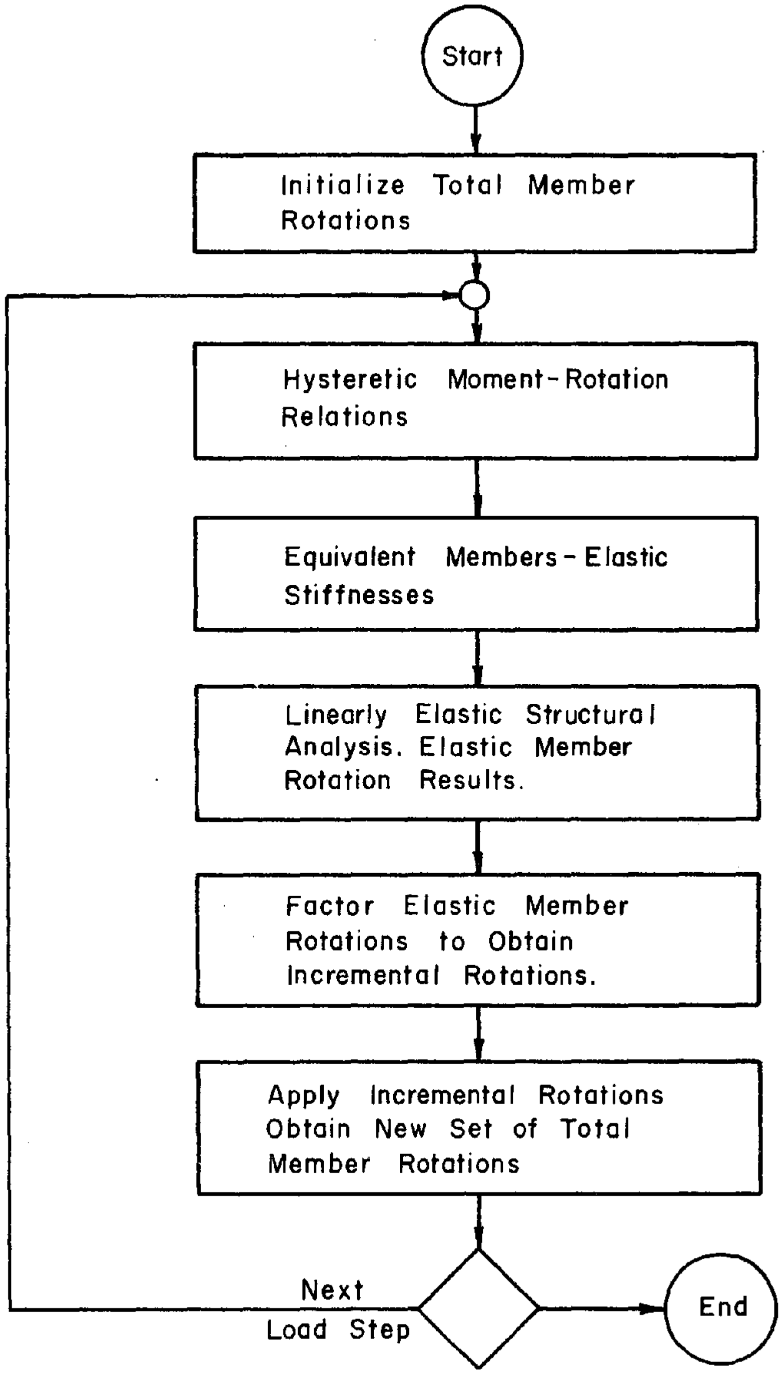


Figure 5.10 Outline of Calculations for Static Analytical Model

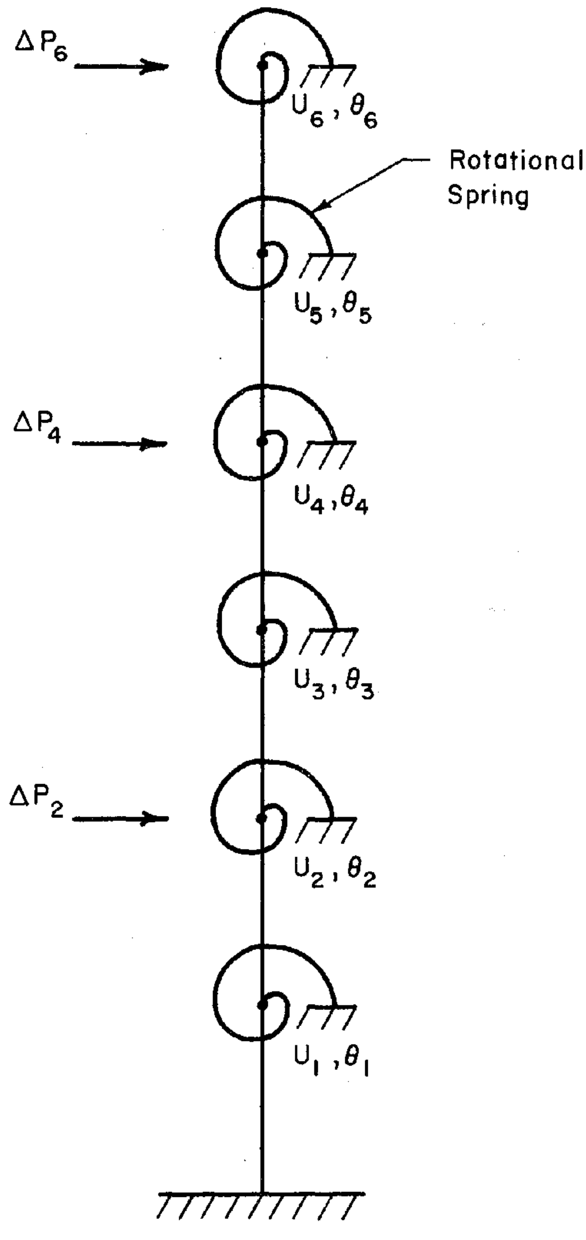


Figure 5.11 Model and Variables for Structural Analysis

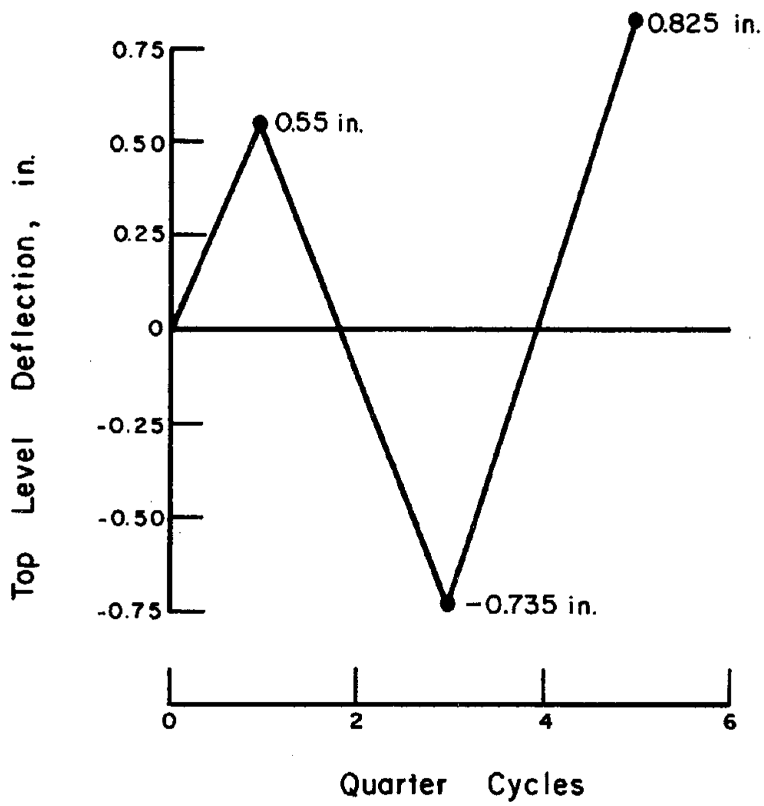


Figure 5.12 Deflection Schedule. Hysteresis Shape Study

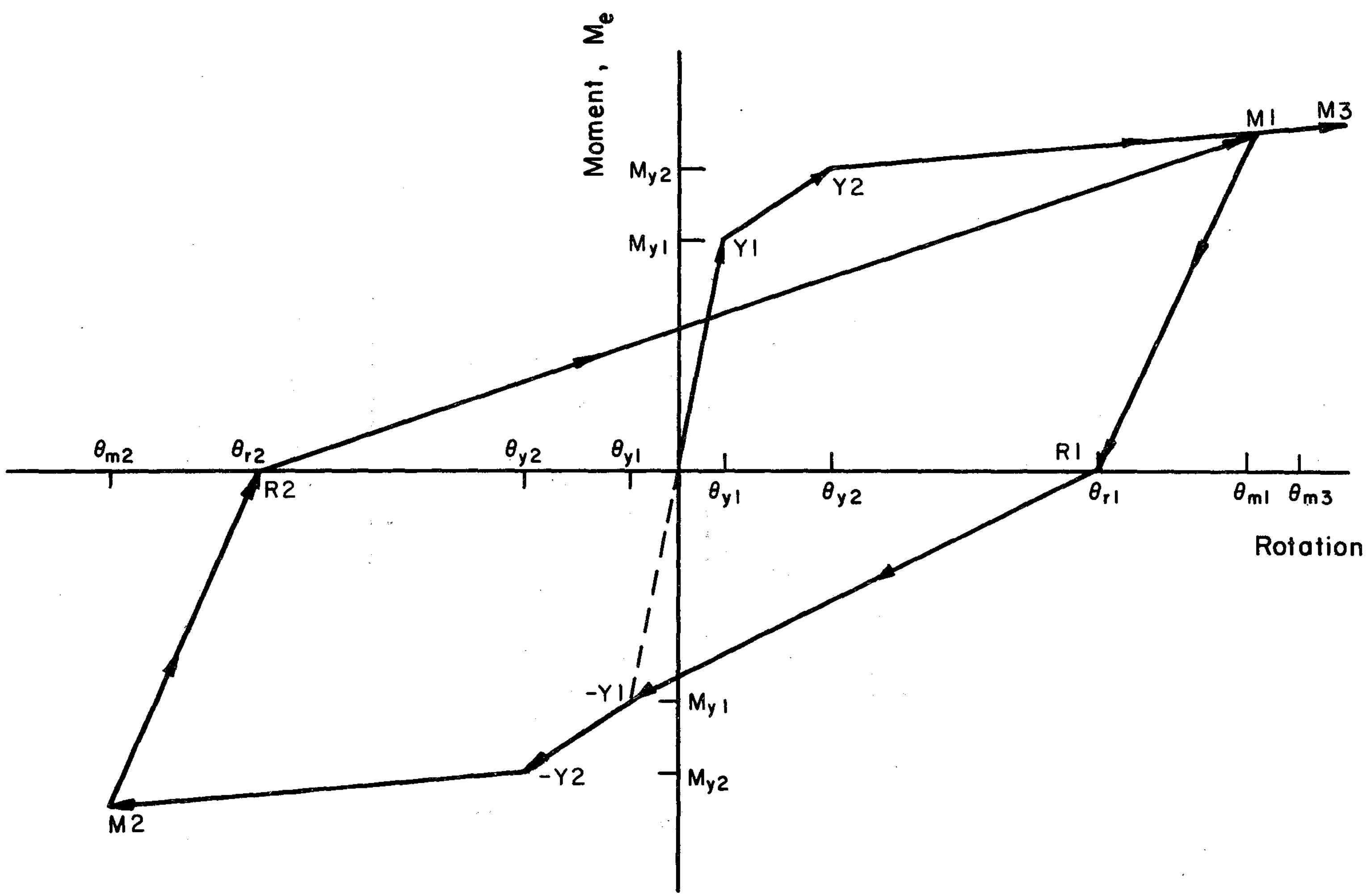


Figure 5.13 Moment-Rotation Relation for a Member. Hysteresis Model 1

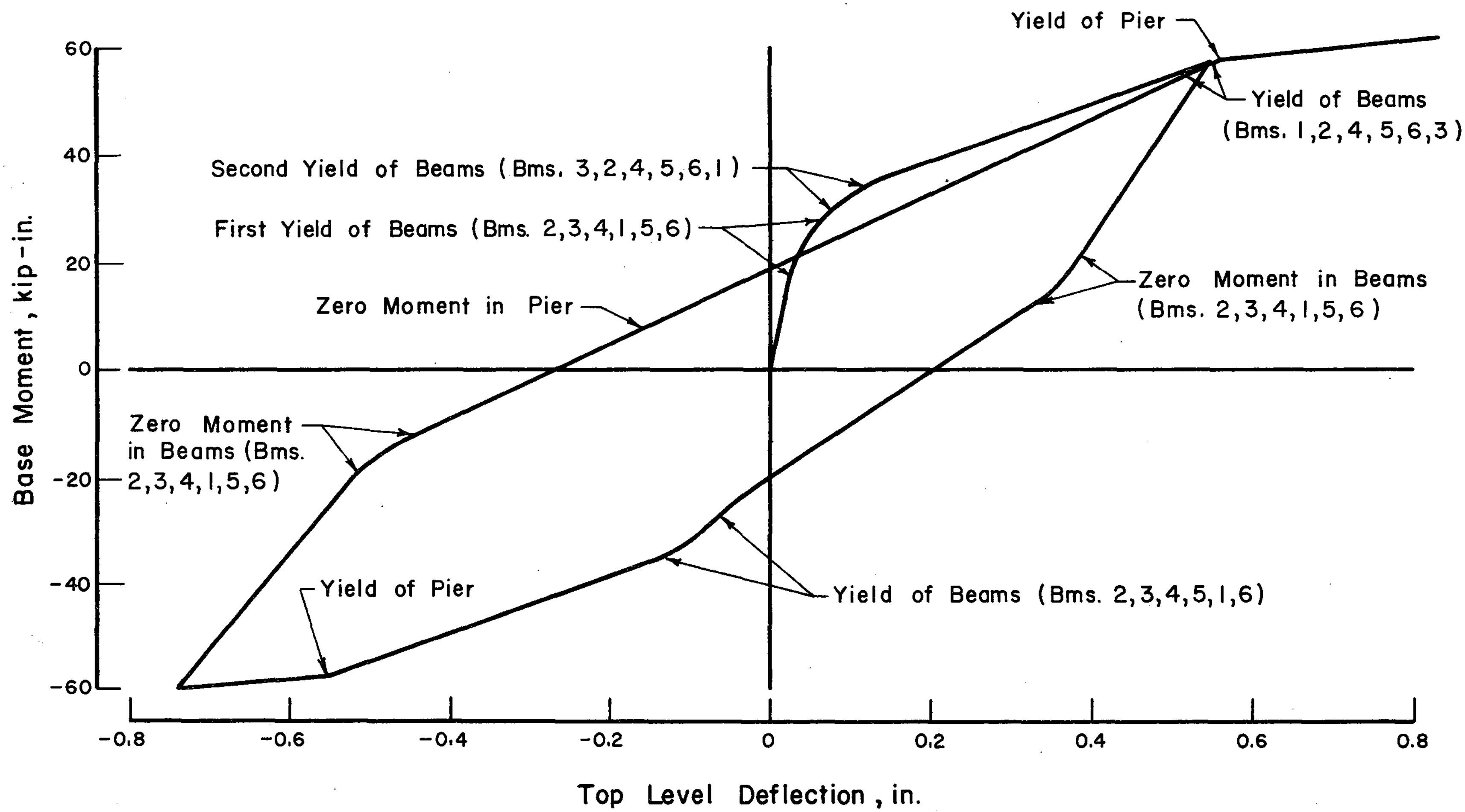


Figure 5.14 Variation of Base Moment with Top-Level Deflection. Hysteresis Model 1

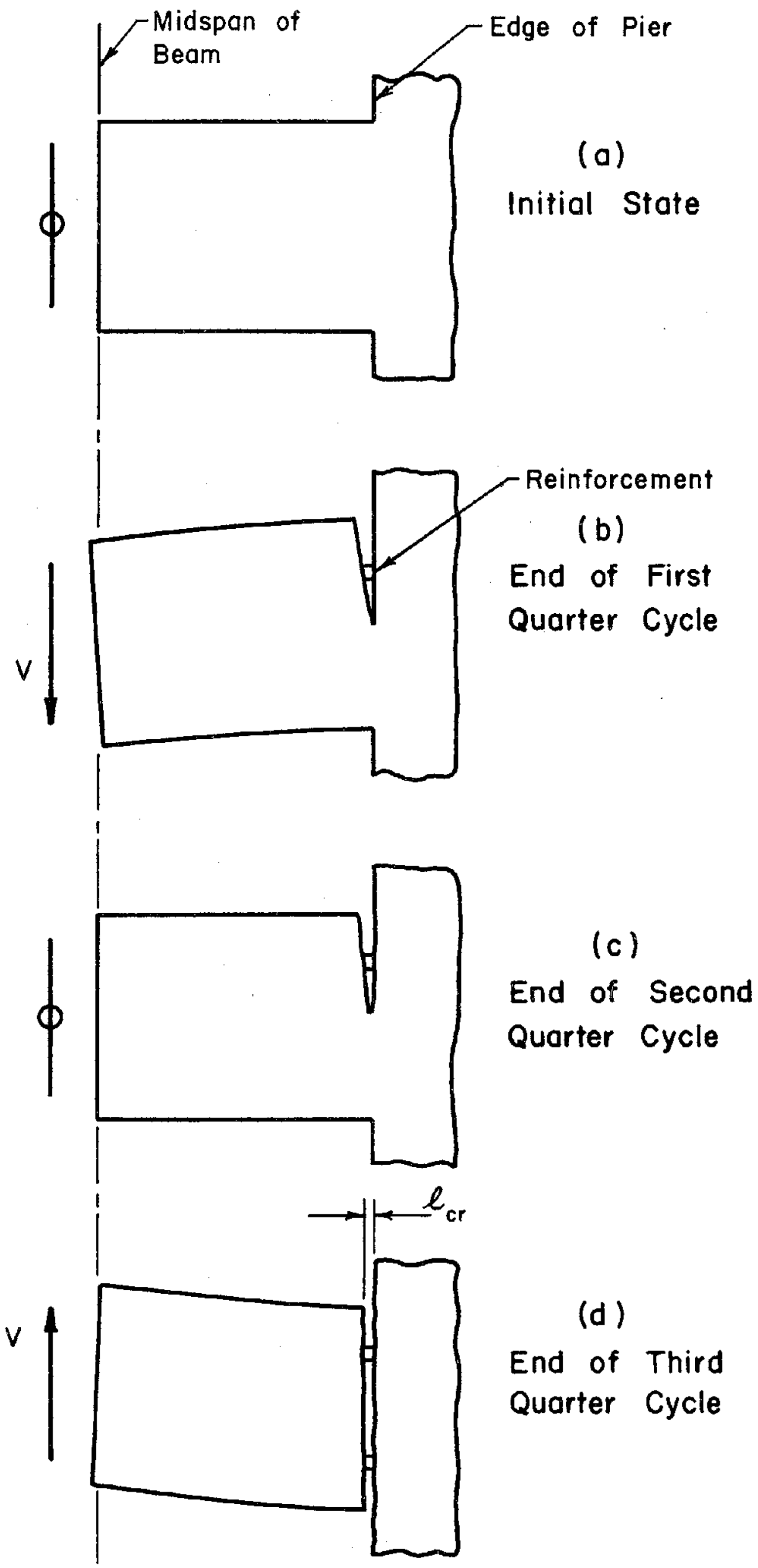
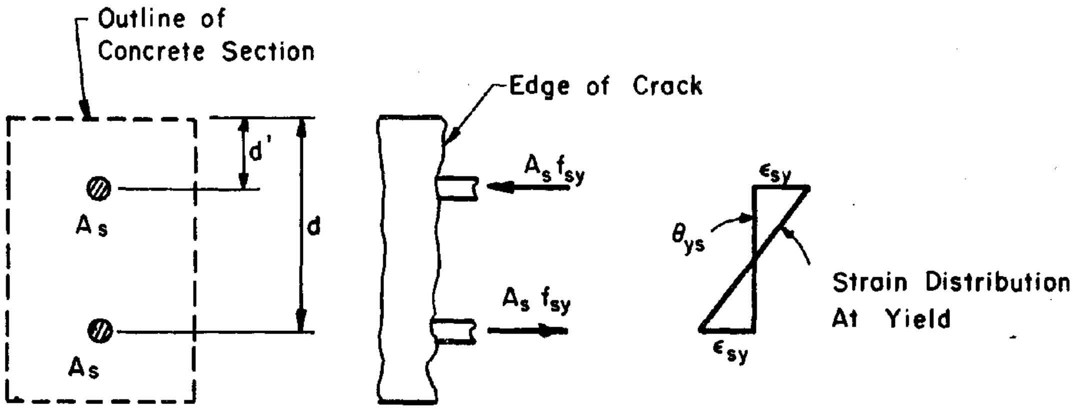
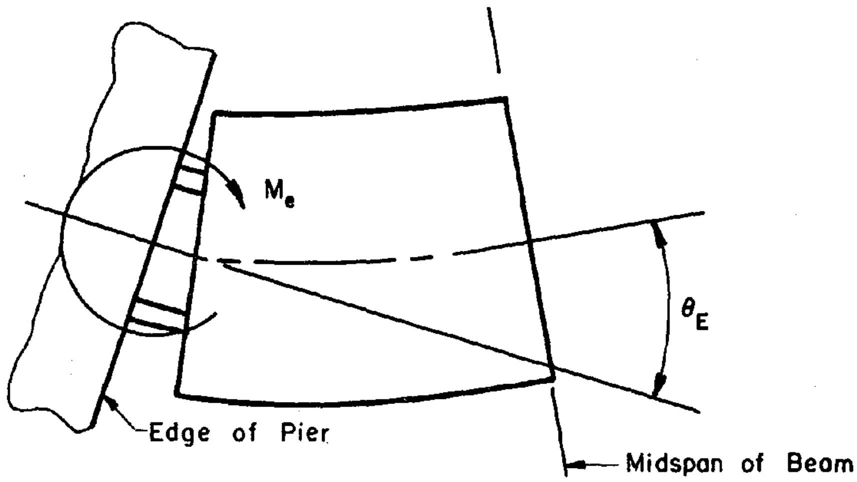


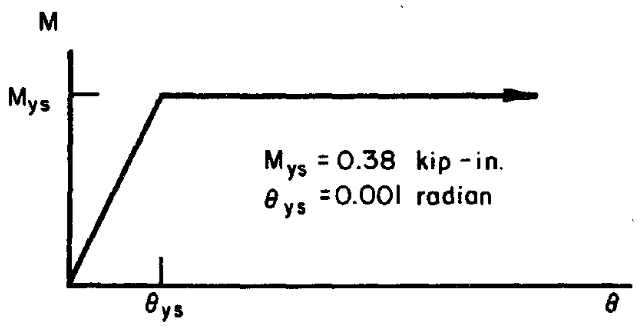
Figure 5.15 General Concept for Behavior Mechanism of Beams. Hysteresis Model 2



(a) Forces, Strains and Section Dimensions



(b) Definition of Moment and Rotation



(c) Idealized Moment - Rotation Relation

Figure 5.16 Idealization of Behavior Mechanism of Beams. Hysteresis Model 2

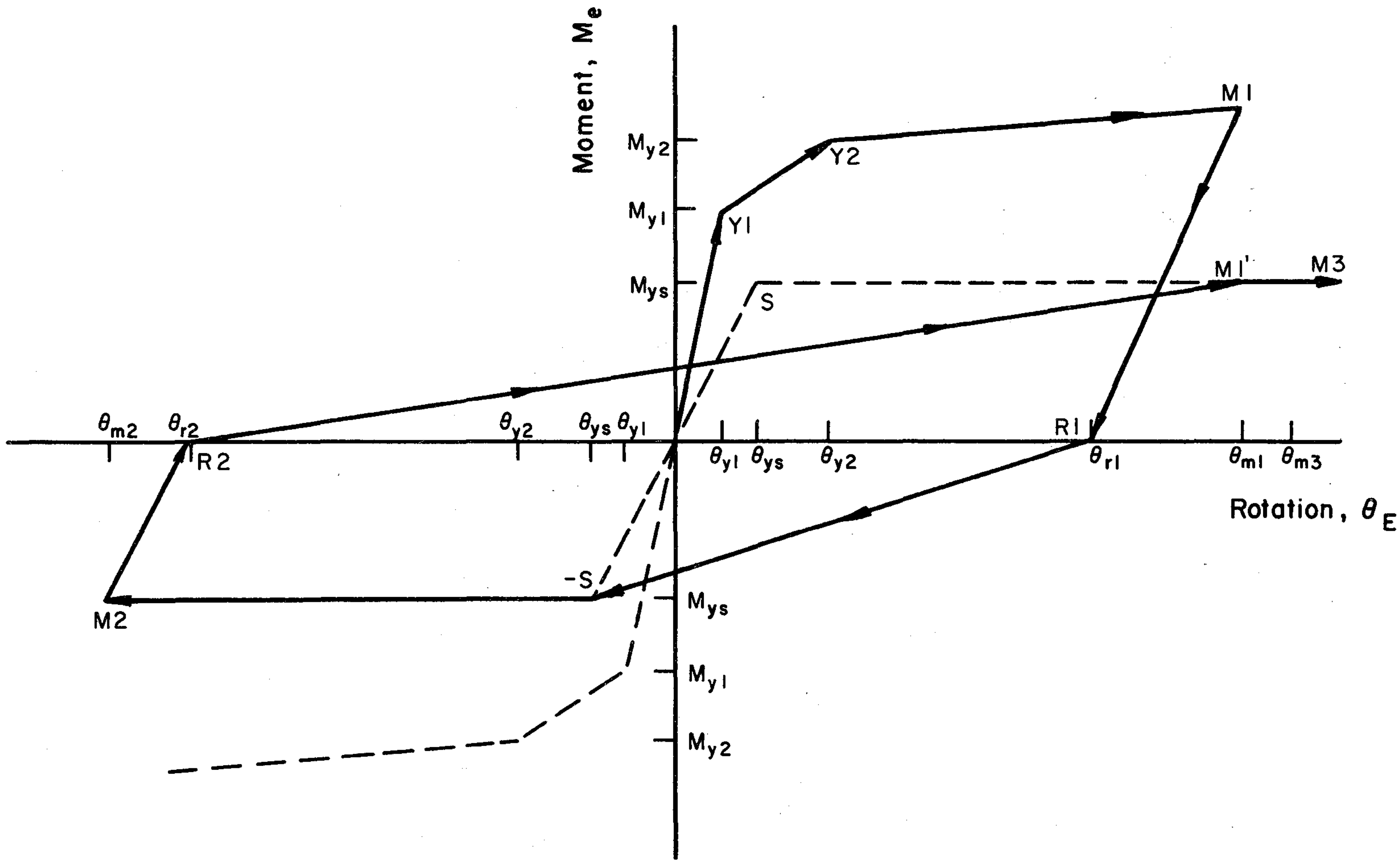


Figure 5.17 Moment-Rotation Relation for a Member. Hysteresis Model 2

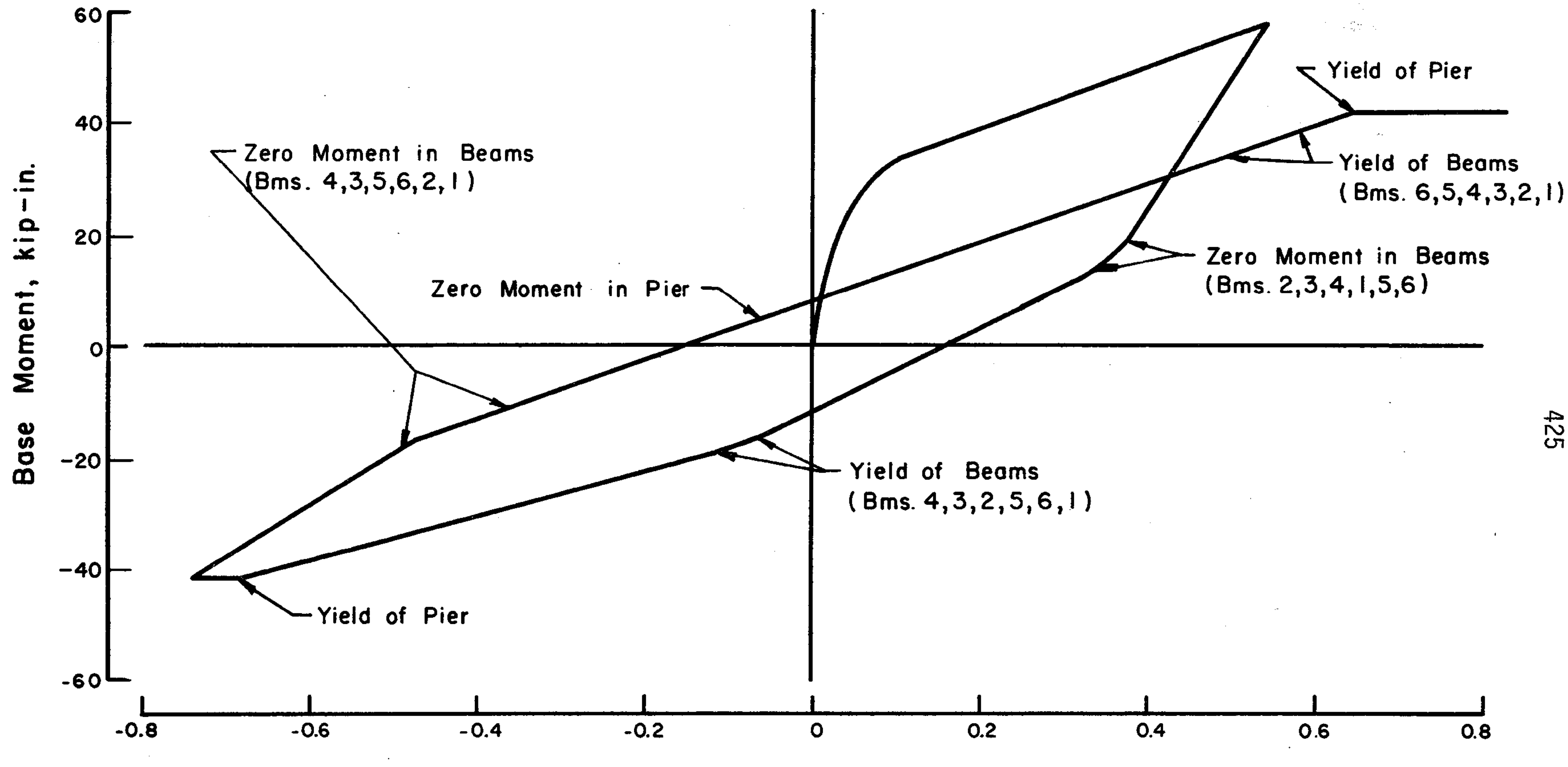
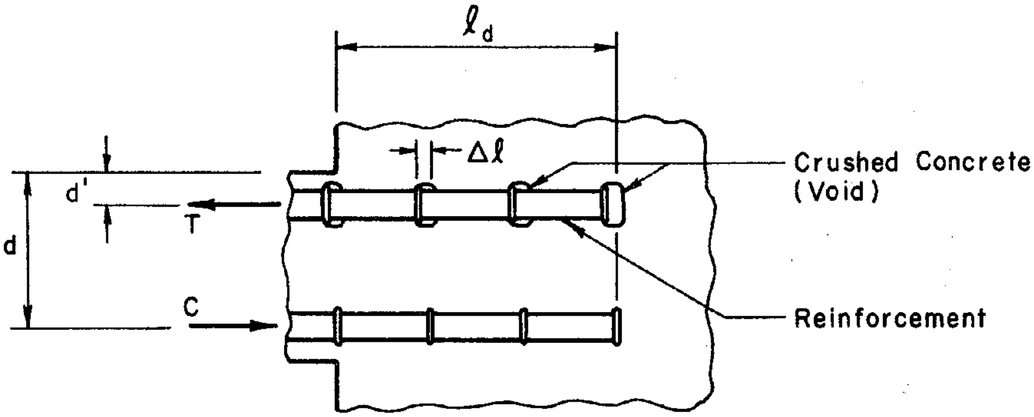
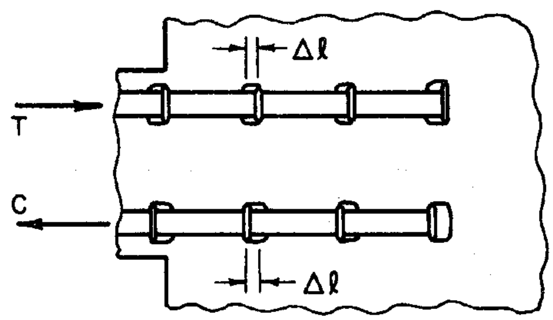


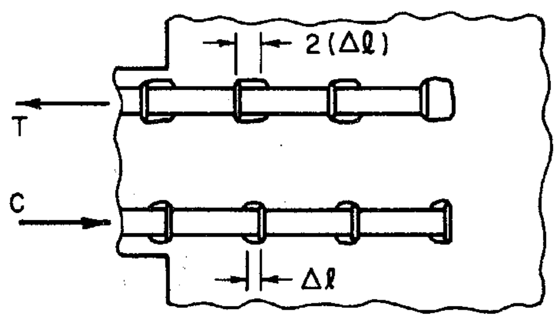
Figure 5.18 Variation of Base Moment with Top-Level Deflection. Hysteresis Model 2



(a) End of First Quarter Cycle



(b) End of Third Quarter Cycle



(c) End of Fifth Quarter Cycle

Figure 5.19 Slip Mechanism for Conventional Reinforcement

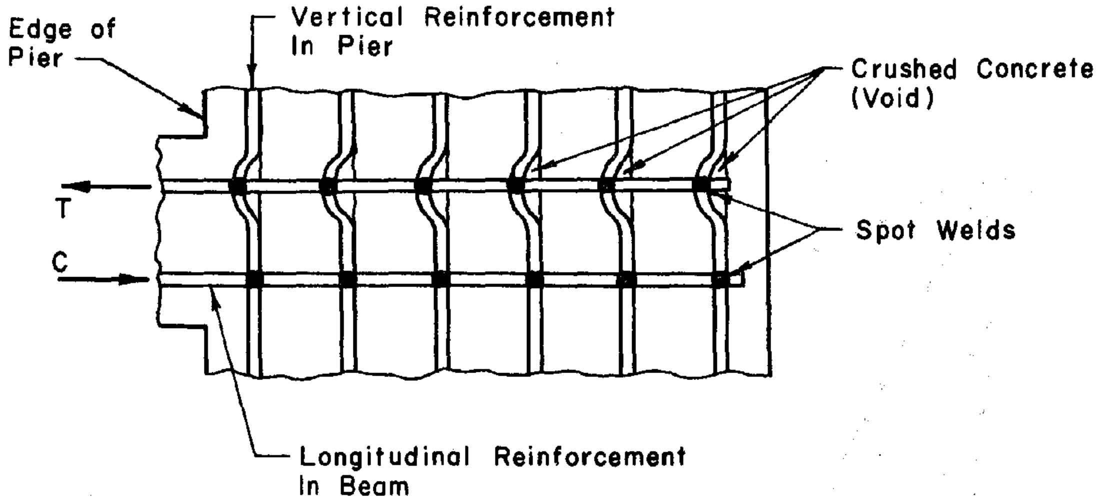


Figure 5.20 Application of Slip Mechanism to Test Structure

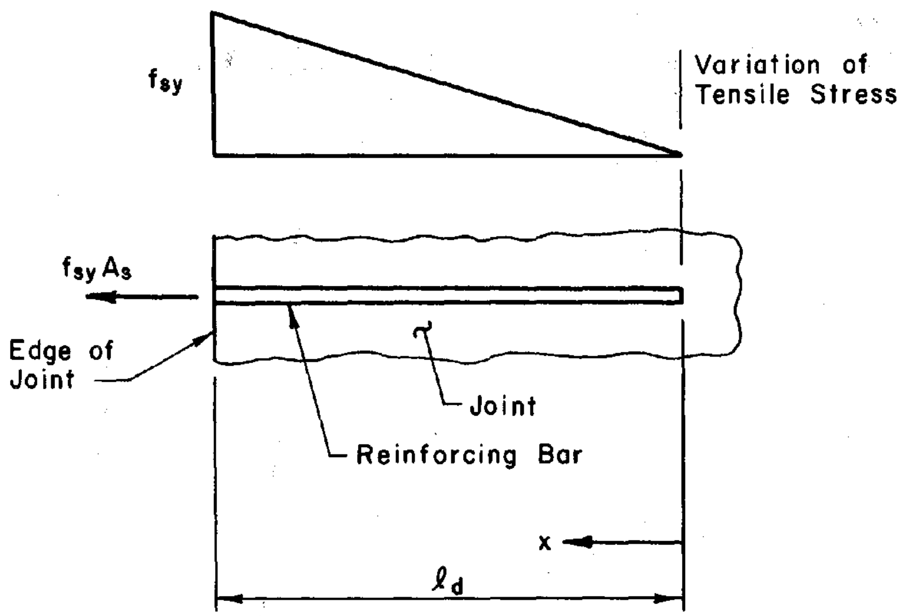


Figure 5.21 Calculation of Magnitude of Slip of Reinforcement

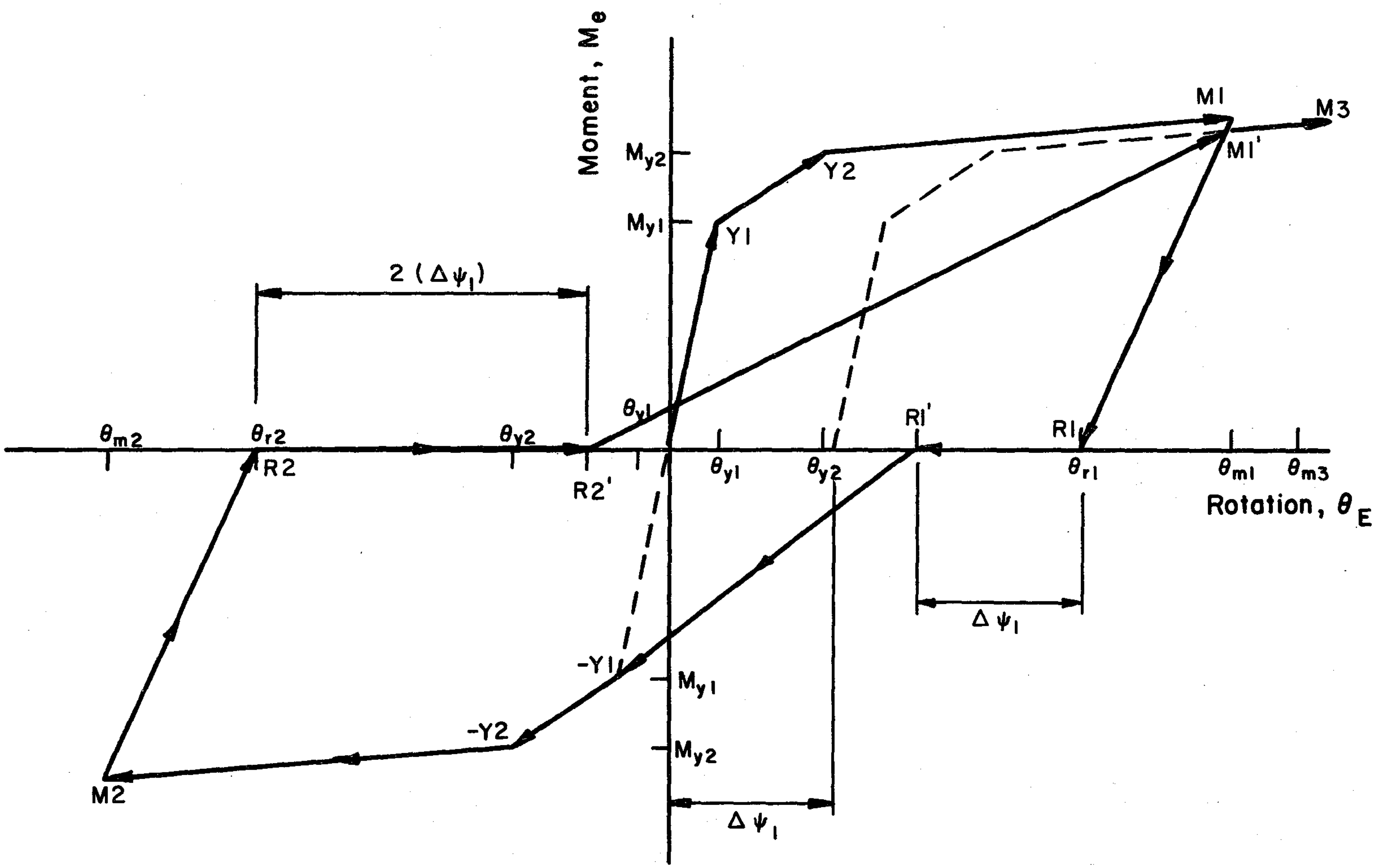


Figure 5.22 Moment-Rotation Relation for a Member. Hysteresis Model 3

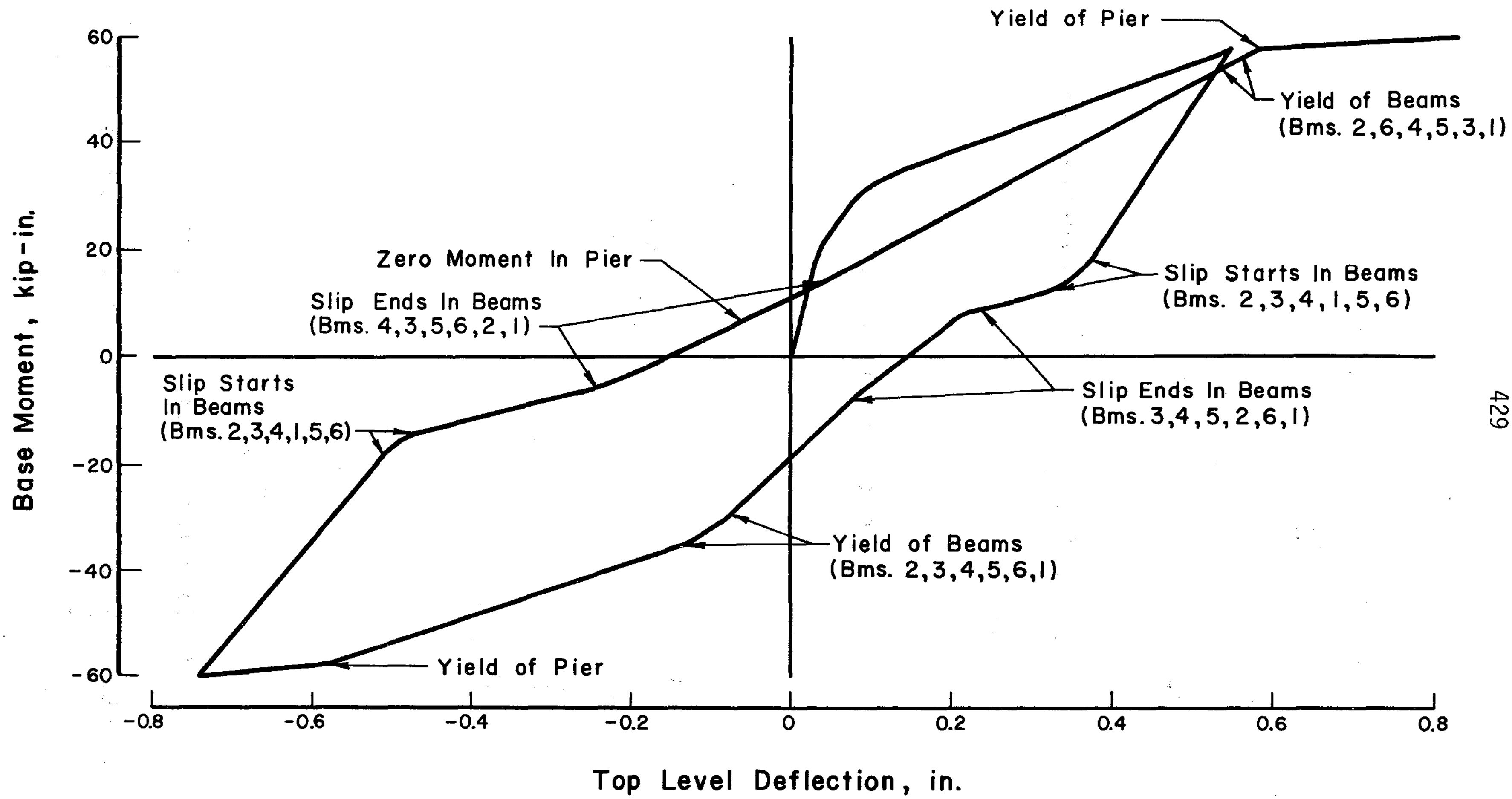


Figure 5.23 Variation of Base Moment with Top-Level Deflection. Hysteresis Model 3

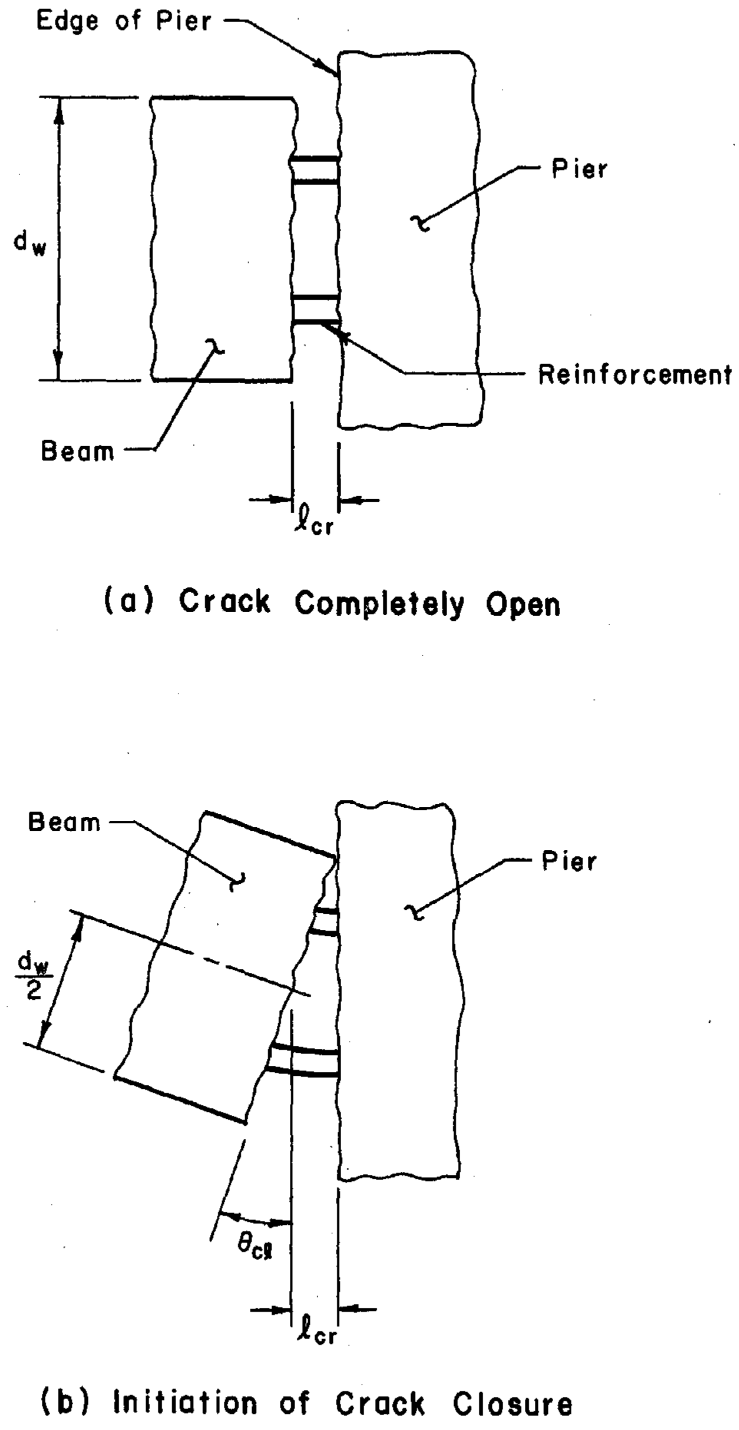


Figure 5.24 Mechanism of Closure of Cracks at Ends of Beams. Hysteresis Models 4 and 5

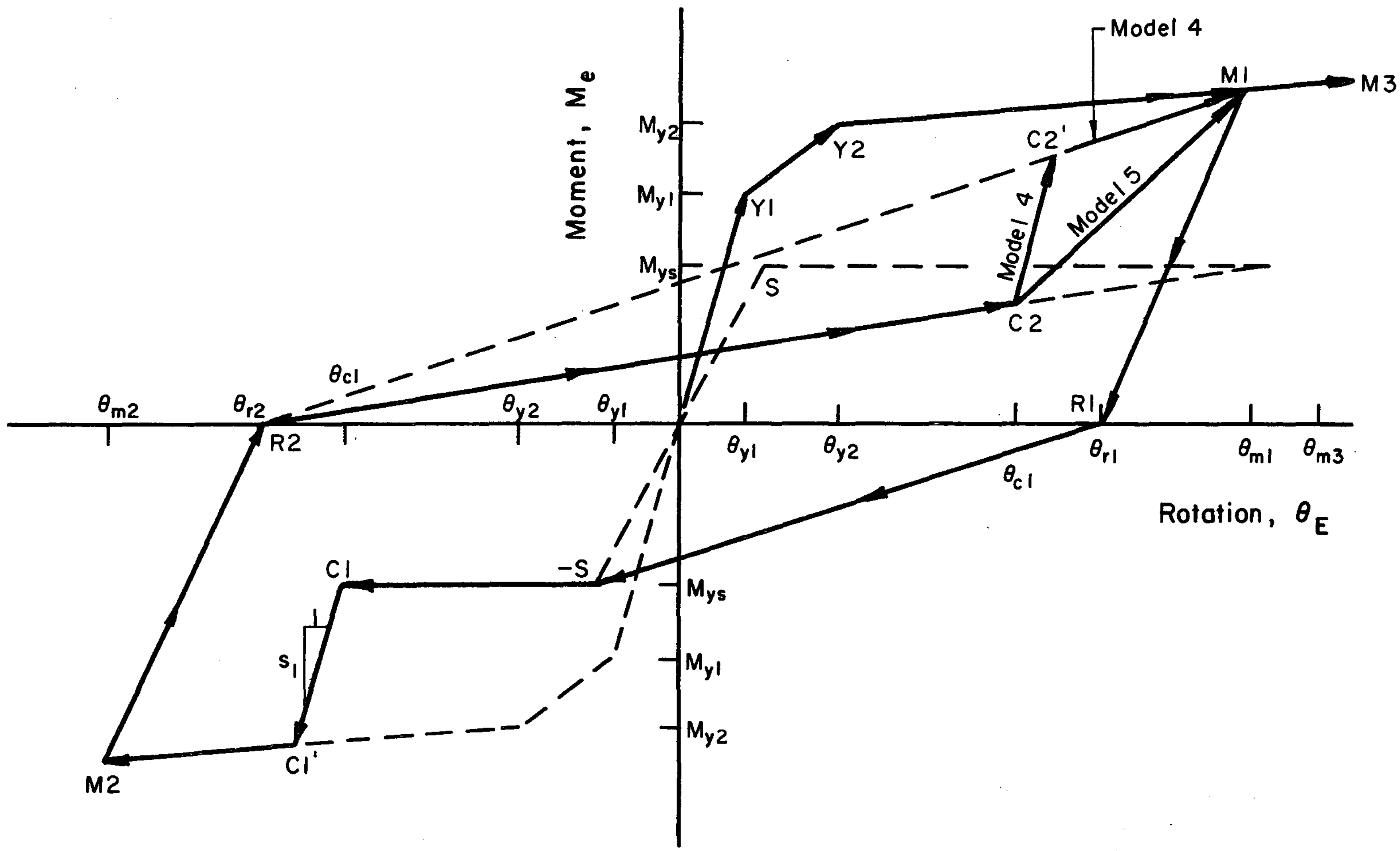


Figure 5.25 Moment Rotation Relation for a Member.
Hysteresis Models 4 and 5

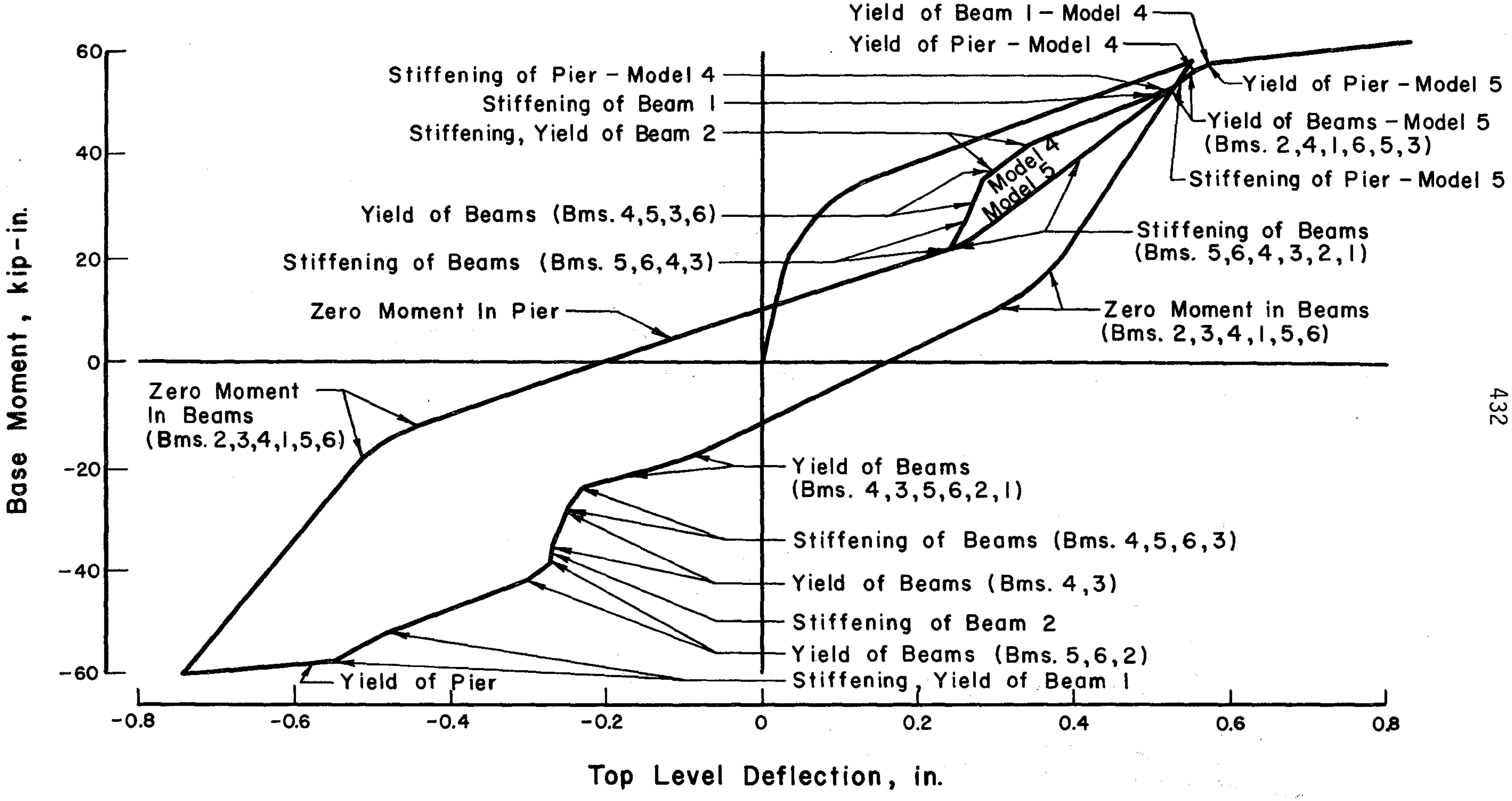


Figure 5.26 Variation of Base Moment with Top-Level Deflection. Hysteresis Model 4 and 5

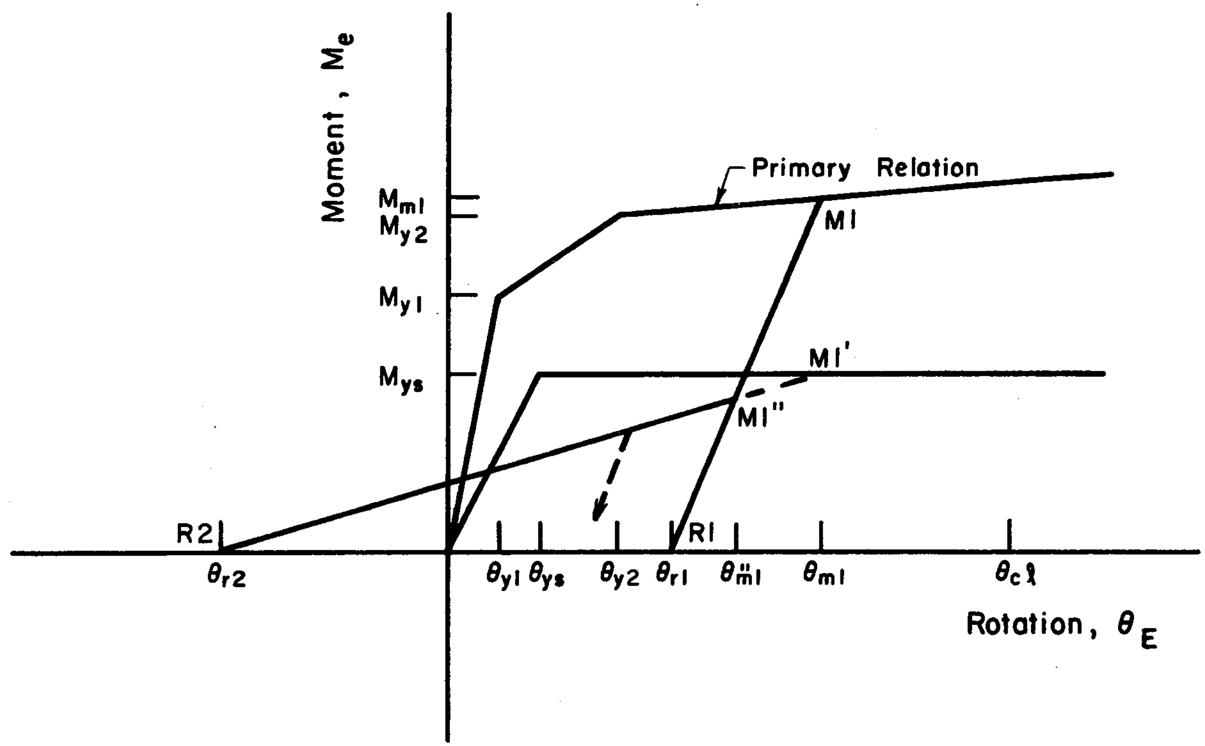


Figure 5.27 Application of Hysteresis Models 4 and 5 to Low-Amplitude Response

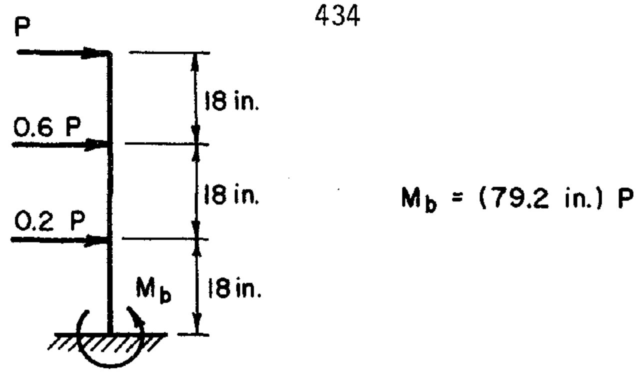
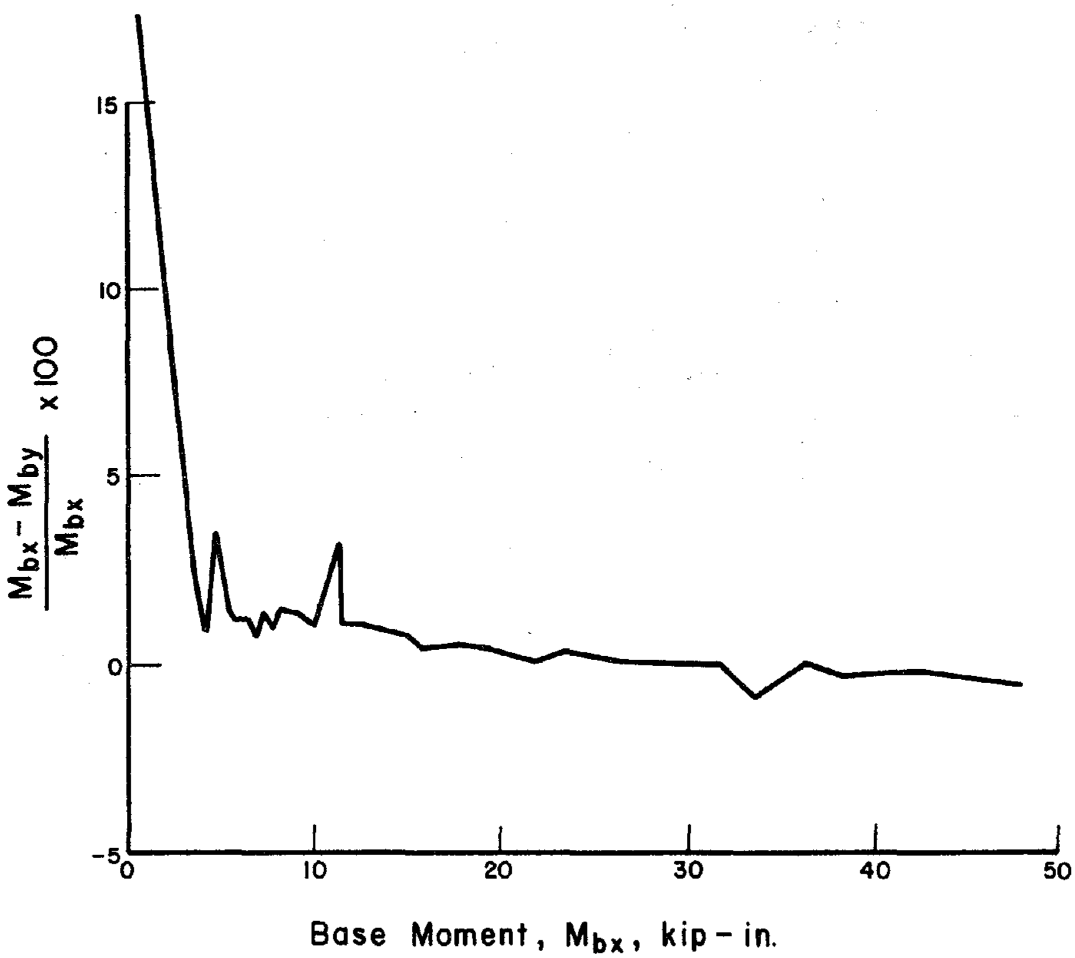


Figure 5.28 Calculation of Base Moment from Observed Top-Level Ram Load



M_{by} = Base moment calculated from top load and nominal load distribution

M_{bx} = Base moment calculated from all three measured loads

Figure 5.29 Relative Deviation of Base Moment

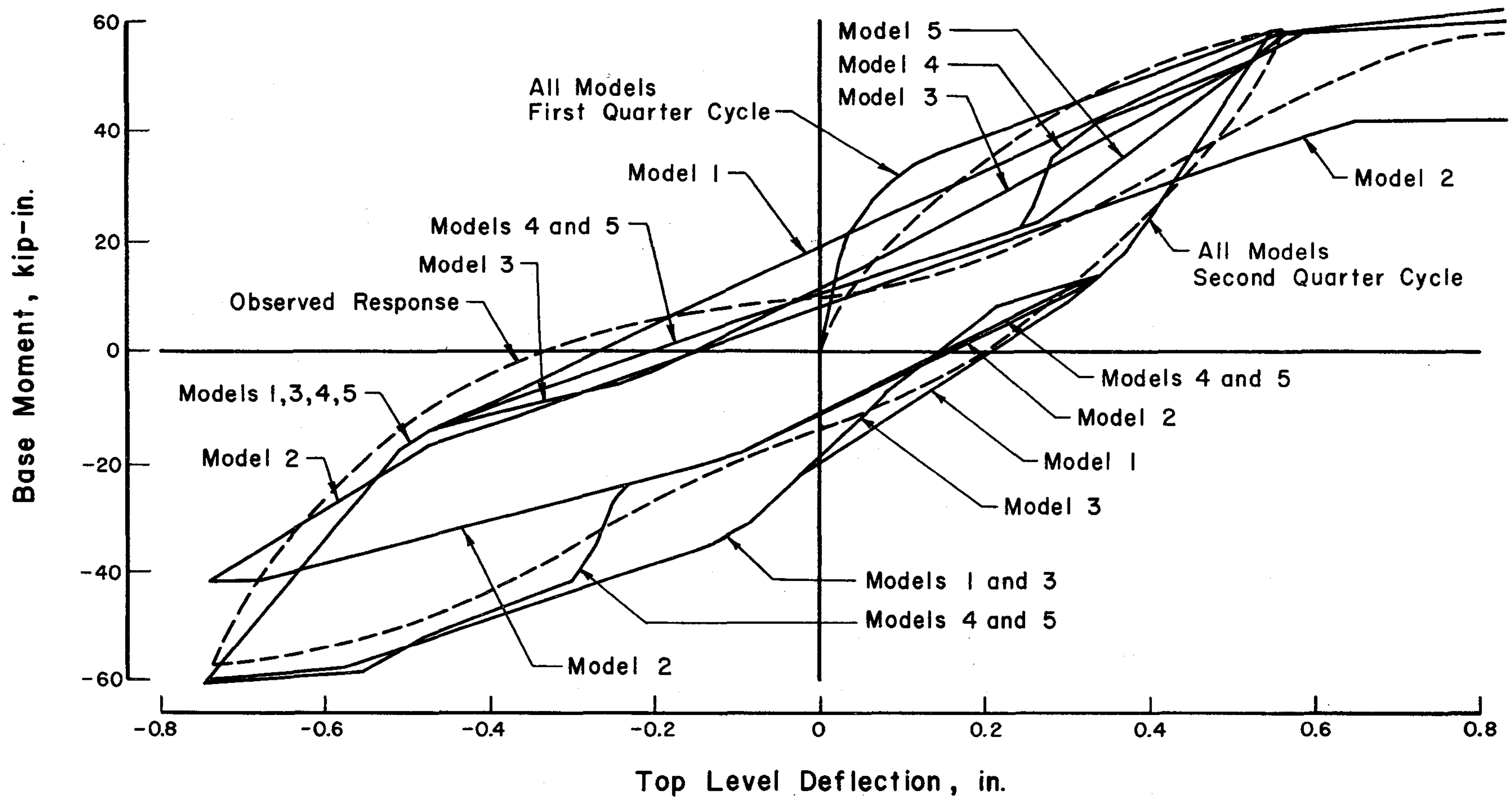


Figure 5.30 Comparison of Results of Study of Hysteresis Shape with Observed Response

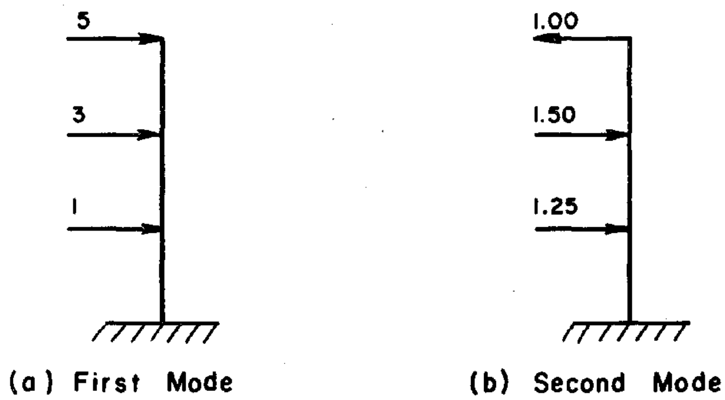


Figure 5.31 Study of Response Amplitude and Equivalent Damping Factor. Ratios Among the Lateral Loads

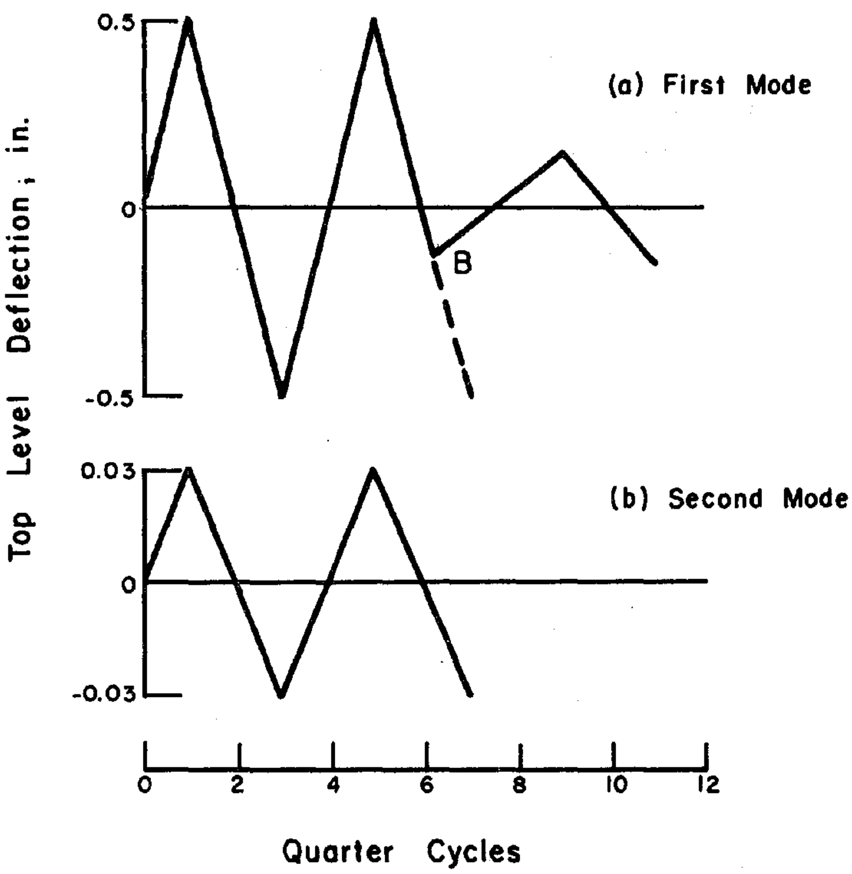


Figure 5.32 Study of Response Amplitude and Equivalent Damping Factor. Deflection Schedule

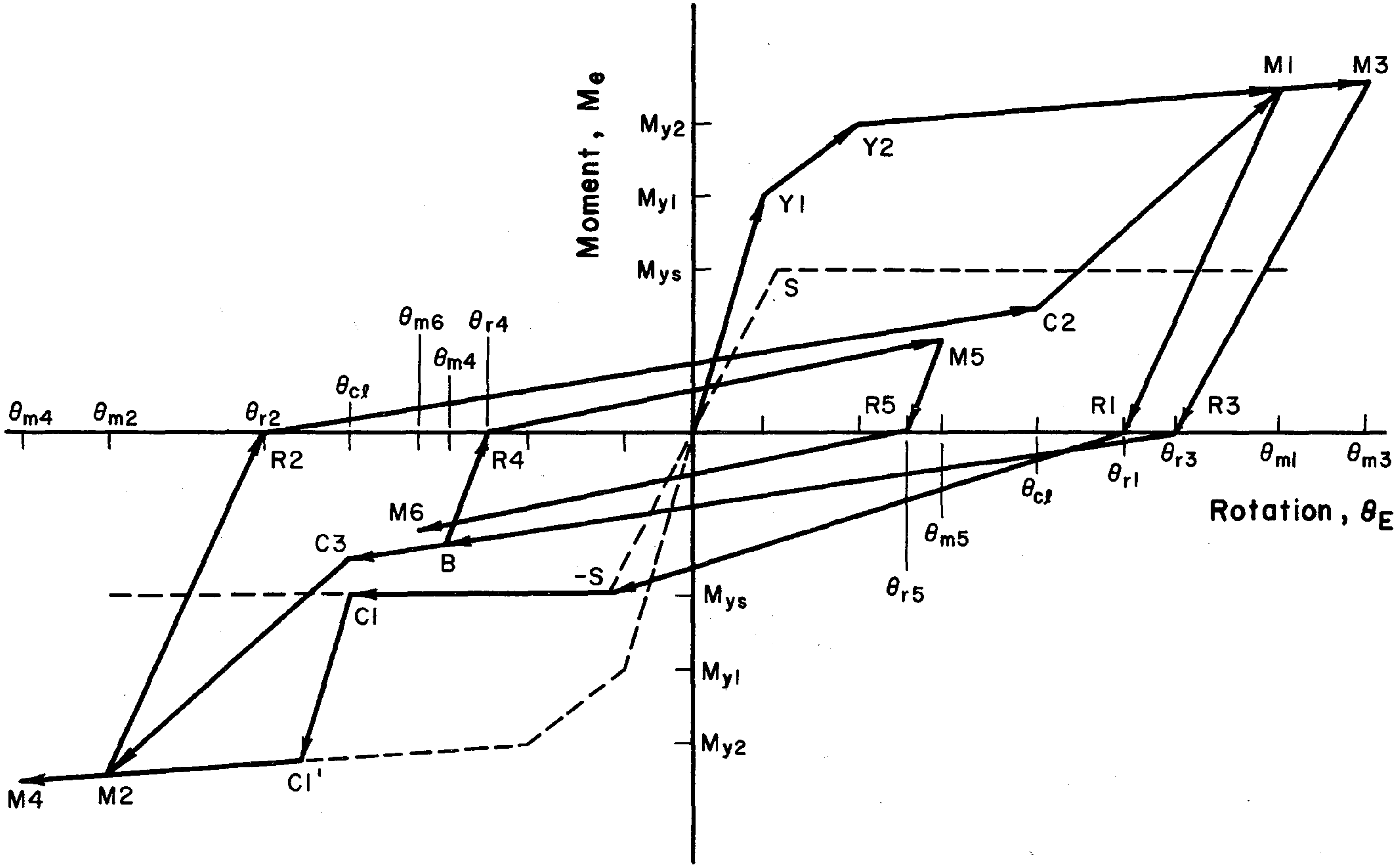


Figure 5.33 Application of Hysteresis Model 5 to Study of Response Amplitude and Equivalent Damping Factor

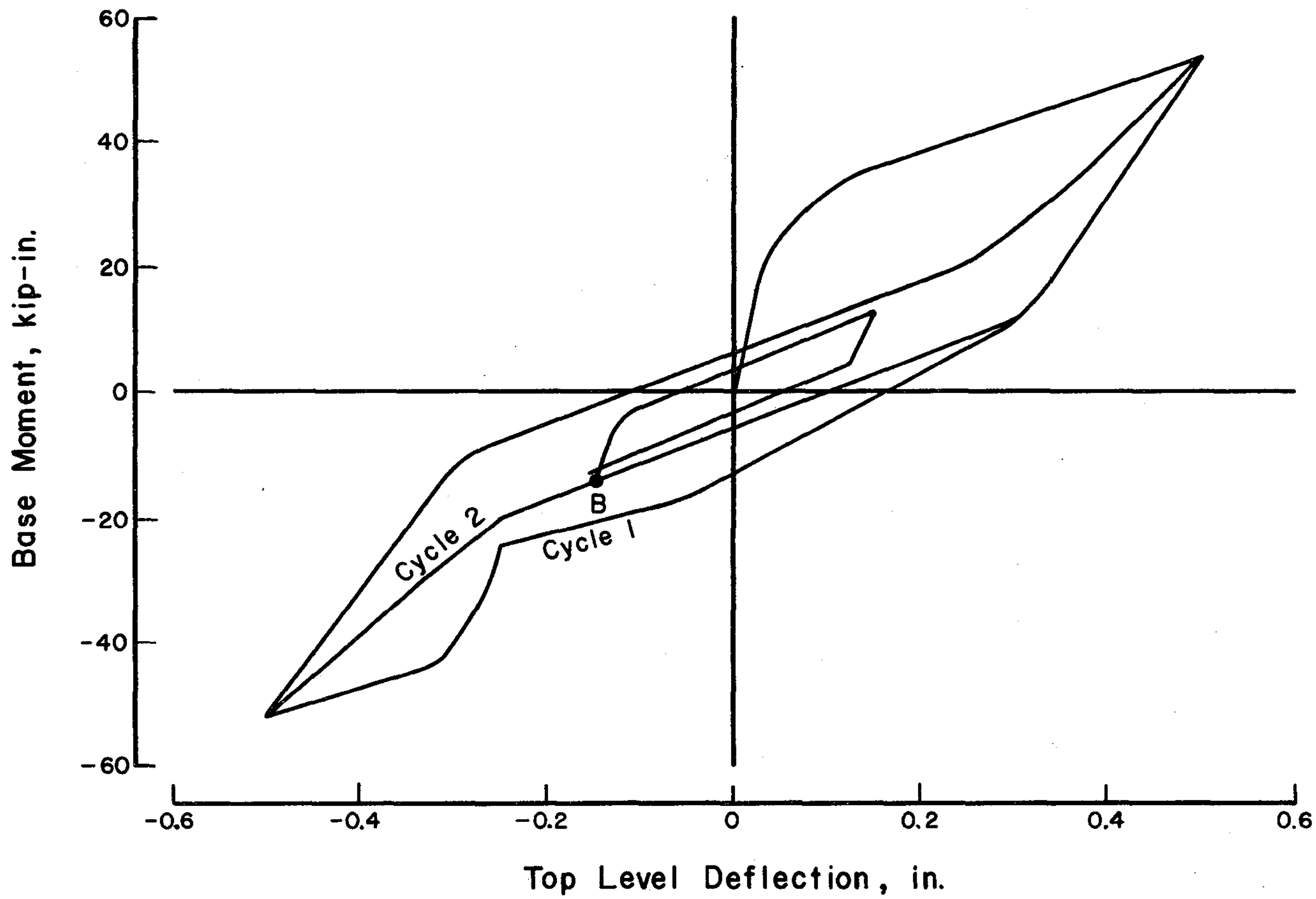


Figure 5.34 Variation of Base Moment with Top Level-Deflection. Study of Response Amplitude and Equivalent Damping Factor. Response in the First Mode

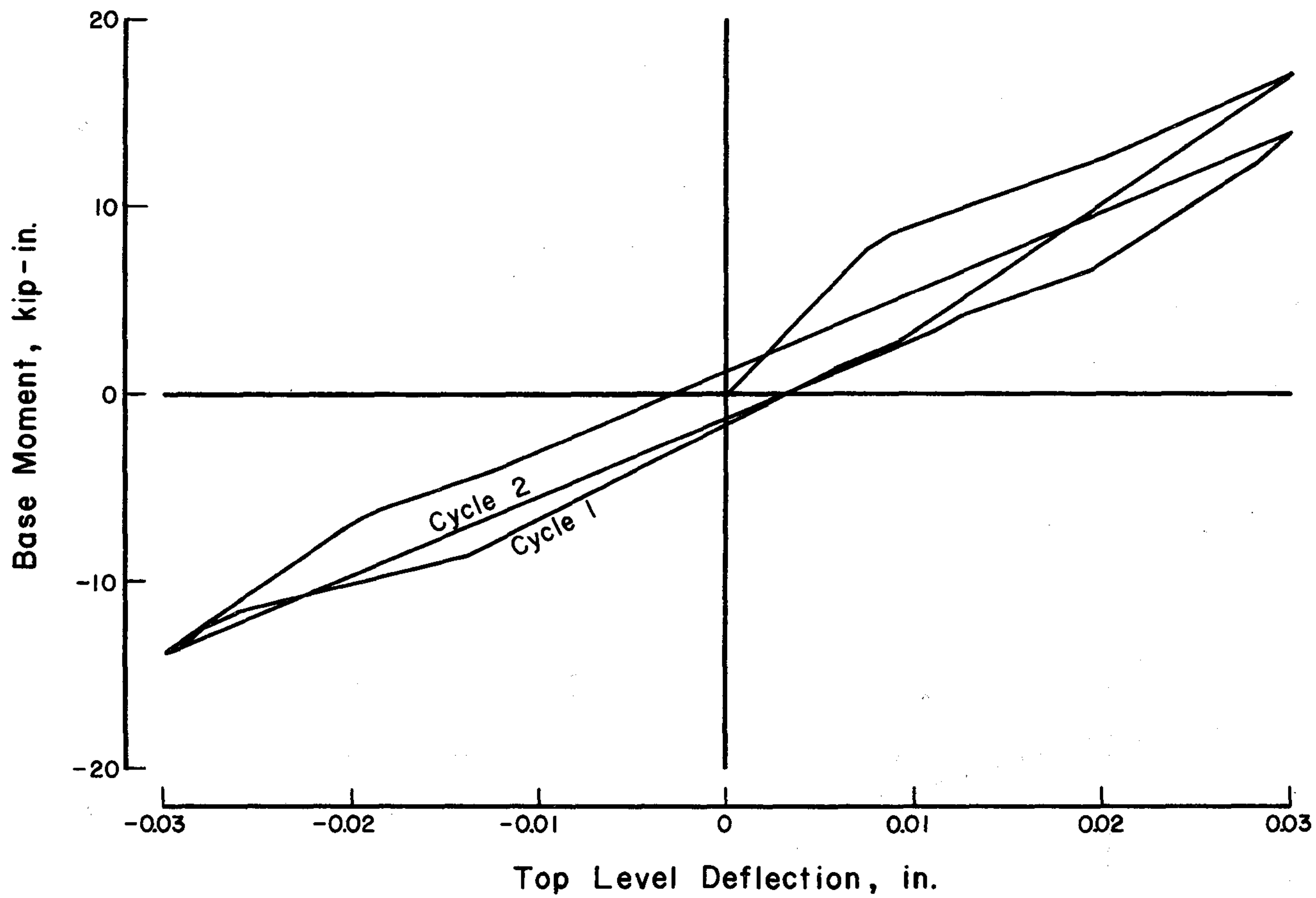
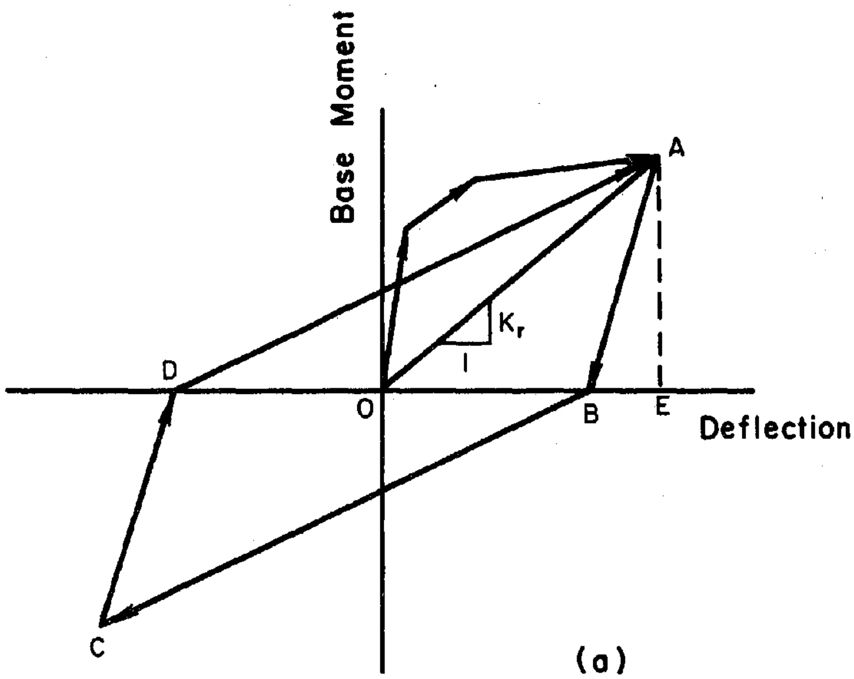


Figure 5.35 Variation of Base Moment with Top-Level Deflection. Study of Response Amplitude and Equivalent Damping Factor. Response in the Second Mode



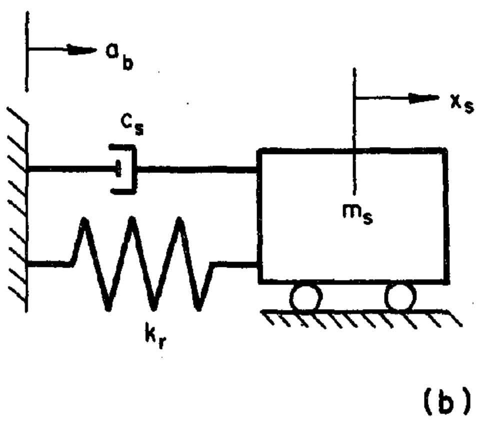
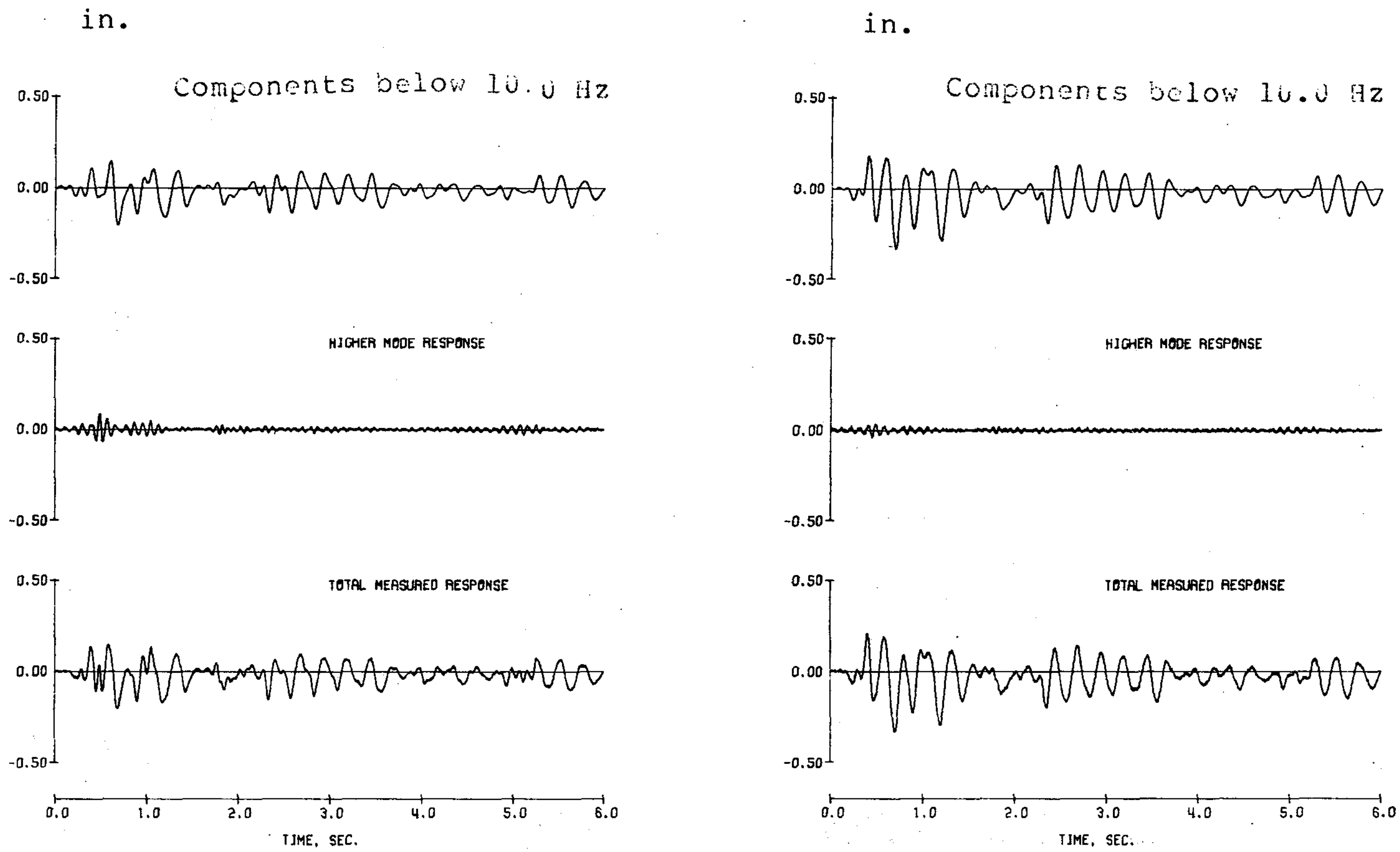


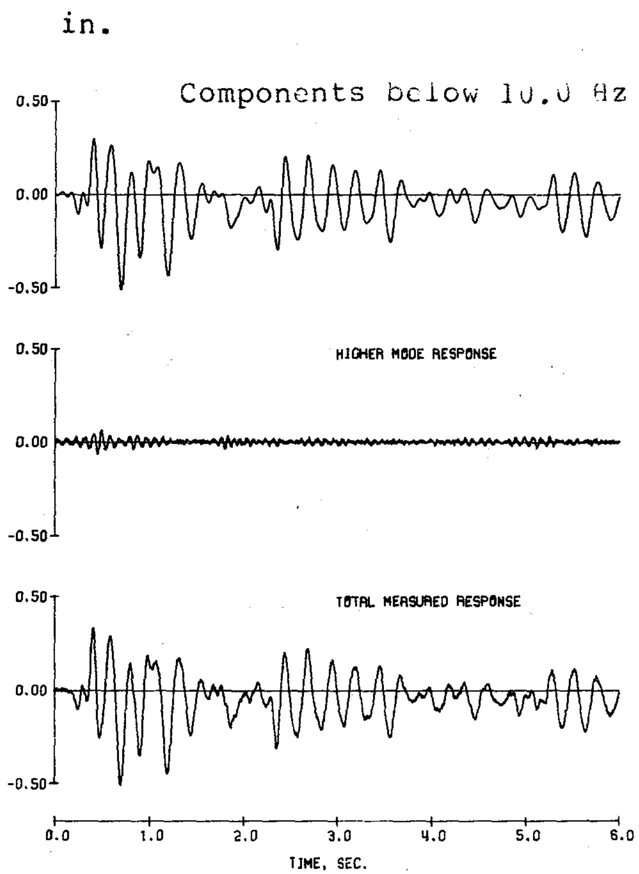
Figure 5.36 Modelling of Inelastic Response by a Substitute Structure



(a) Lower Level

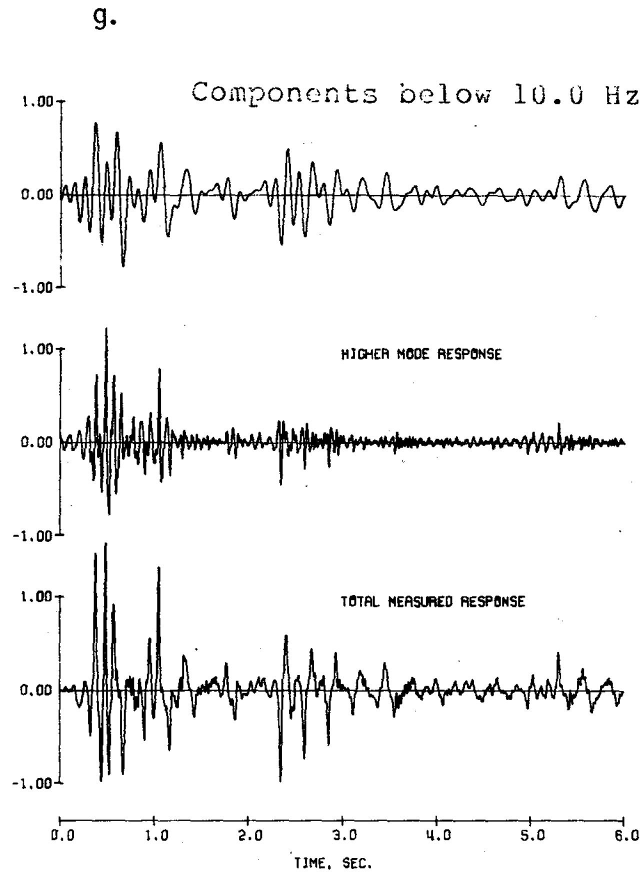
(b) Middle Level

Figure 6.1 Fourier Analysis. Horizontal Deflections. Test Run D1-4.



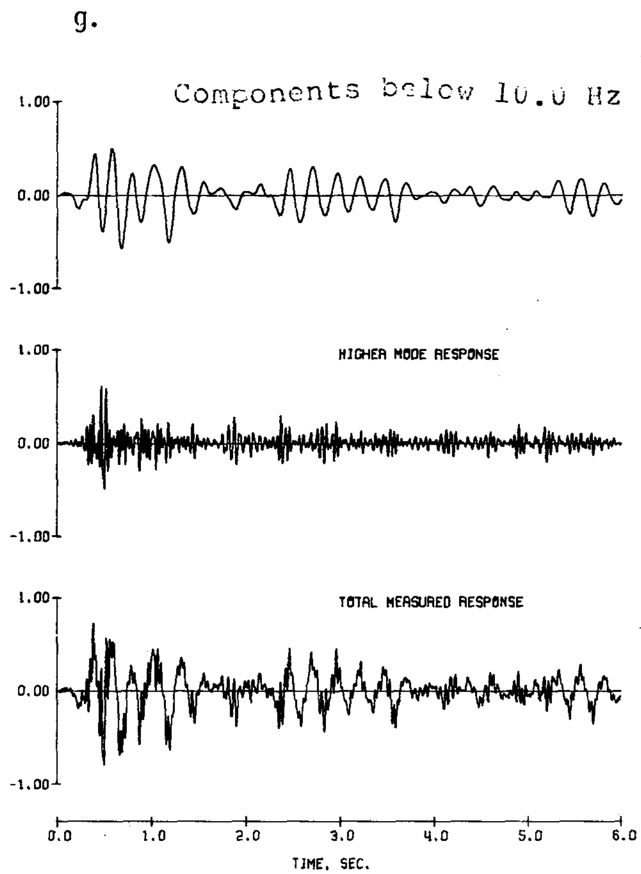
(c) Top Level

Figure 6.1 (contd.) Fourier Analysis. Horizontal Deflections Test Run D1-4.

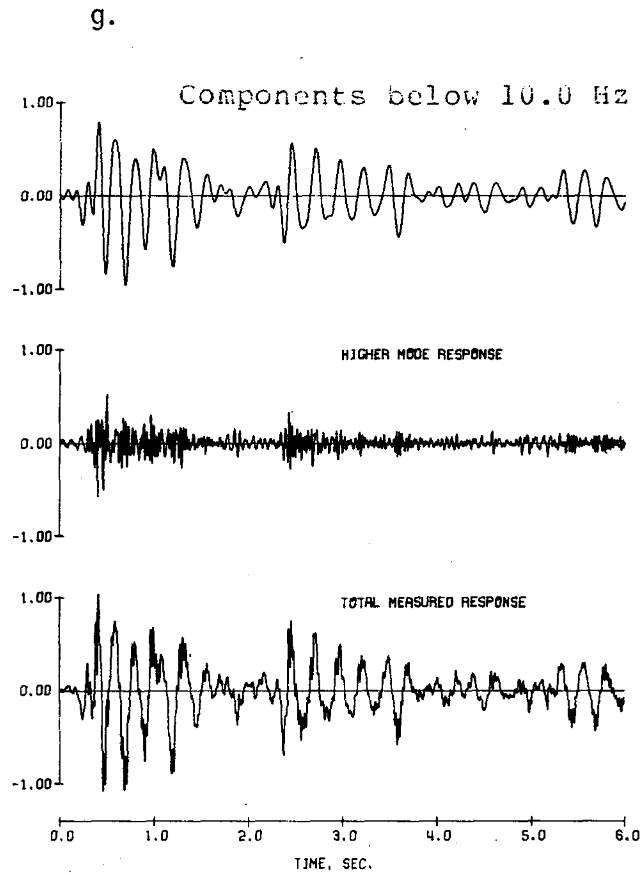


(a) Lower Level

Figure 6.2 Fourier Analysis. Horizontal Accelerations. Test Run D1-4.

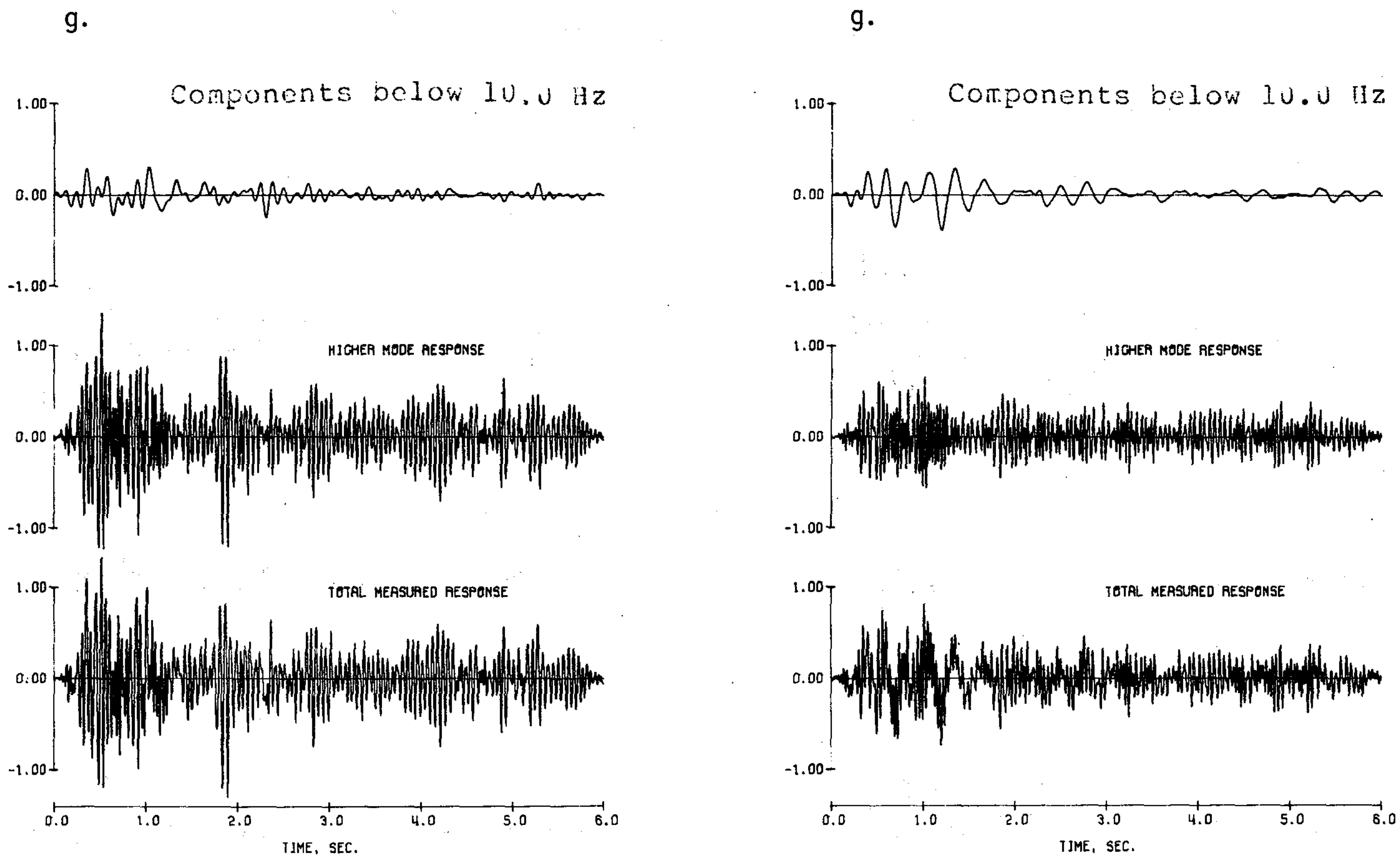


(b) Middle Level



(c) Top Level

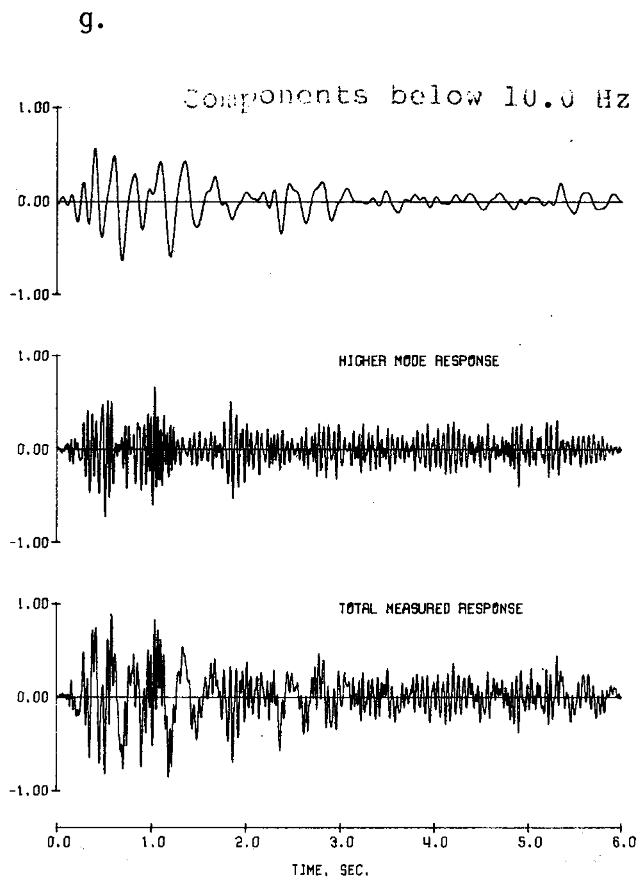
Figure 6.2 (contd.) Fourier Analysis. Horizontal Accelerations. Test Run D1-4.



(a) Lower Level

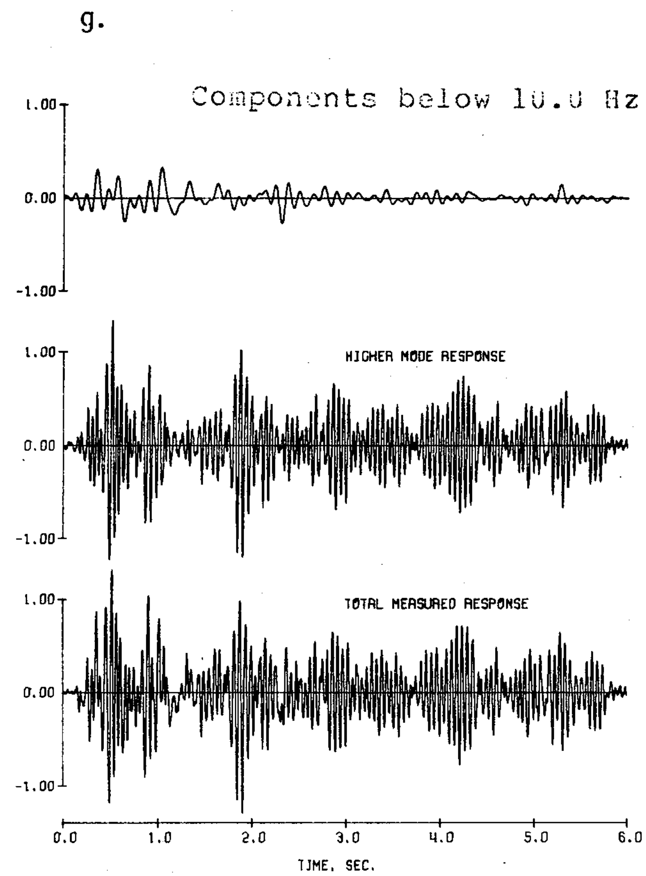
(b) Middle Level

Figure 6.3 Fourier Analysis. Horizontal Accelerations. Test Run D2-1.



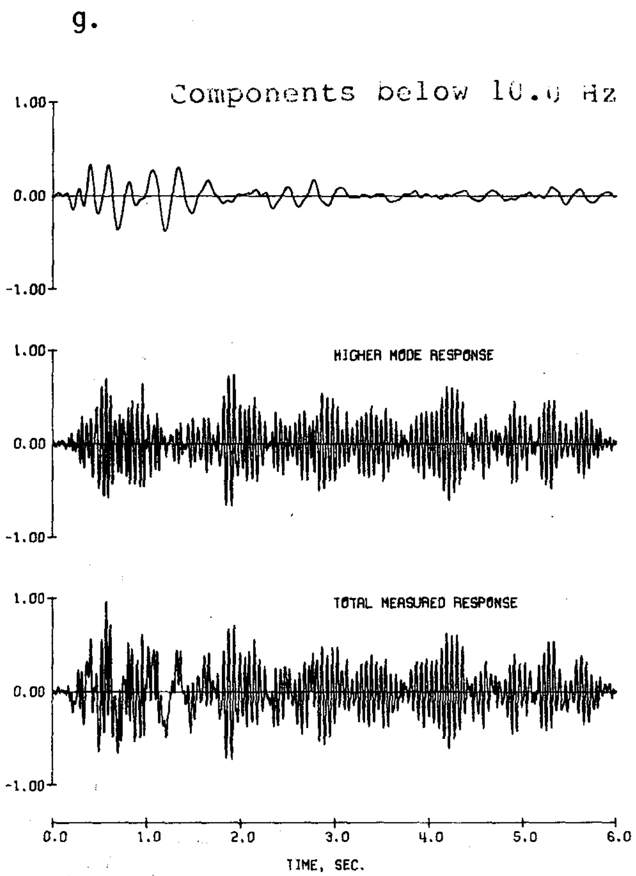
(c) Top Level

Figure 6.3 (contd.) Fourier Analysis. Horizontal Accelerations. Test Run D2-1.

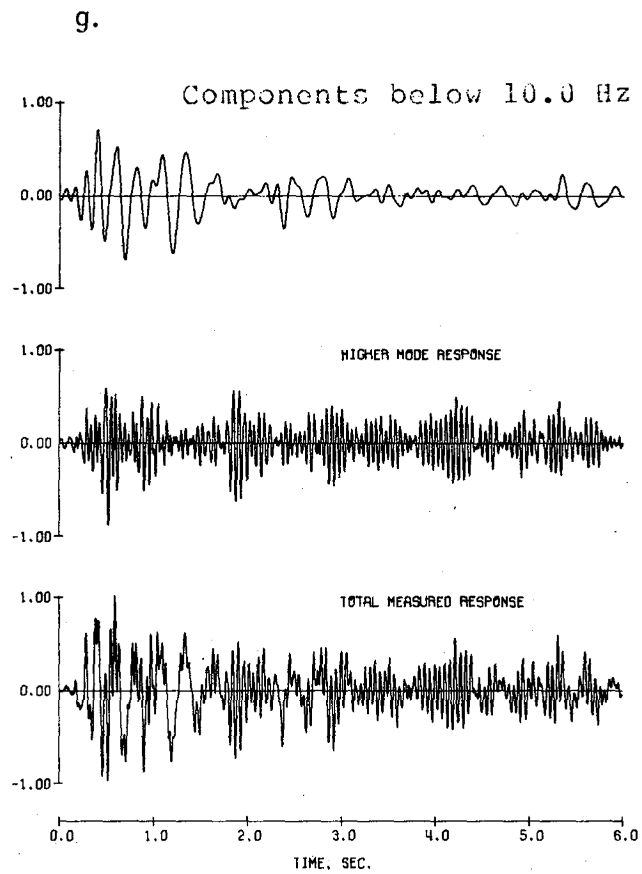


(a) Lower Level

Figure 6.4 Fourier Analysis. Horizontal Accelerations. Test Run D3-1.

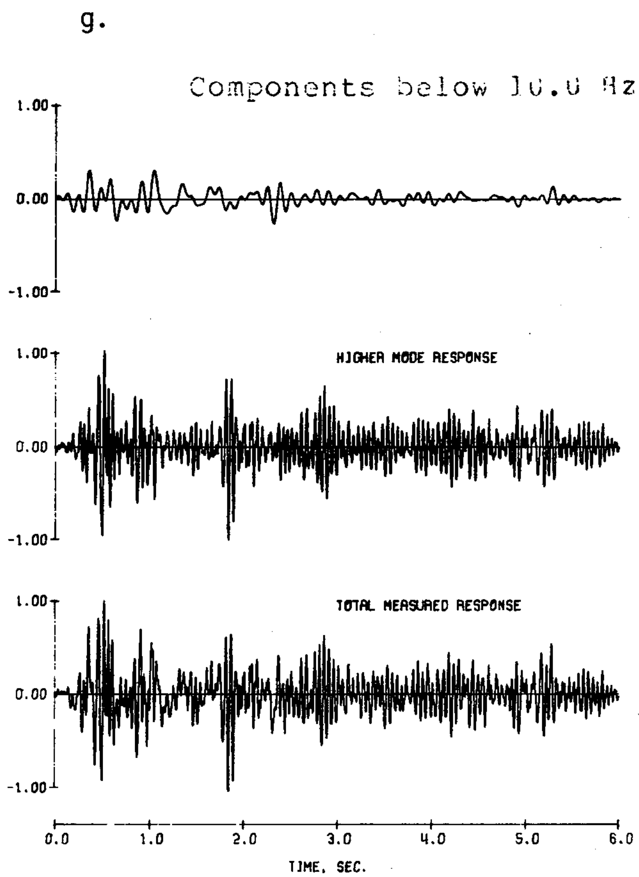


(b) Middle Level

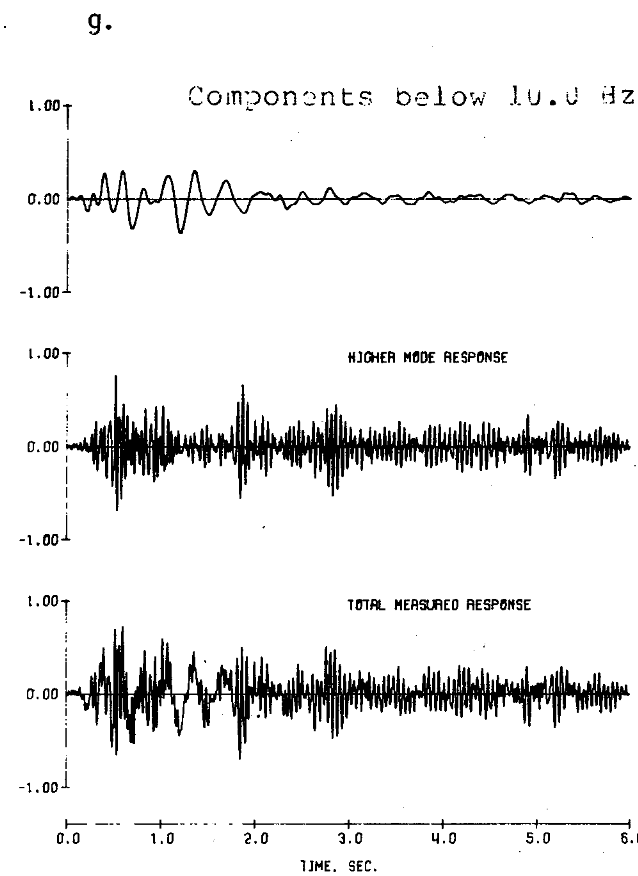


(c) Top Level

Figure 6.4 (contd.) Fourier Analysis. Horizontal Accelerations. Test Run D3-1.

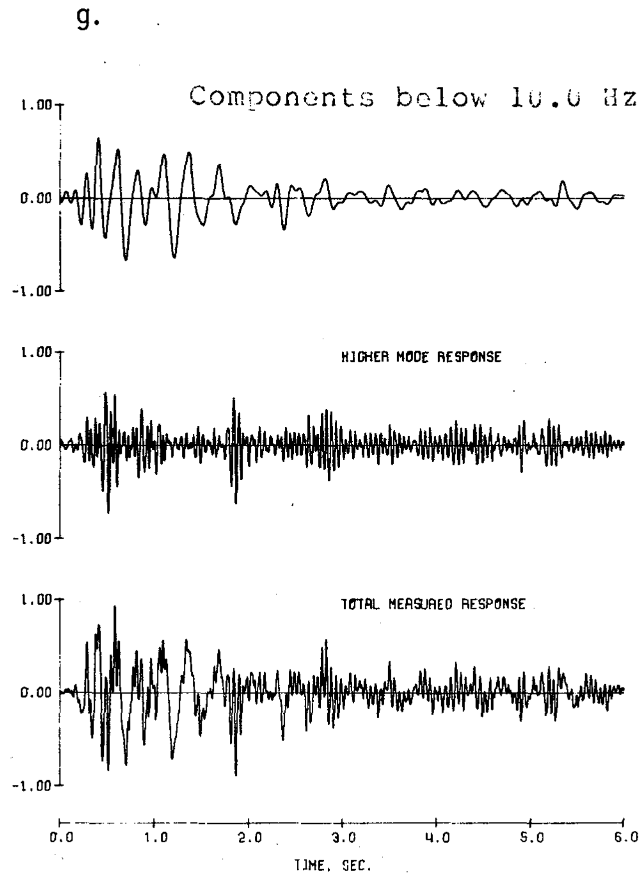


(a) Lower Level



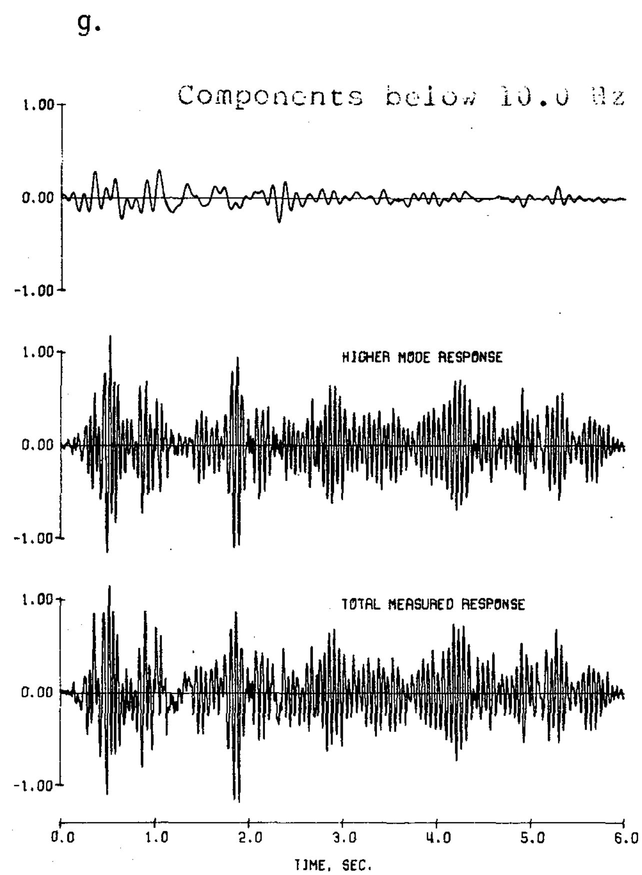
(b) Middle Level

Figure 6.5 Fourier Analysis. Horizontal Accelerations. Test Run D4-1.



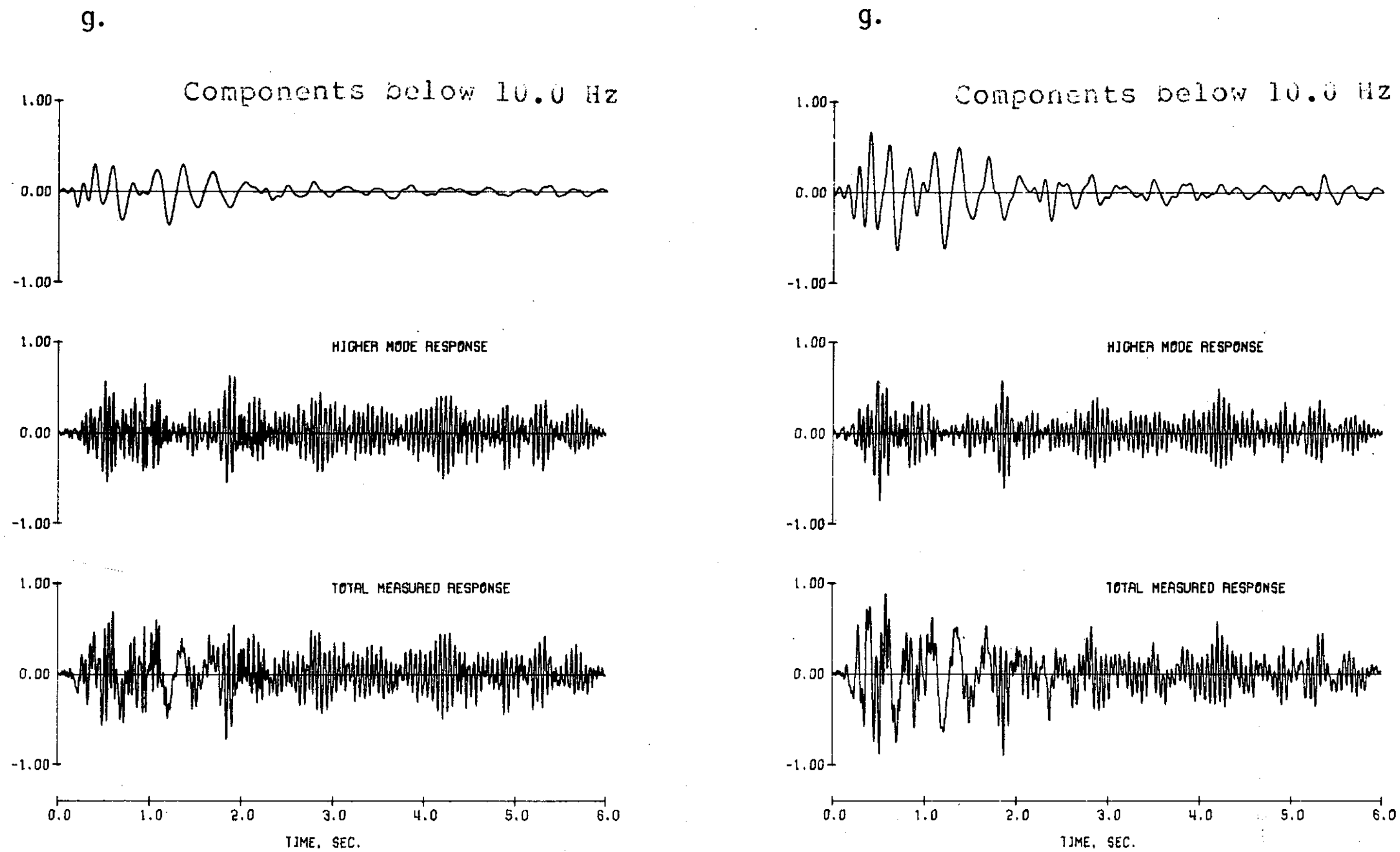
(c) Top Level

Figure 6.5 (contd.) Fourier Analysis. Horizontal Accelerations. Test Run D4-1.



(a) Lower Level

Figure 6.6 Fourier Analysis. Horizontal Accelerations. Test Run D5-1.



(b) Middle Level

(c) Top Level

Figure 6.6 (contd.) Fourier Analysis. Horizontal Accelerations.
Test Run D5-1.

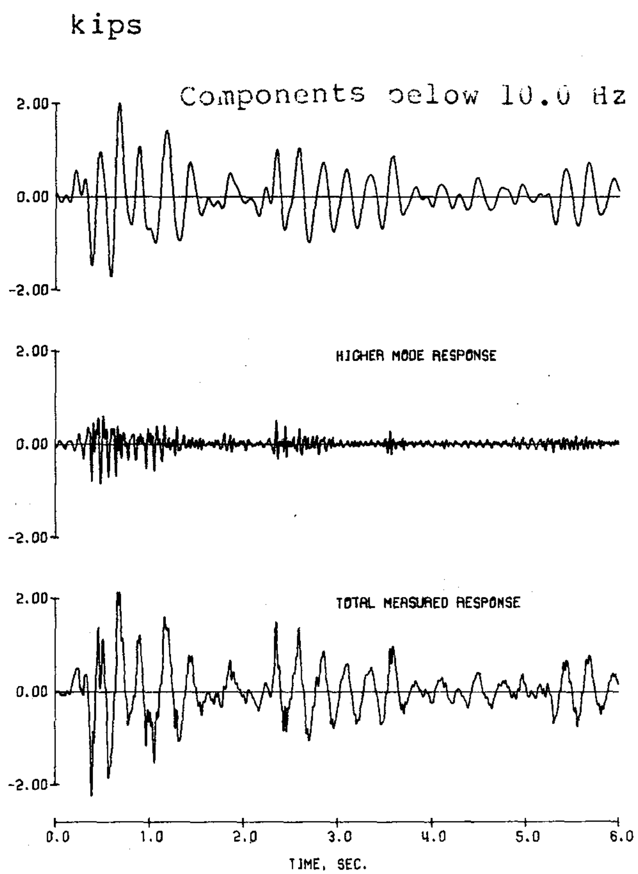


Figure 6.7 Fourier Analysis. Base Shear. Test Run D1-4.

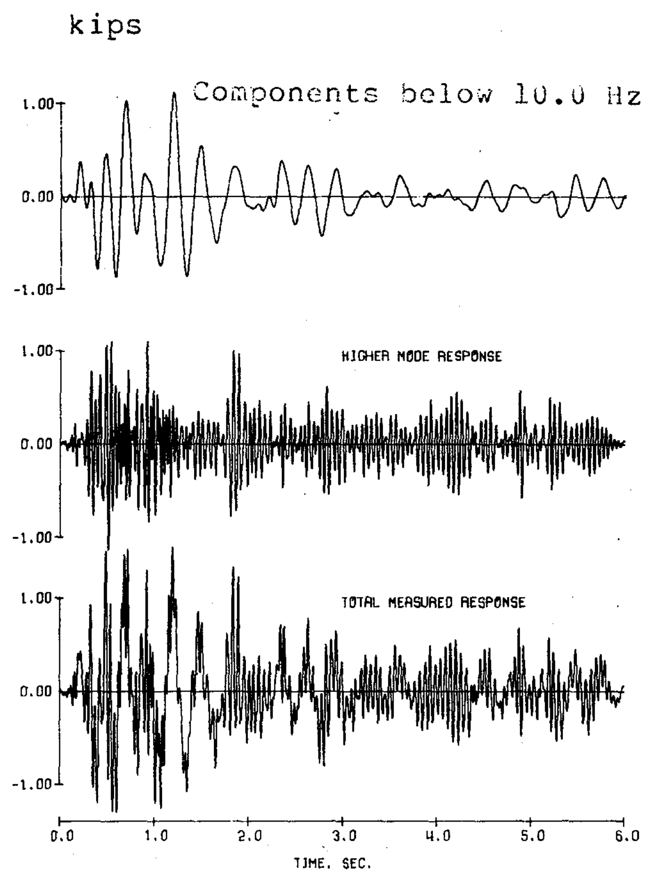


Figure 6.8 Fourier Analysis. Base Shear. Test Run D2-1.

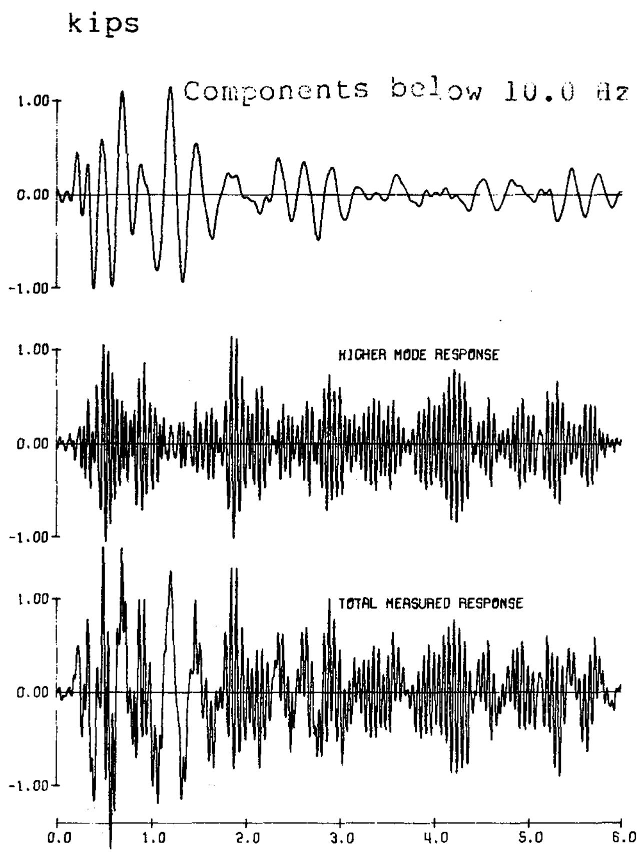


Figure 6.9 Fourier Analysis. Base Shear Test Run D3-1.

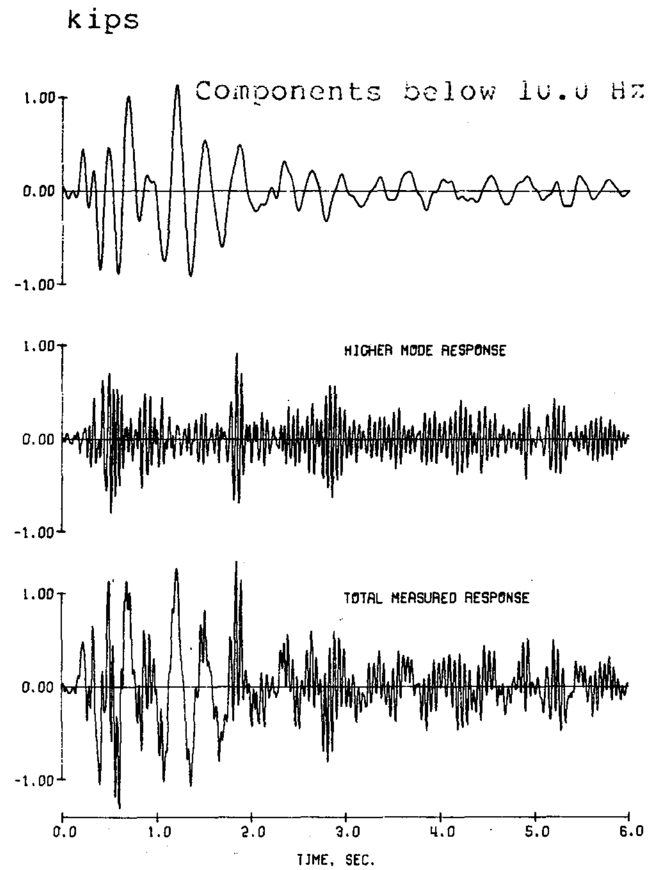


Figure 6.10 Fourier Analysis. Base Shear. Test Run D4-1.

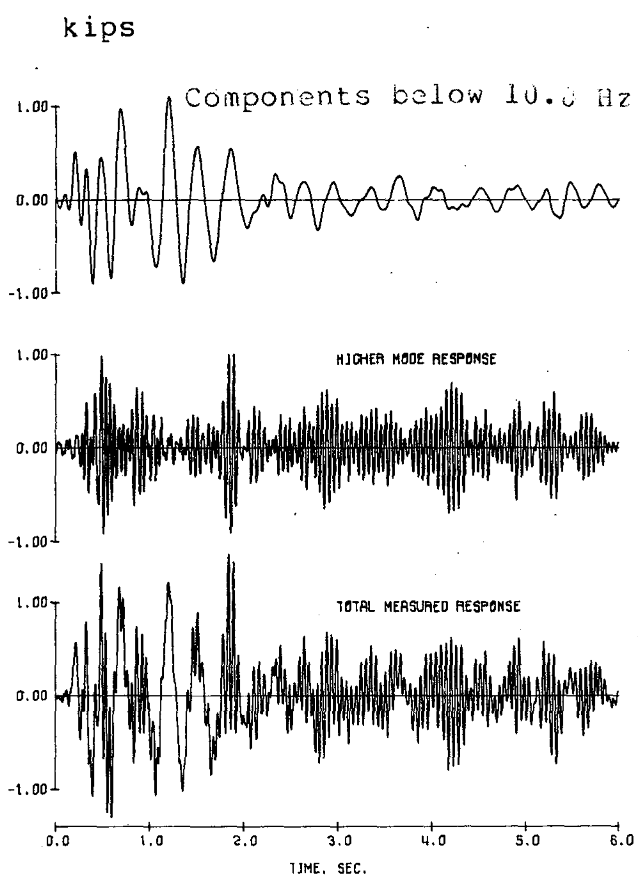


Figure 6.11 Fourier Analysis. Base Shear. Test Run D5-1.

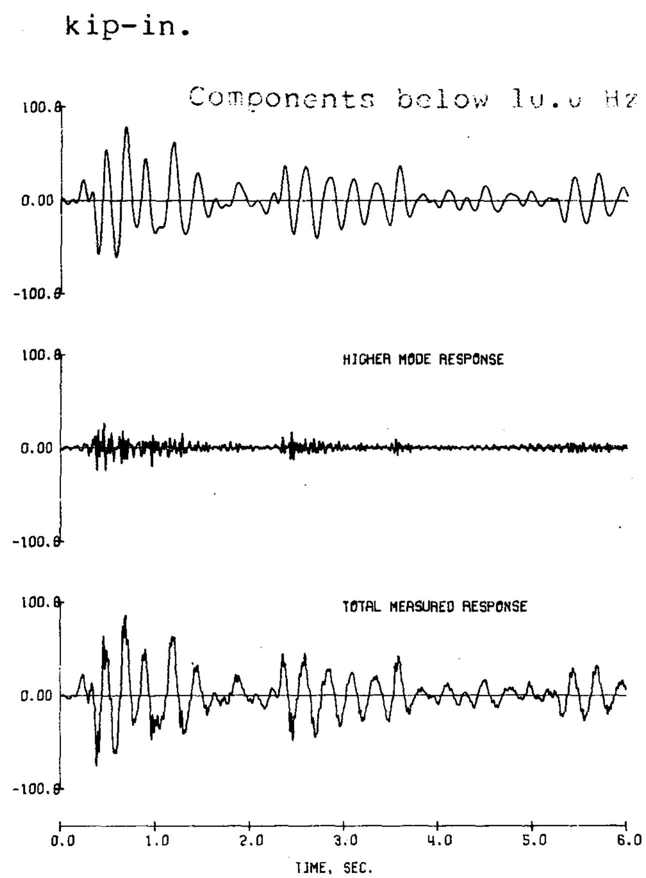


Figure 6.12 Fourier Analysis. Base Moment. Test Run D1-4.

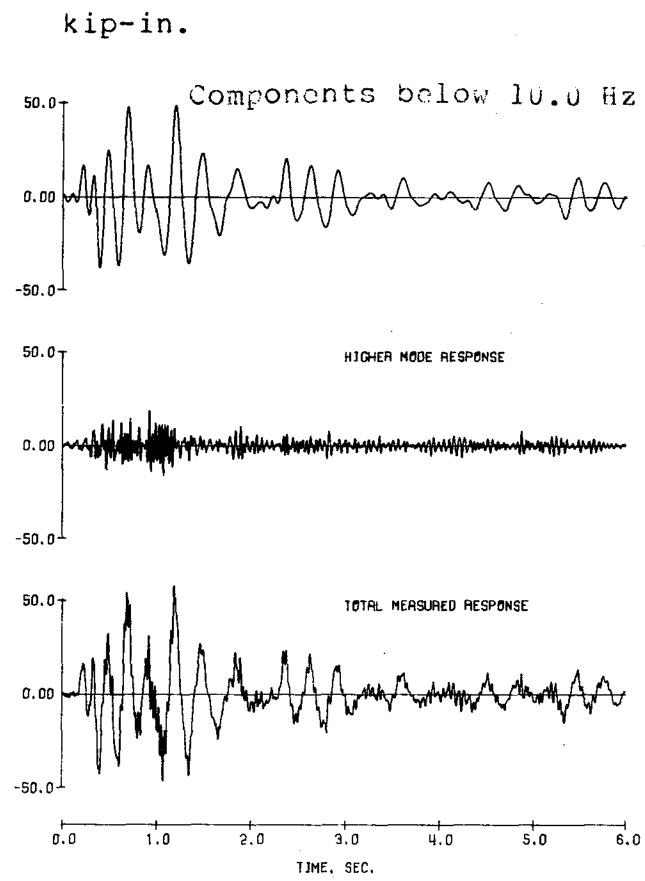


Figure 6.13 Fourier Analysis. Base Moment. Test Run D2-1.

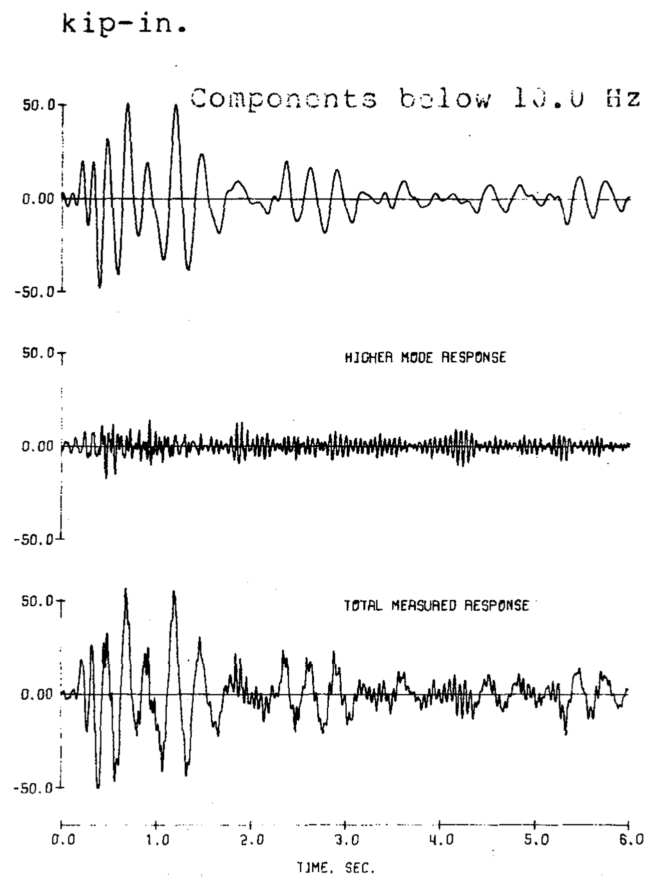


Figure 6.14 Fourier Analysis. Base Moment. Test Run D3-1.

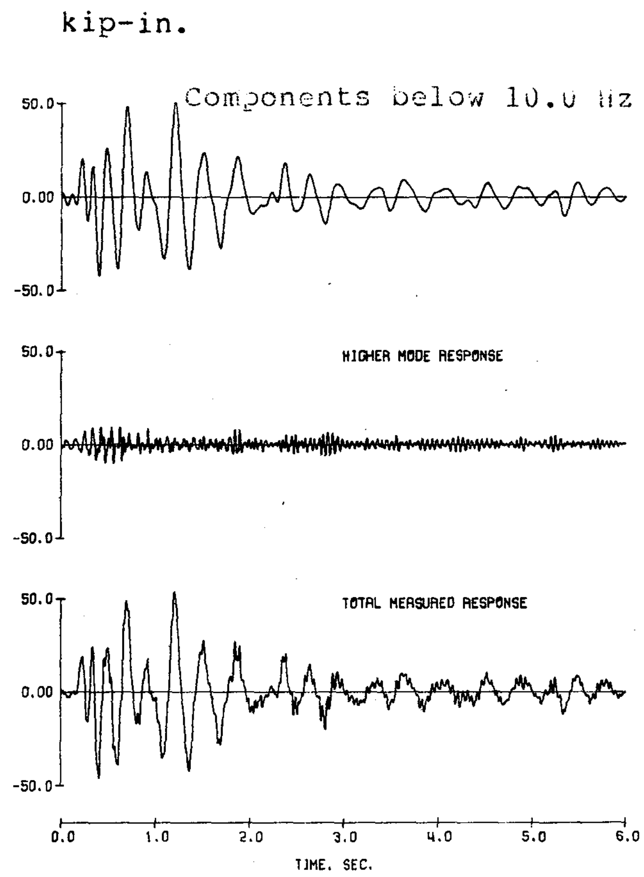


Figure 6.15 Fourier Analysis. Base Moment. Test Run D4-1.

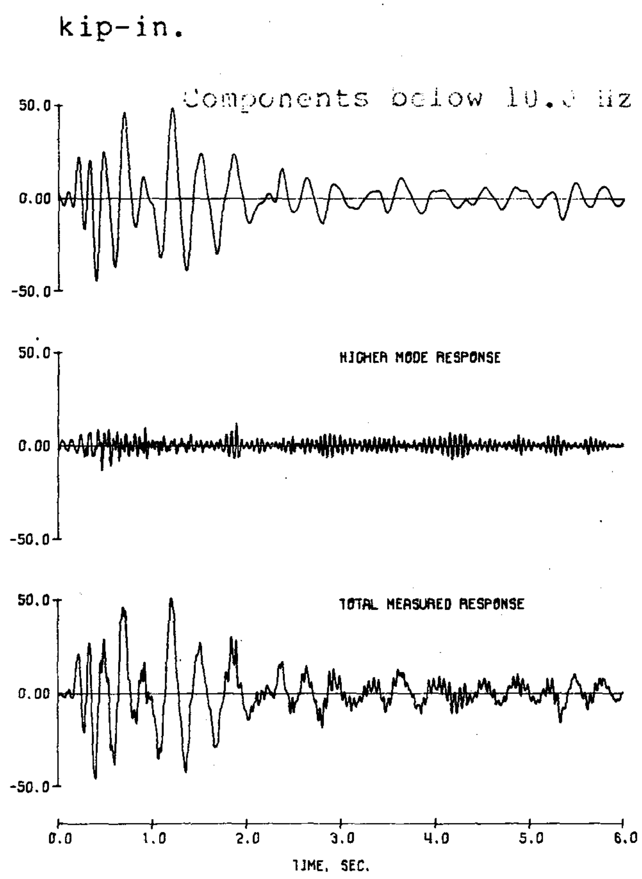


Figure 6.16 Fourier Analysis. Base Moment. Test Run D5-1.

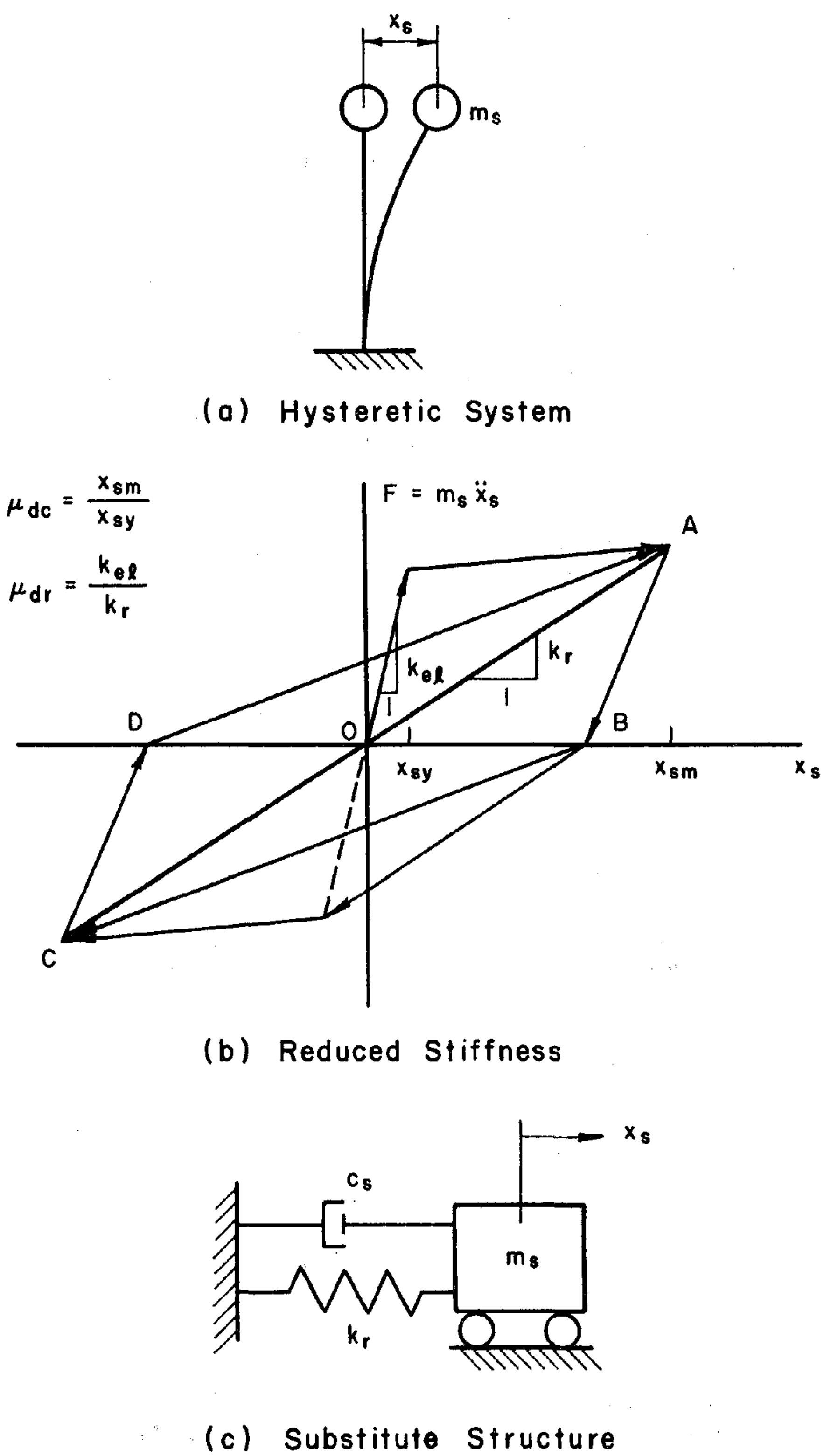


Figure 7.1 Substitute Structure Concept Illustrated by a Single-Degree-of-Freedom System

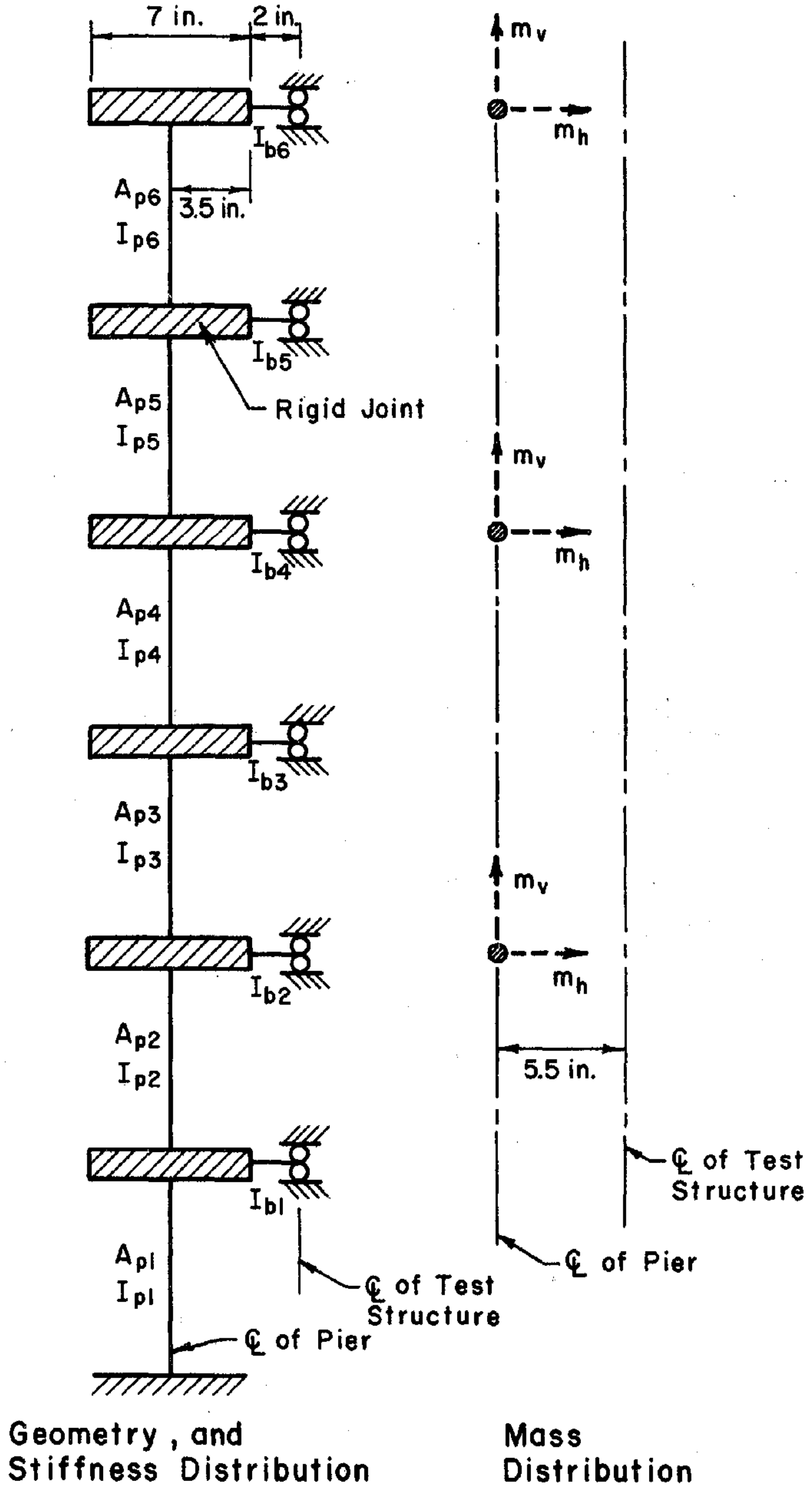


Figure 7.2 Structure Idealization for Study of Dynamic Linear Response

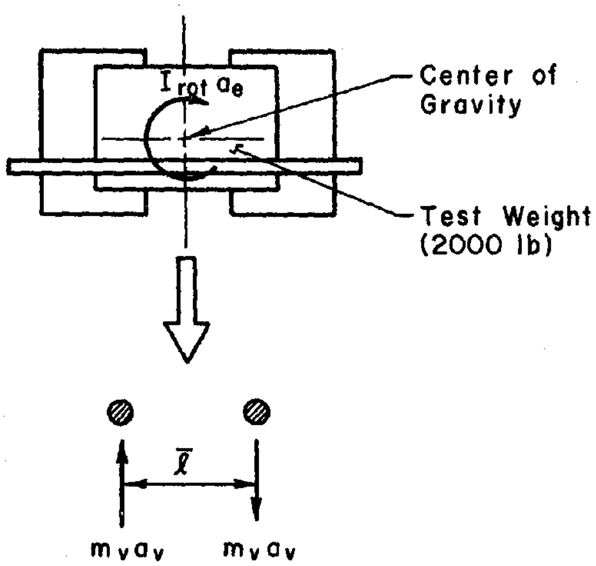


Figure 7.3 Consideration of Rotational Inertia of Test Weights

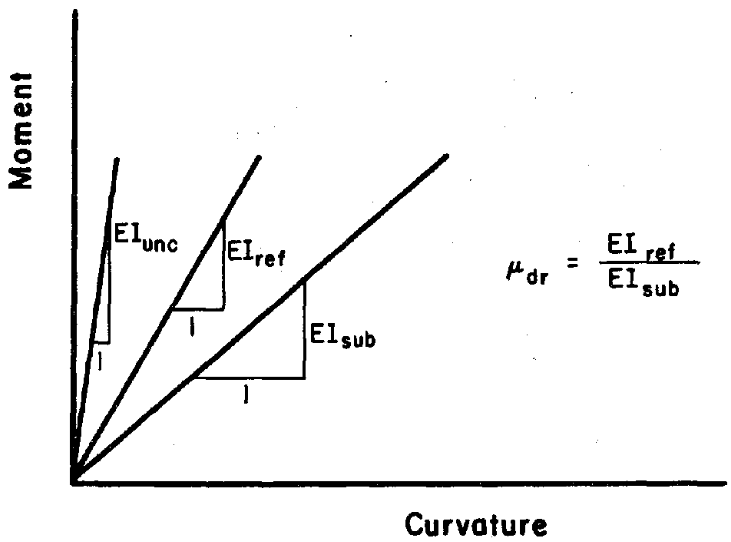


Figure 7.4 Reduction in Section Stiffnesses for Substitute Structures in Study of Dynamic Response

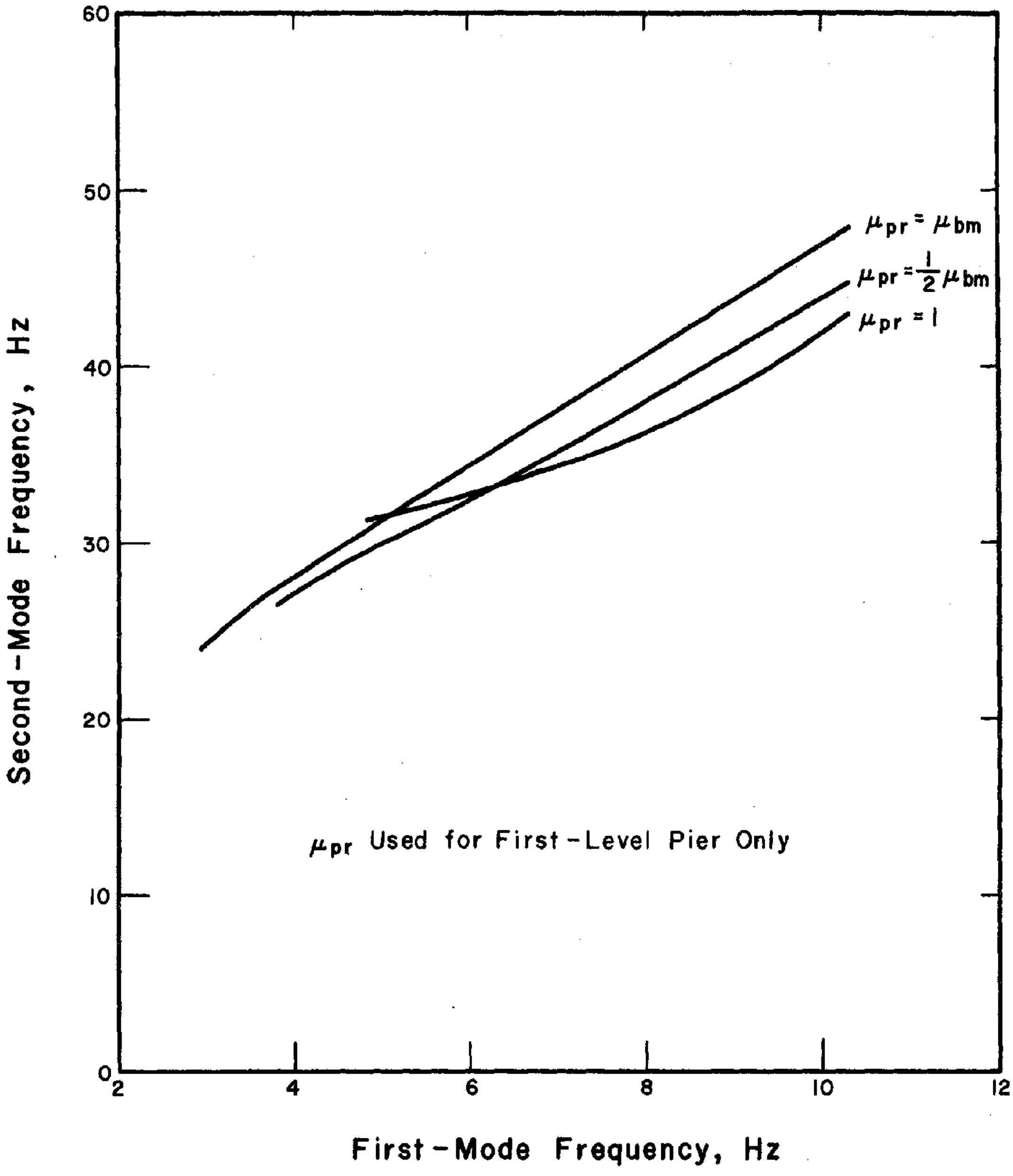


Figure 7.5 Variation of Second-Mode Frequency with First-Mode Frequency. Type A Structure

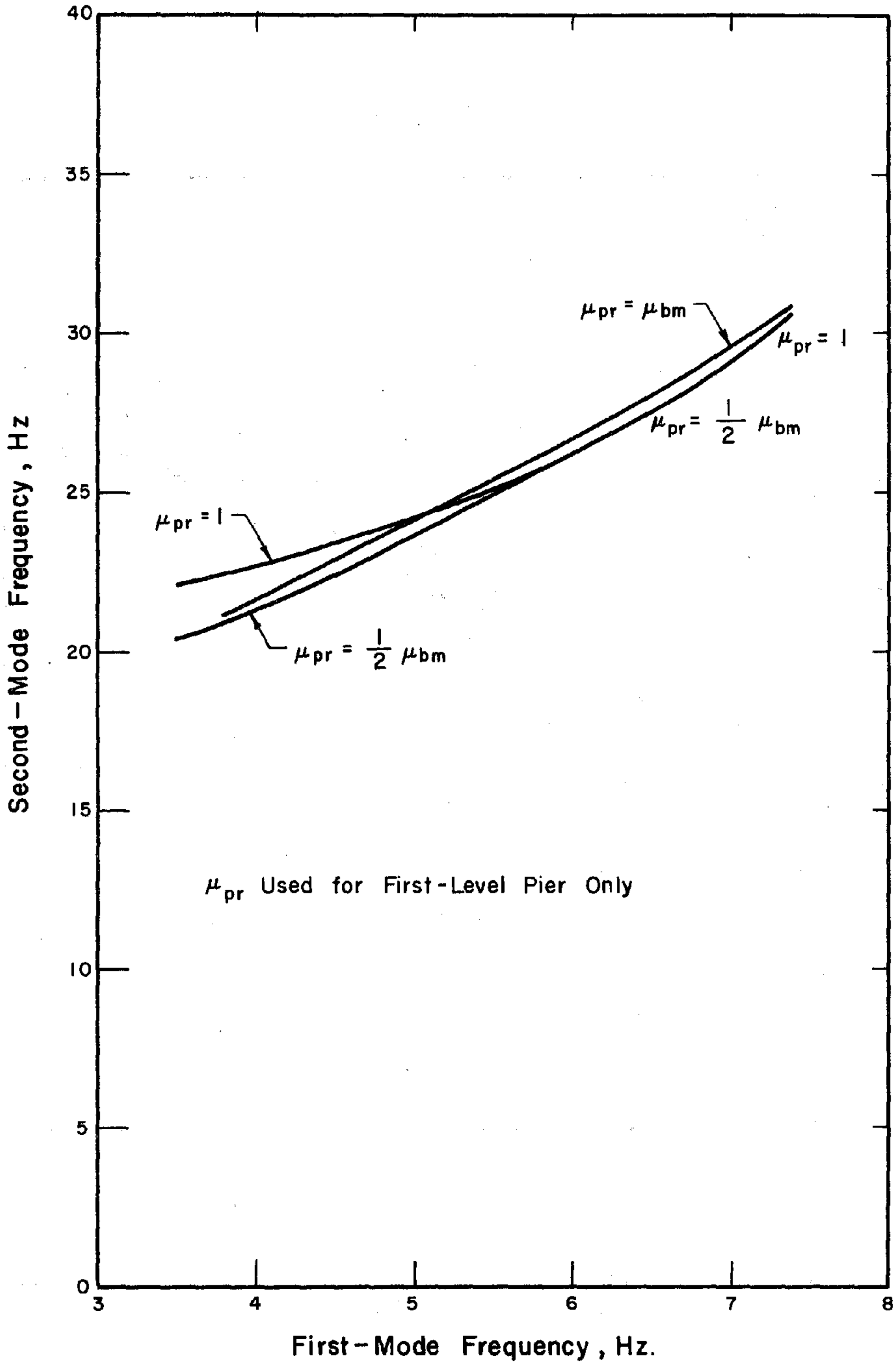


Figure 7.5 (contd.) Variation of Second-Mode Frequency with First-Mode Frequency. Types B and C Structures

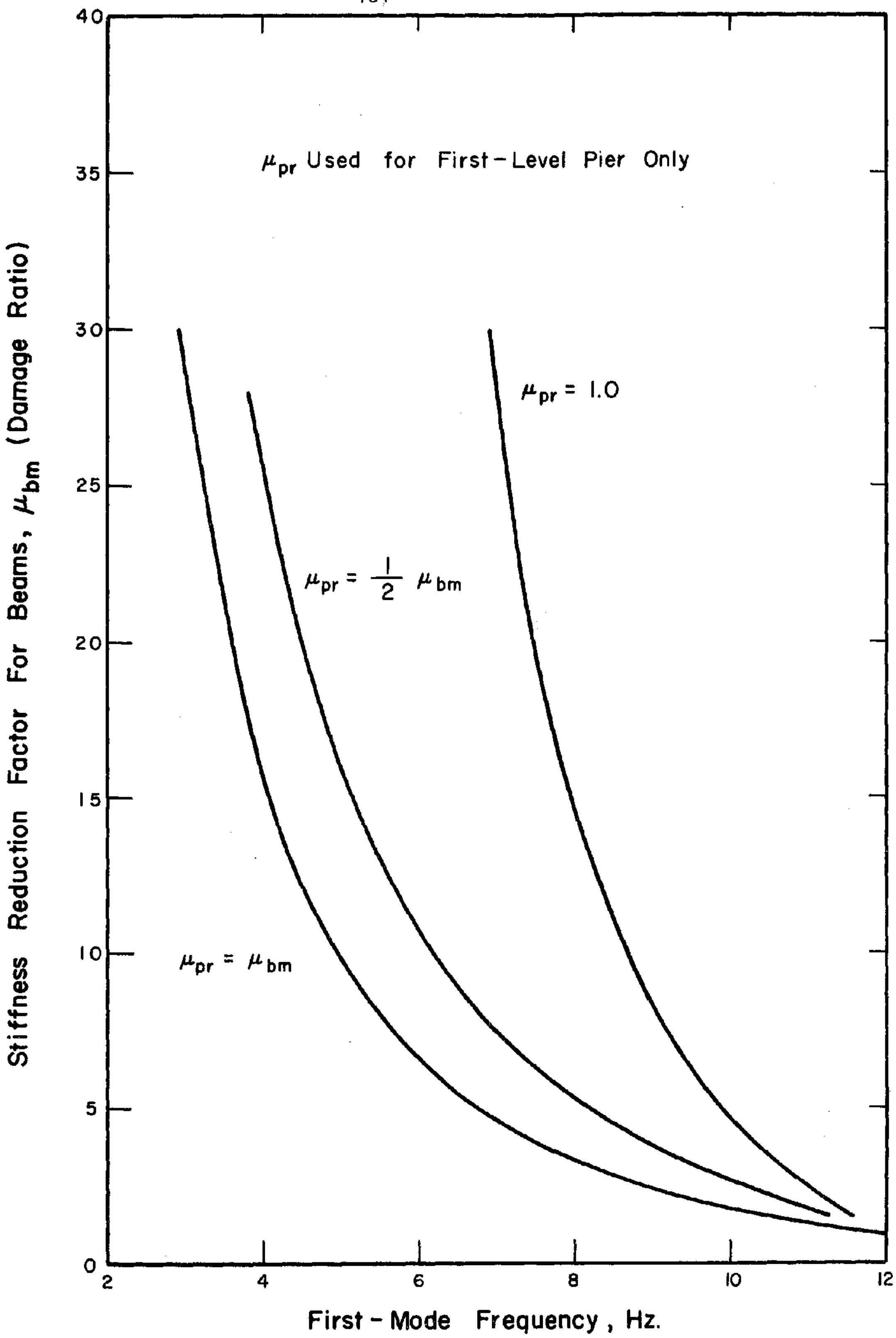


Figure 7.6 Variation of First-Mode Frequency with Damage Ratio for Beams. Type A Structure

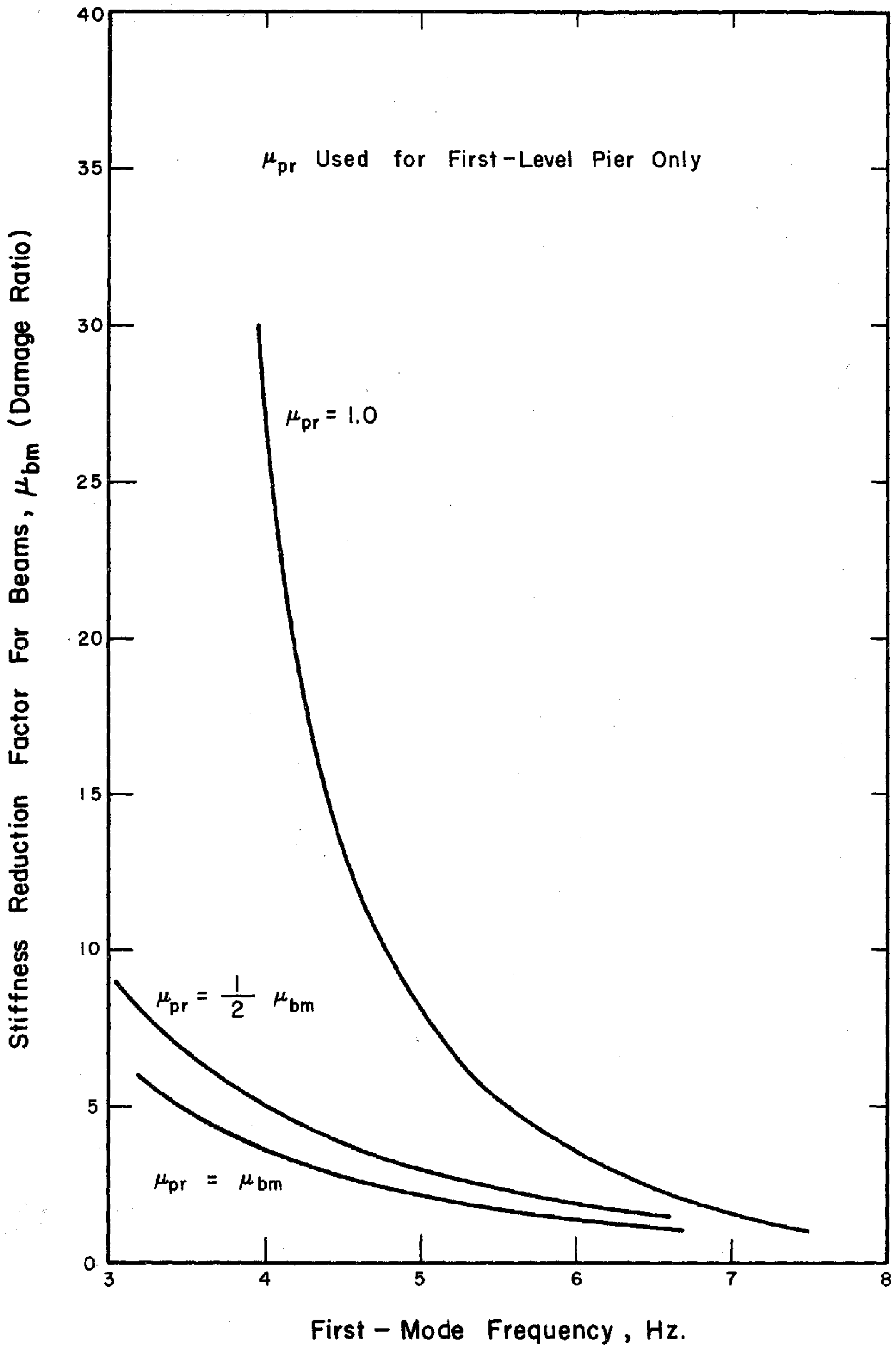


Figure 7.6 (contd.) Variation of First-Mode Frequency with Damage Ratio for the Beams. Types B and C Structures

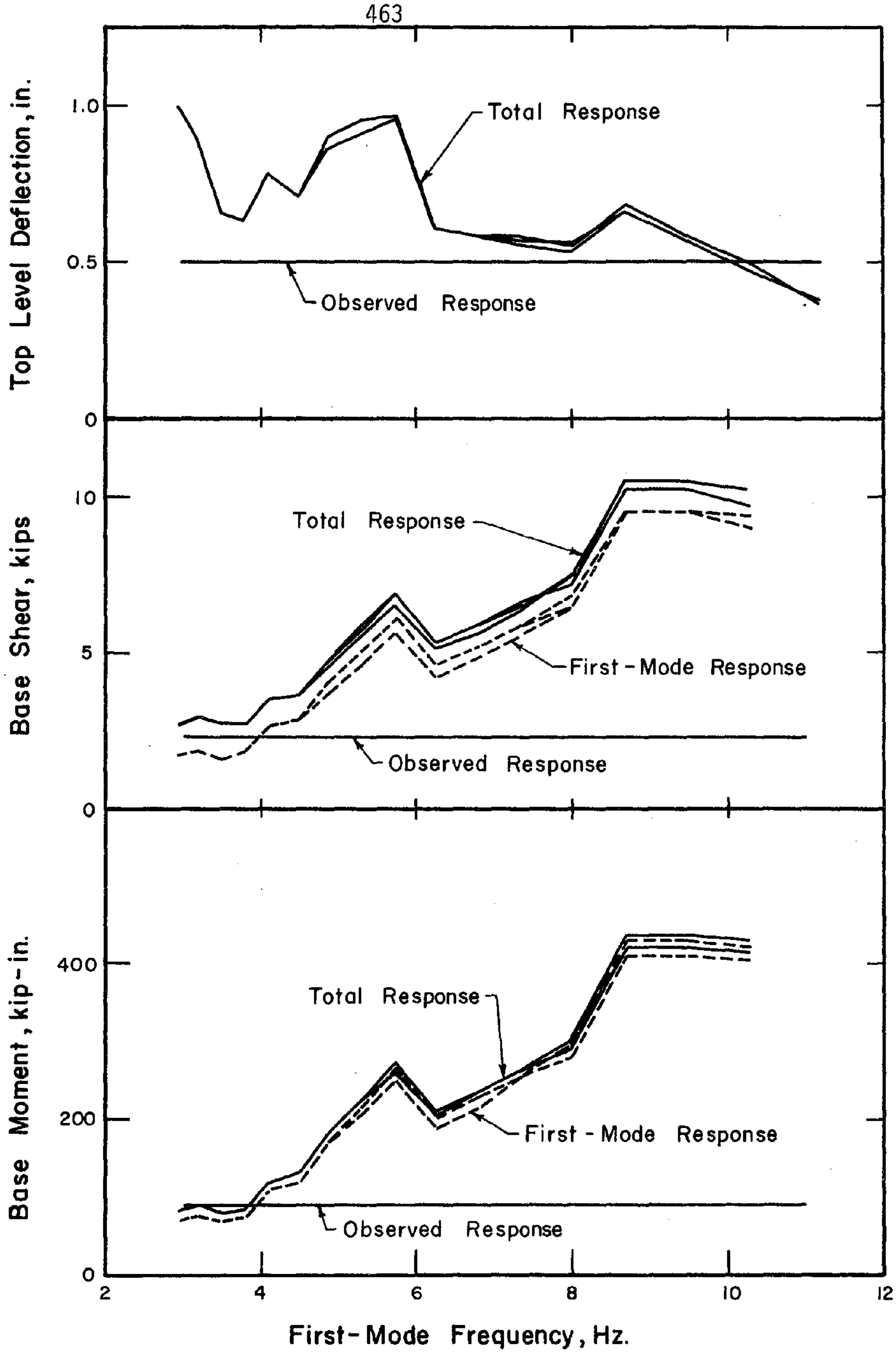


Figure 7.7 Variation of Maximum Calculated Response with First-Mode Frequency. Test D1-4. $\beta = 0.02$

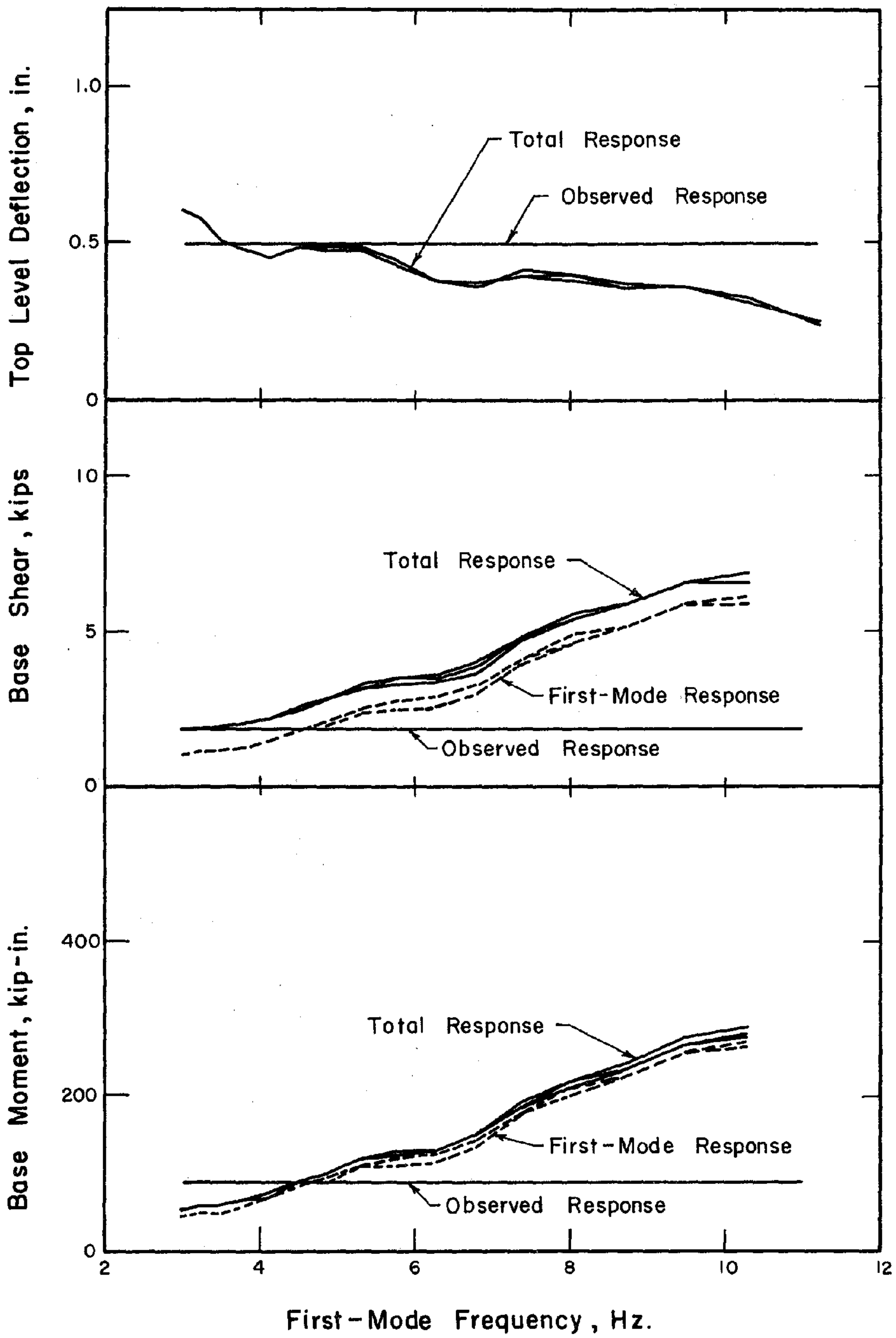


Figure 7.7 (contd.) Variation of Maximum Calculated Response with First-Mode Frequency. Test D1-4. β = 0.10

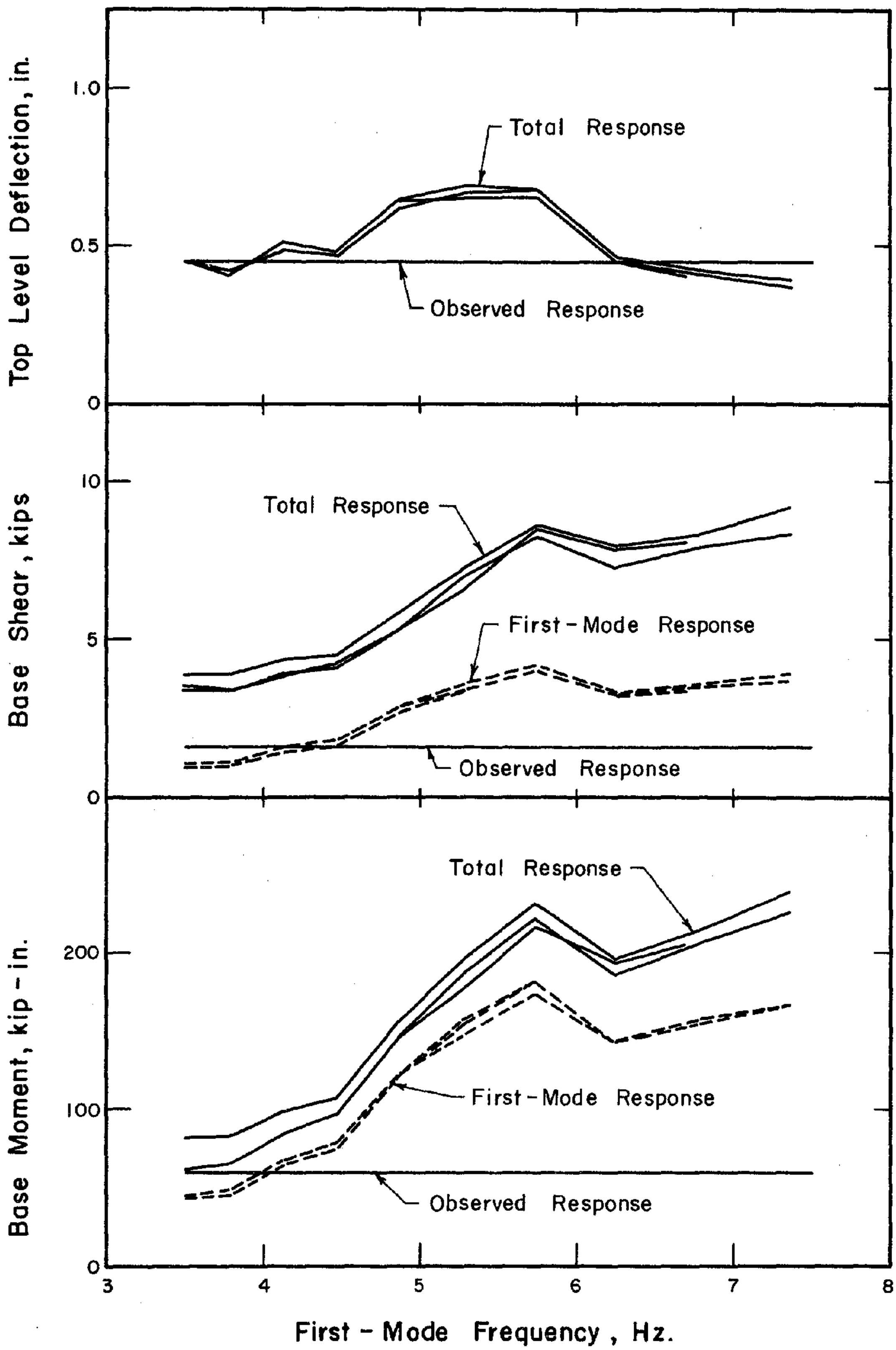


Figure 7.8 Variation of Maximum Calculated Response with First-Mode Frequency. Test D2-1, $\beta = 0.02$

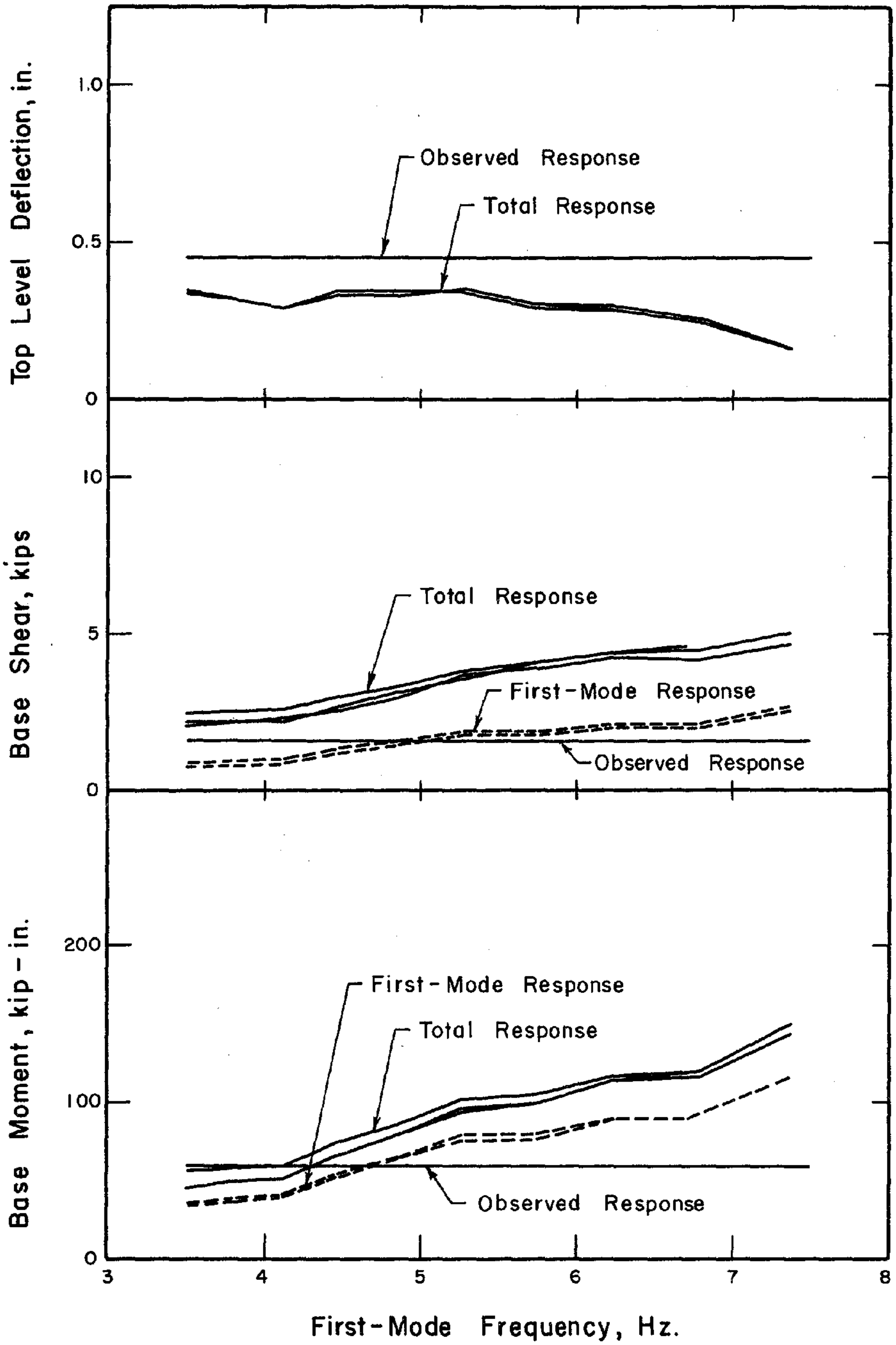


Figure 7.8 (contd.) Variation of Maximum Calculated Response with First-Mode Frequency. Test D2-1. $\beta = 0.10$

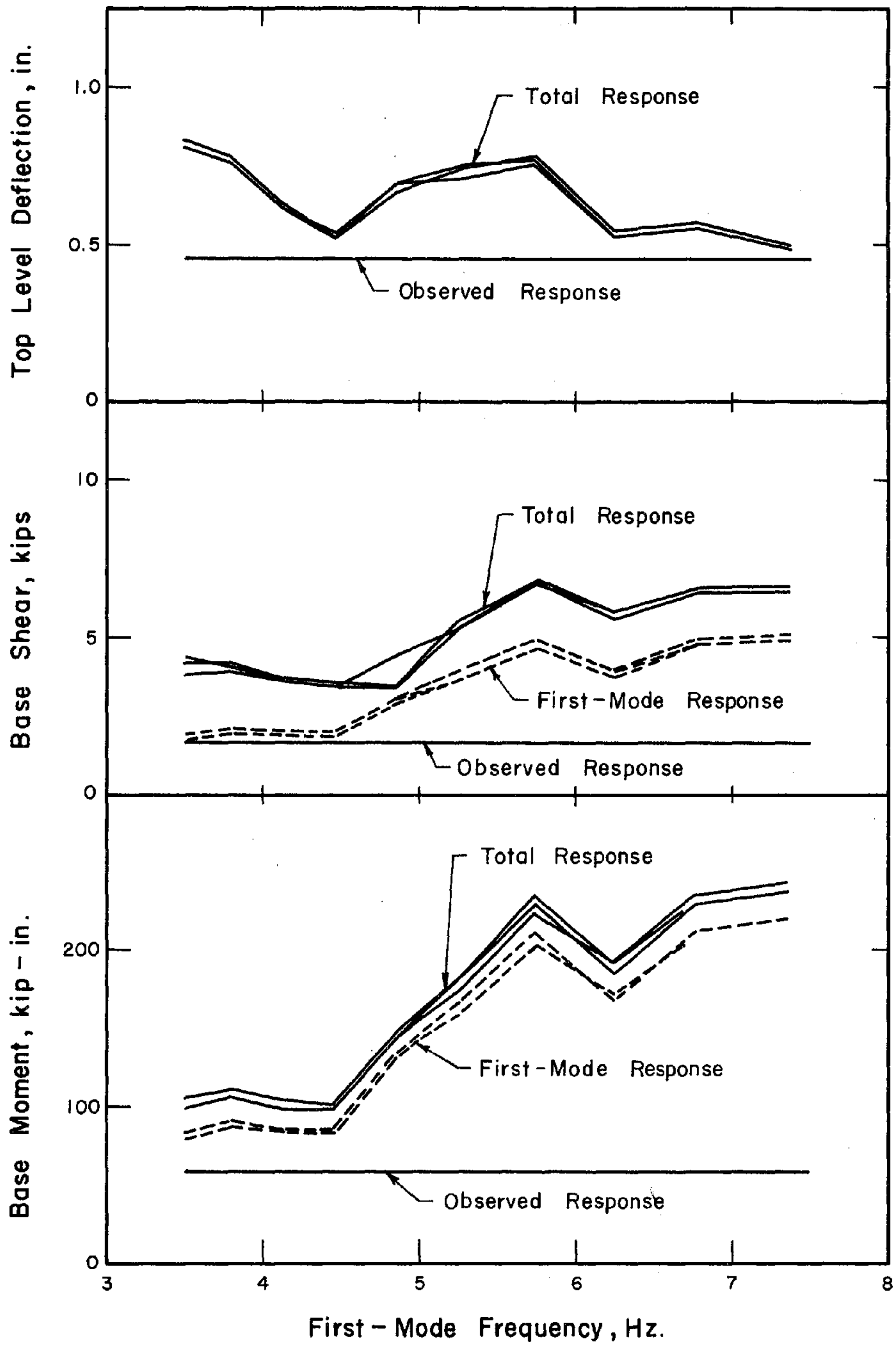


Figure 7.9 Variation of Maximum Calculated Response with First-Mode Frequency. Test D3-1. $\beta = 0.02$

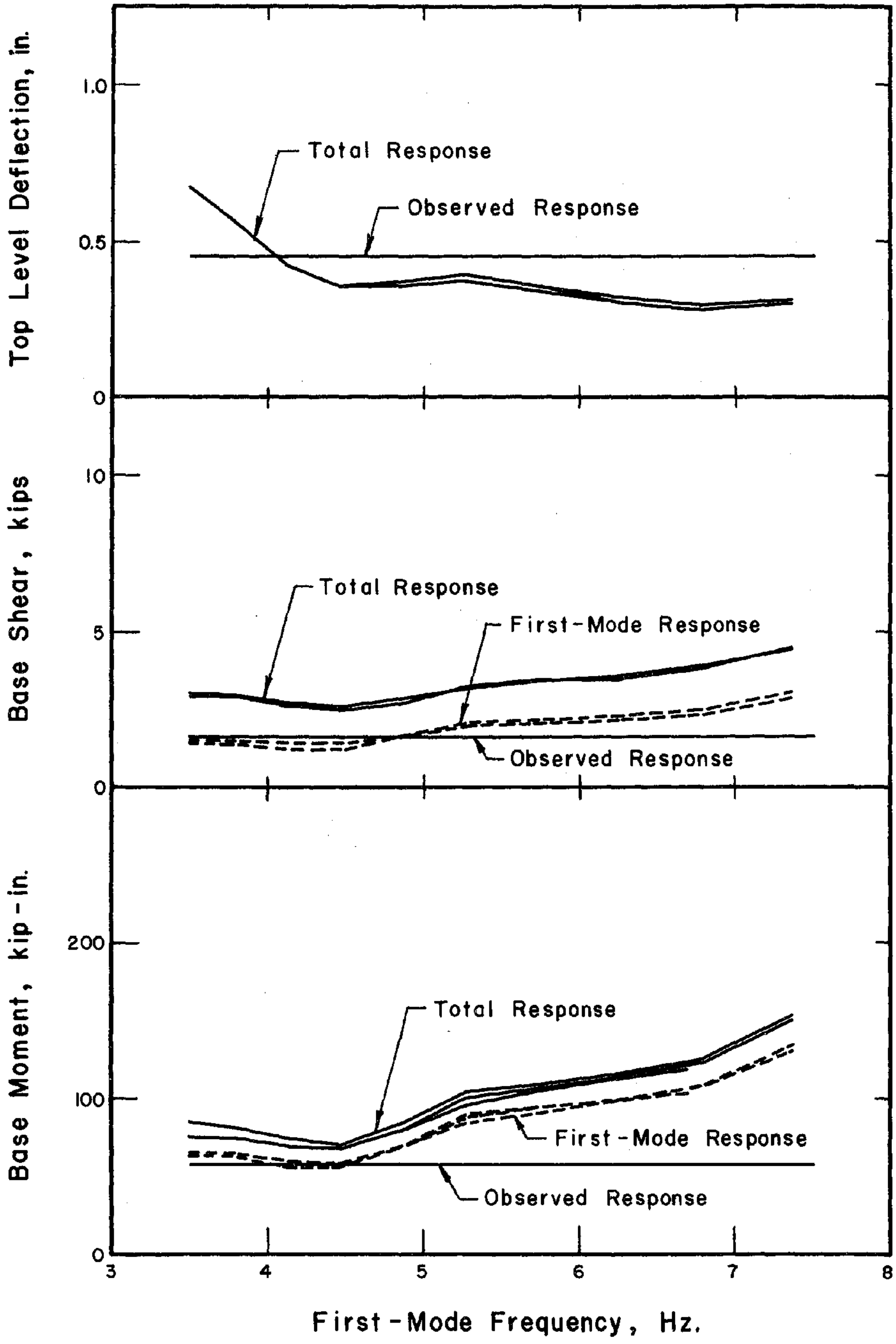


Figure 7.9 (contd.) Variation of Maximum Calculated Response with First-Mode Frequency. Test D3-1. β = 0.10

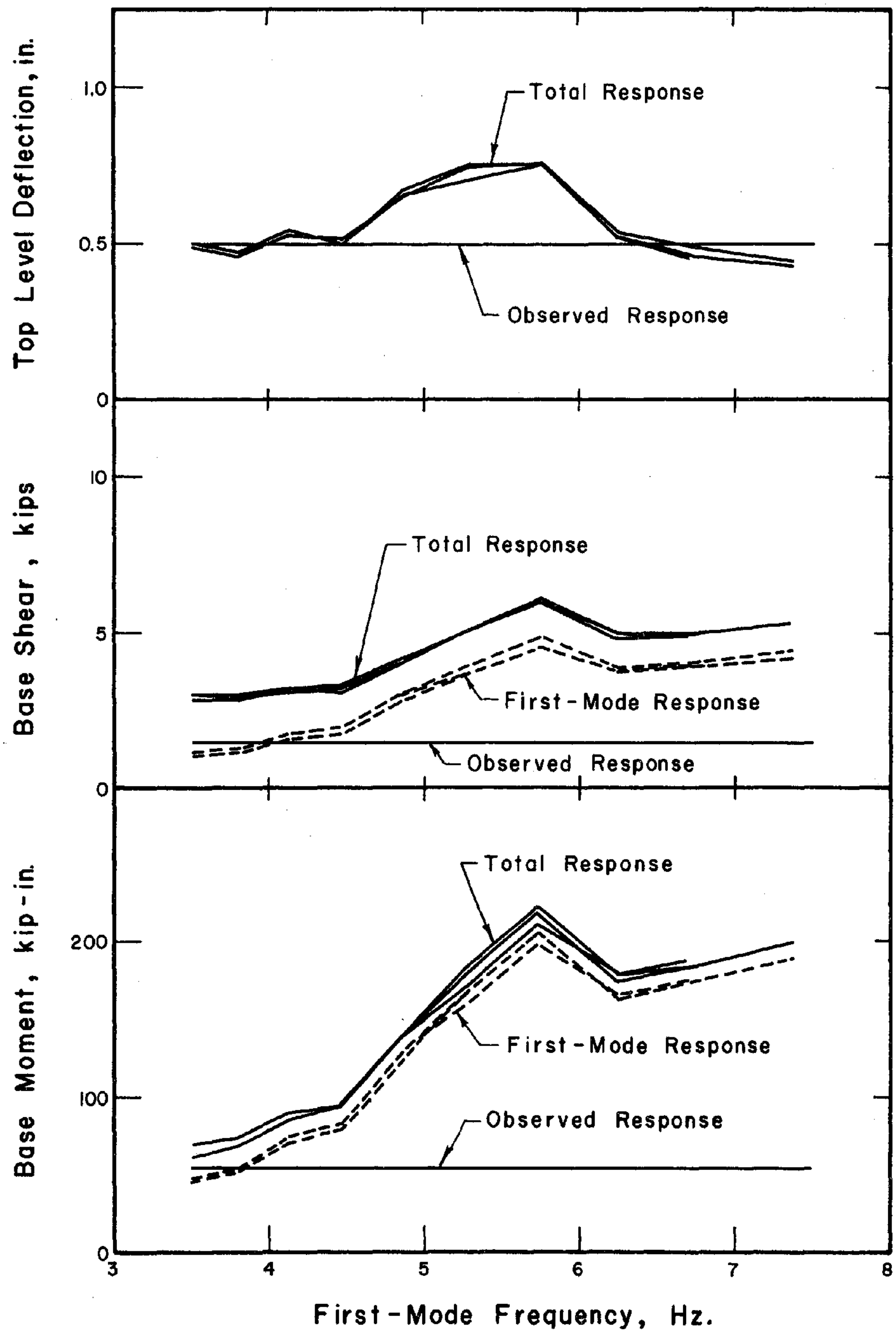


Figure 7.10 Variation of Maximum Calculated Response with First-Mode Frequency. Test D4-1. $\beta = 0.02$

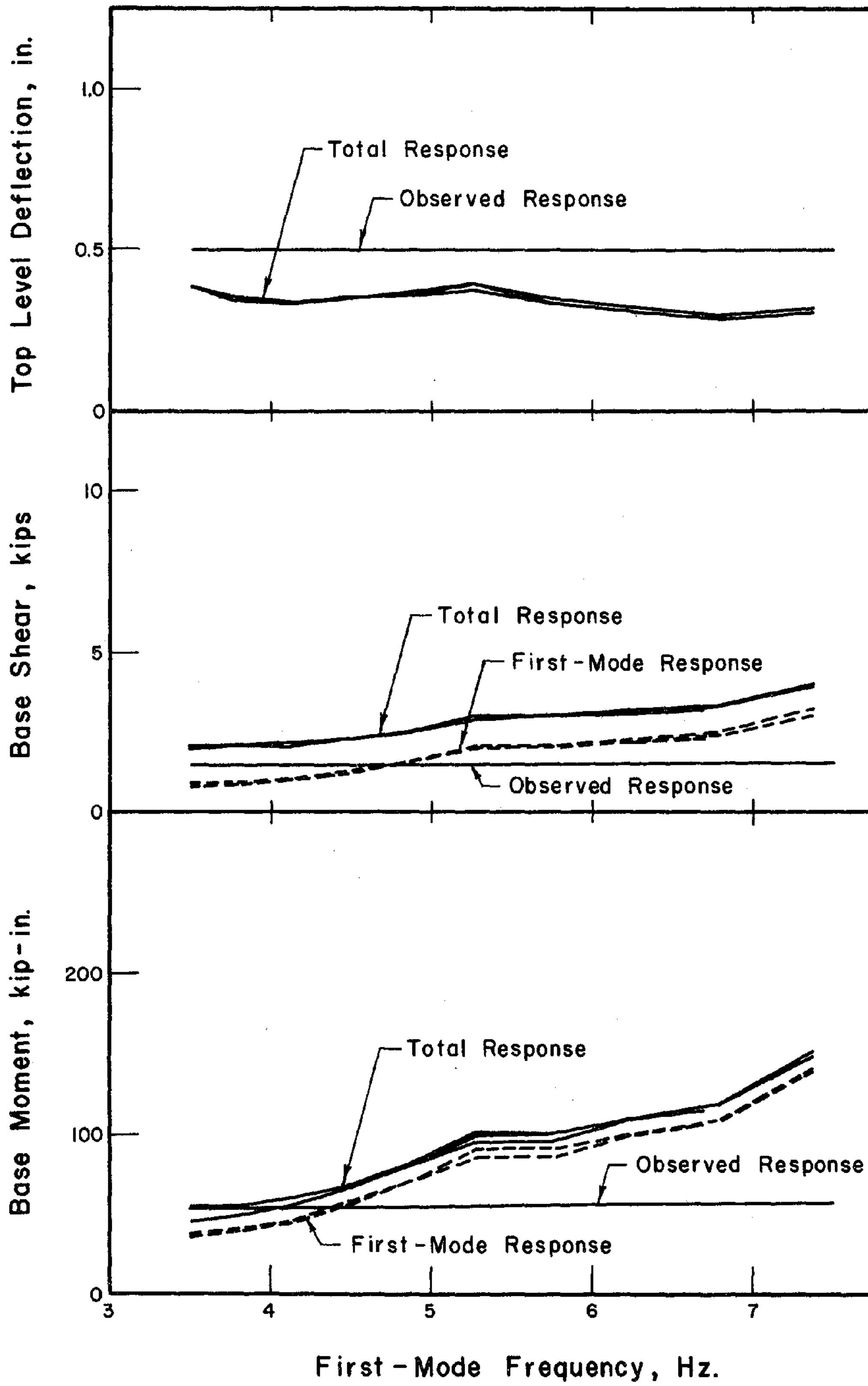


Figure 7.10 (contd.) Variation of Maximum Calculated Response with First-Mode Frequency. Test D4-1. $\beta = 0.10$

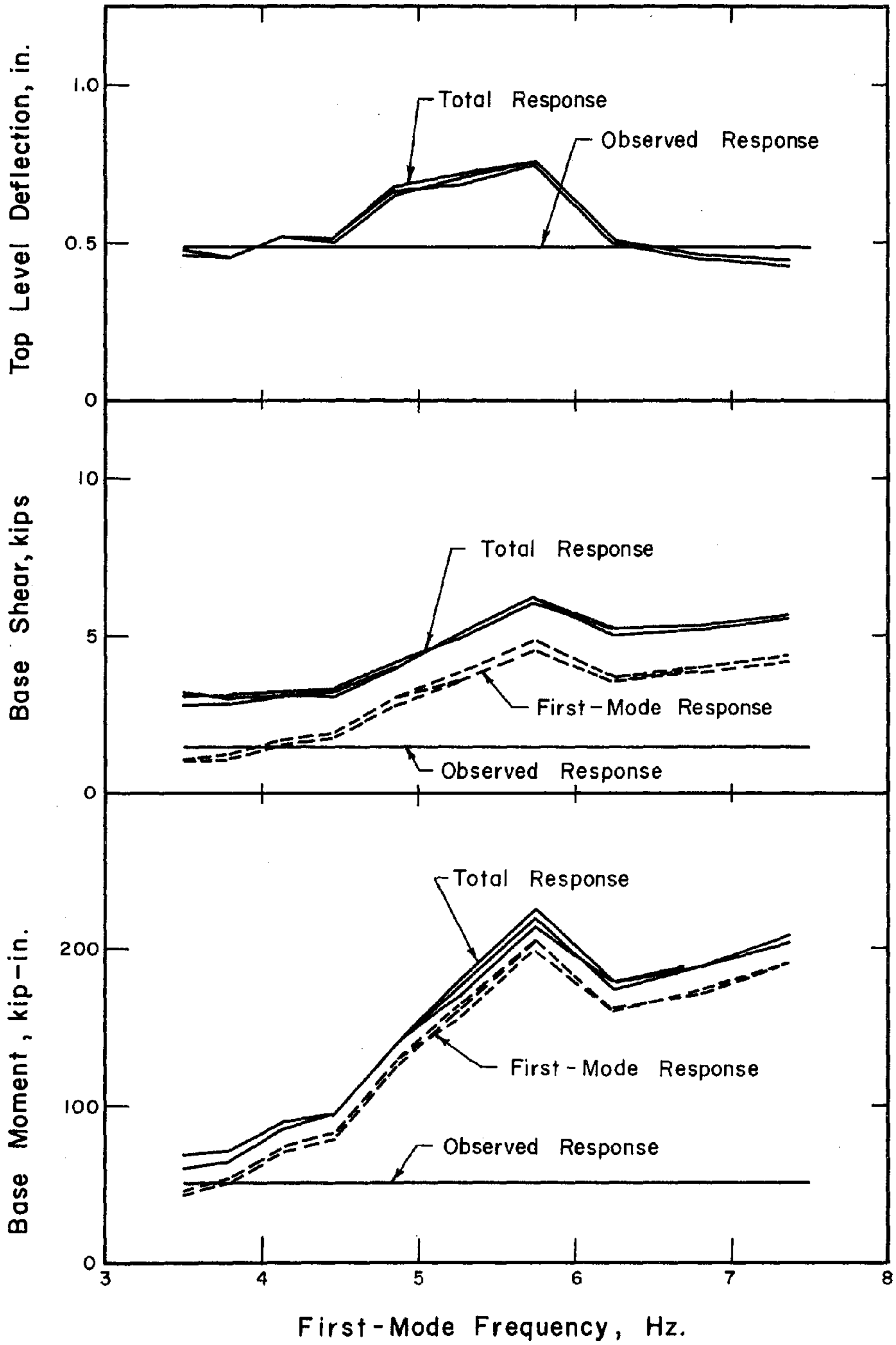


Figure 7.11 Variation of Maximum Calculated Response with First-Mode Frequency. Test D5-1. $\beta = 0.02$

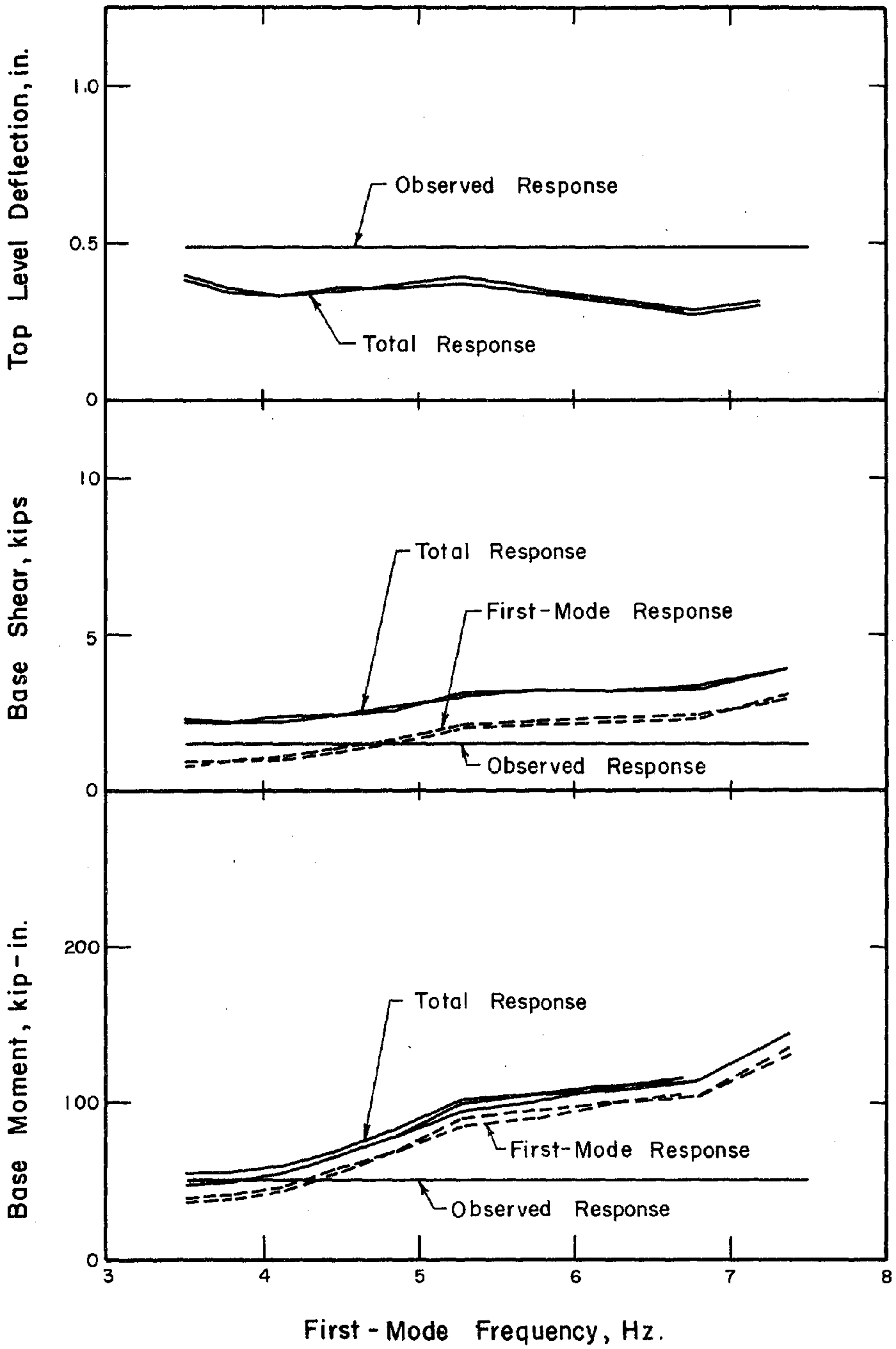


Figure 7.11 (contd.) Variation of Maximum Calculated Response with First-Mode Frequency. Test D5-1. β = 0.10

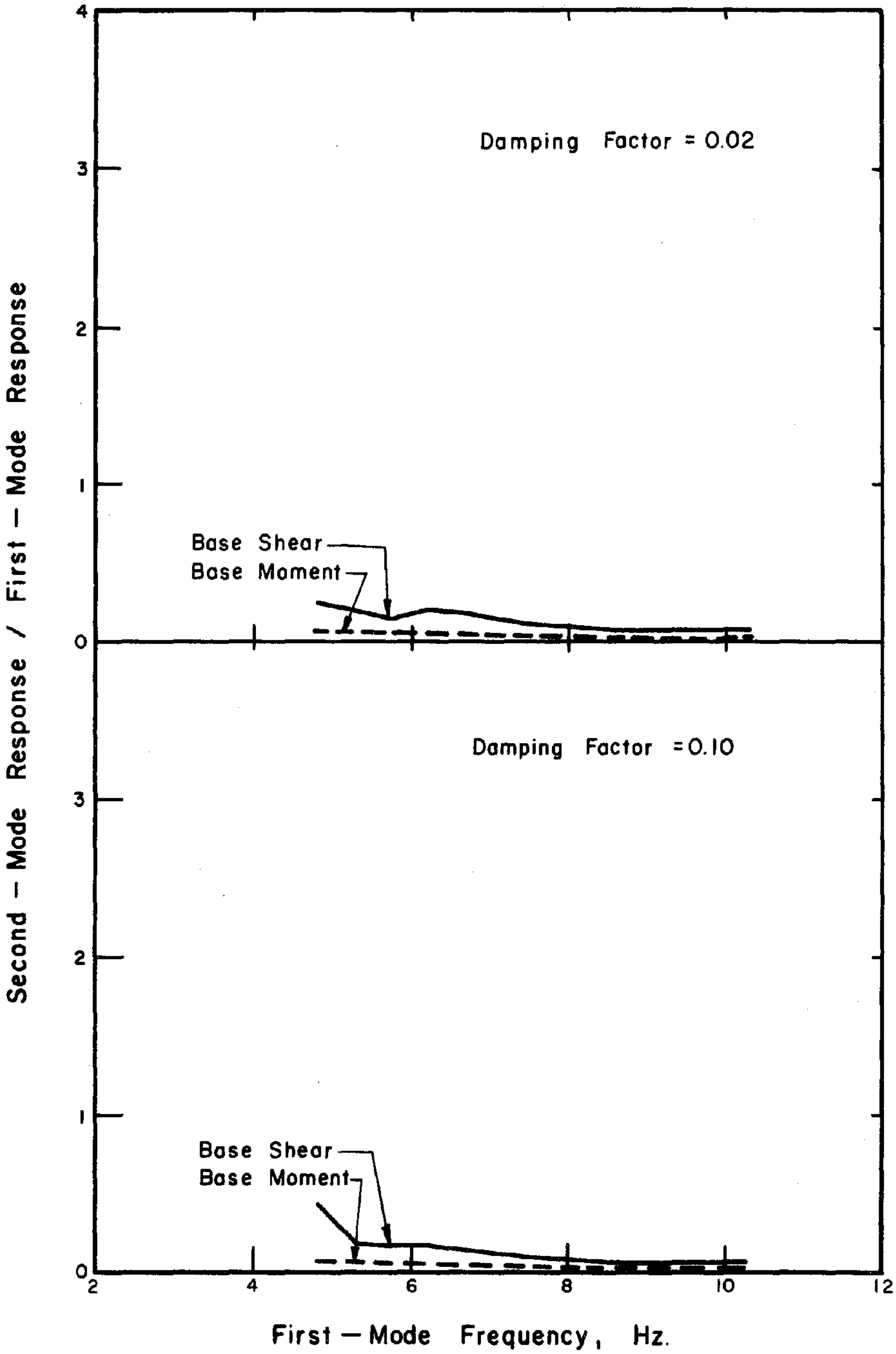


Figure 7.12 Variation of the Ratio of Second-Mode Response to First-Mode Response with First-Mode Frequency. Test D1-4

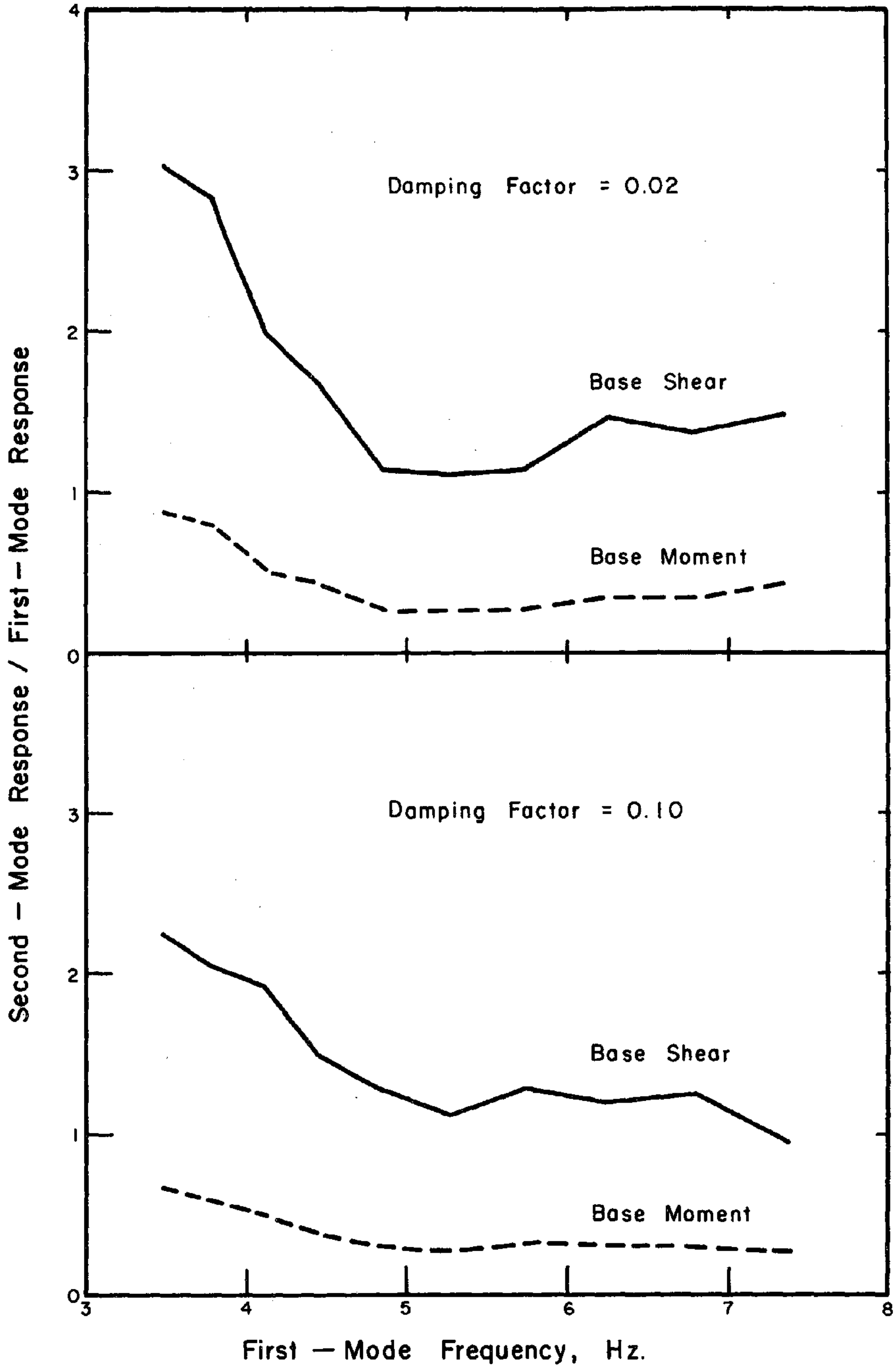


Figure 7.13 Variation of Ratio of Second-Mode Response to First-Mode Response with First-Mode Frequency. Test D2-1

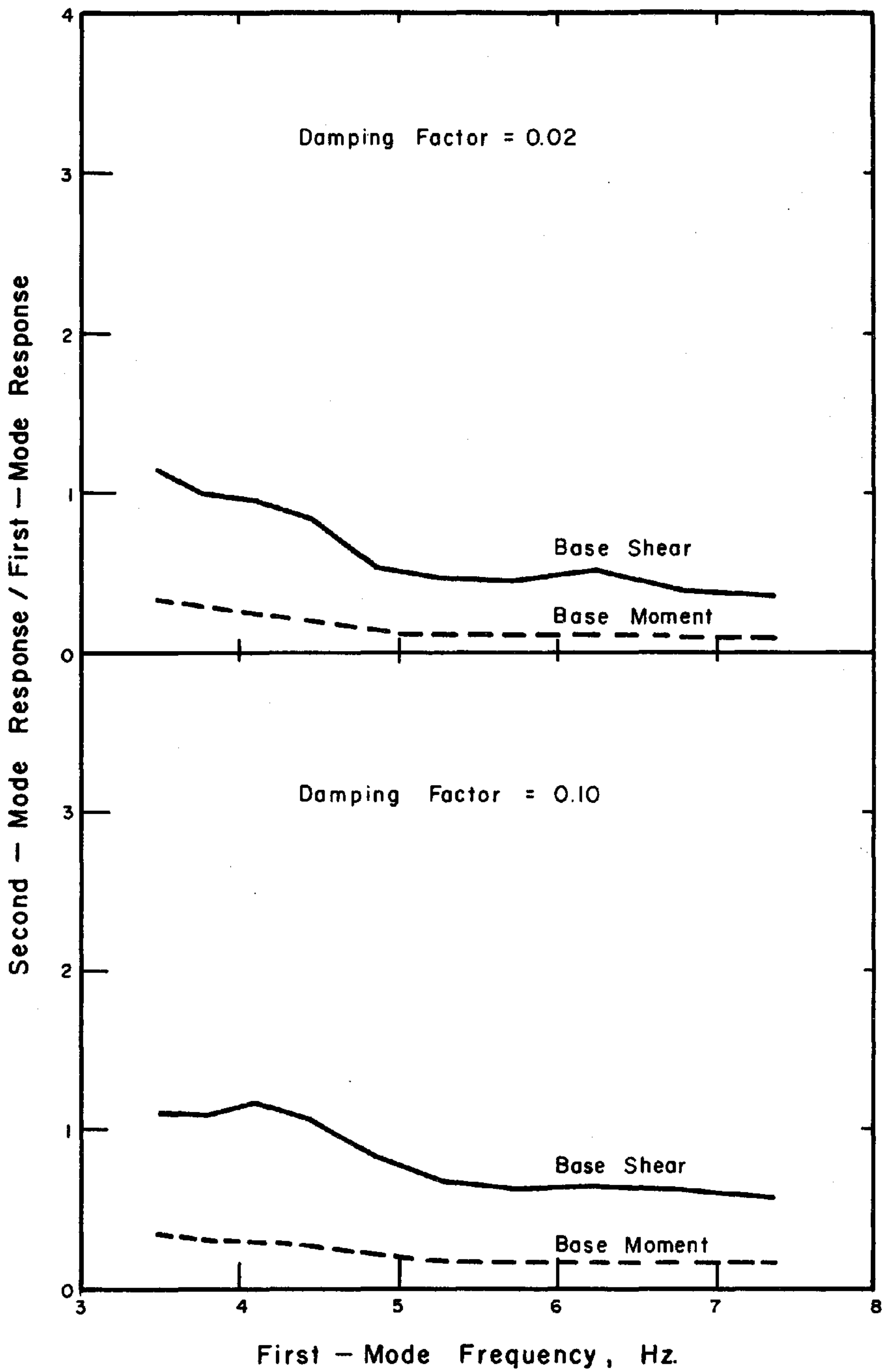


Figure 7.14 Variation of Ratio of Second-Mode Response to First-Mode Response with First-Mode Frequency. Test D3-1

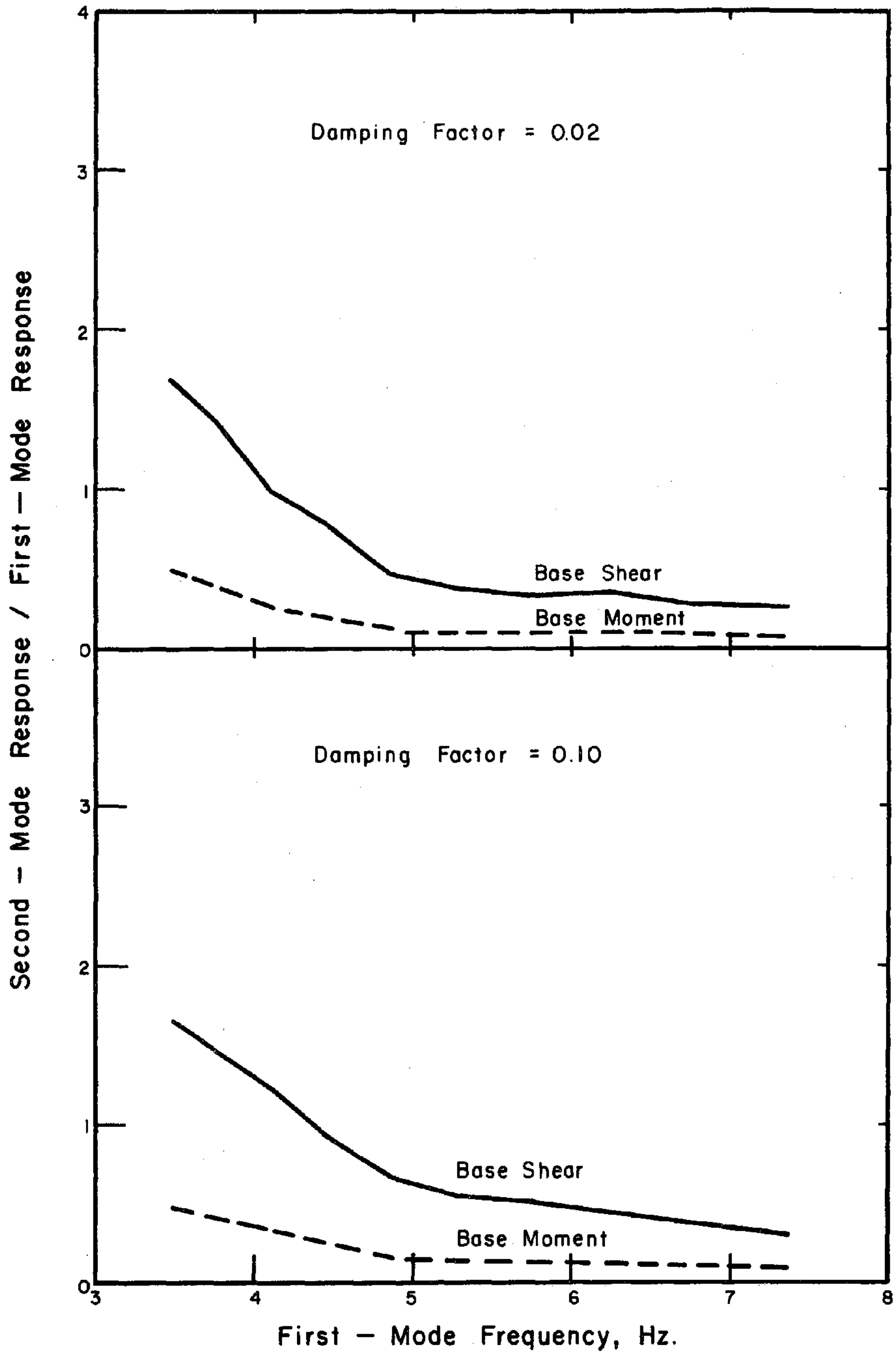


Figure 7.15 Variation of Ratio of Second-Mode Response to First-Mode Response with First-Mode Frequency. Test D4-1

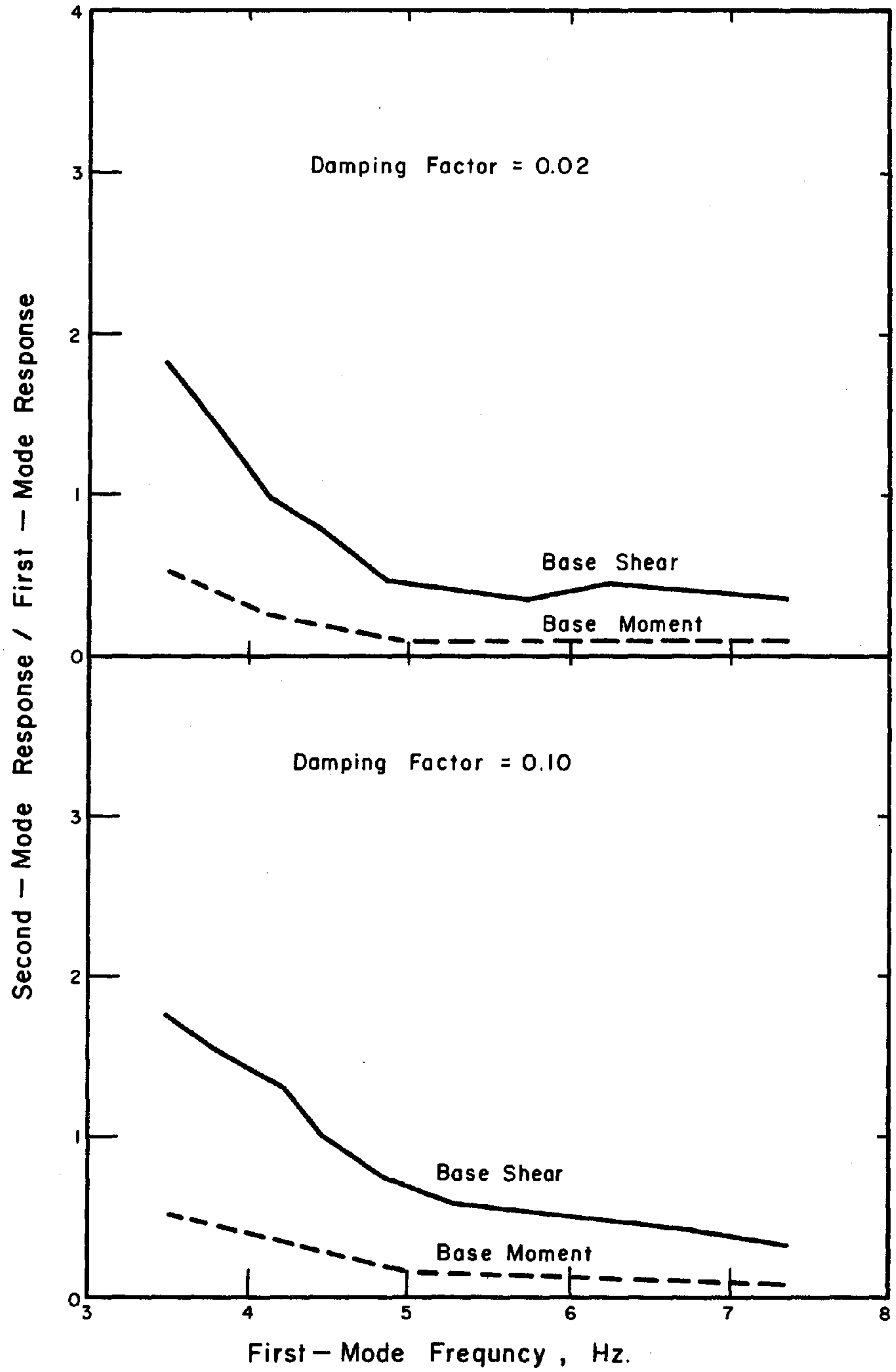
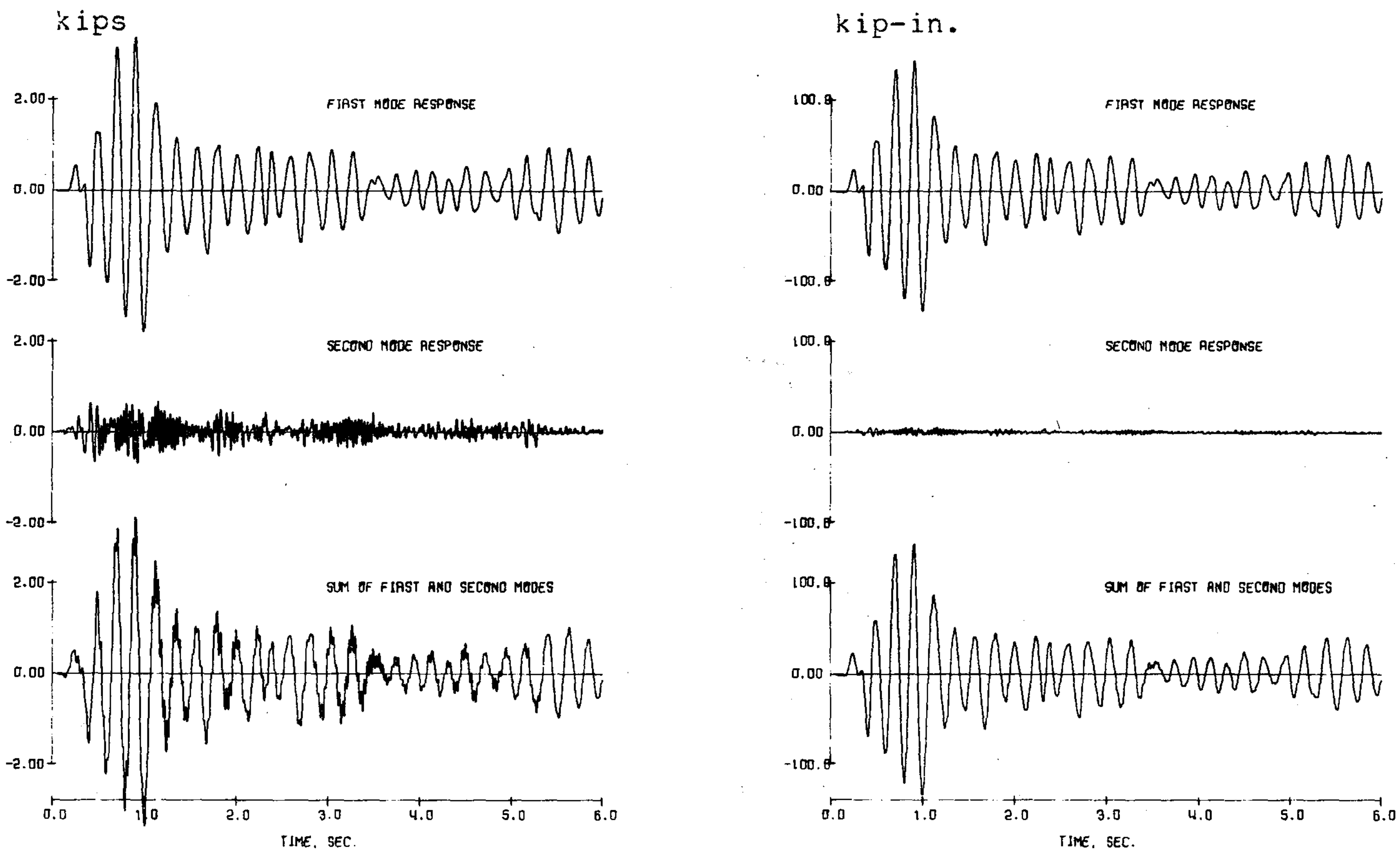


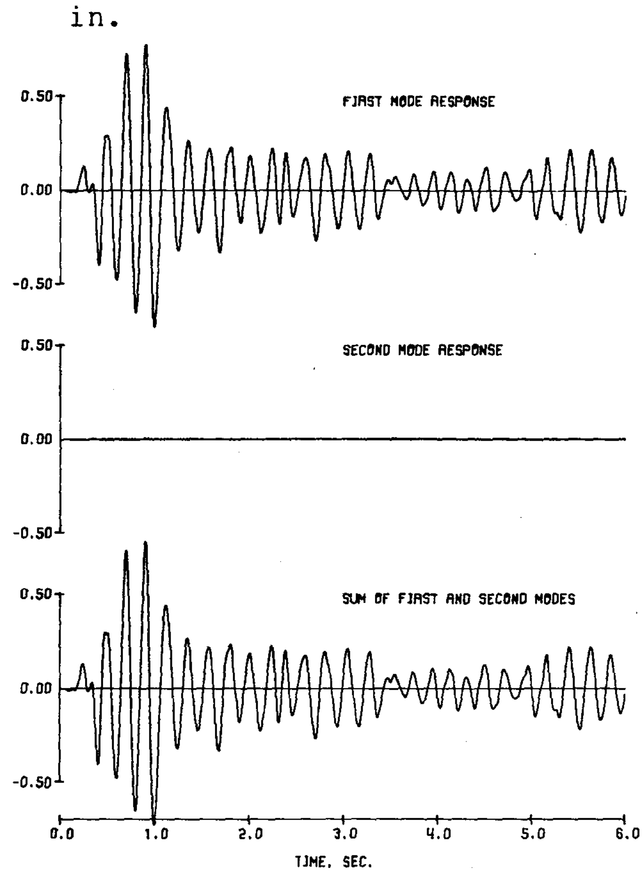
Figure 7.16 Variation of Ratio of Second-Mode Response to First-Mode Response with First-Mode Frequency. Test D5-1



(a) Base Shear

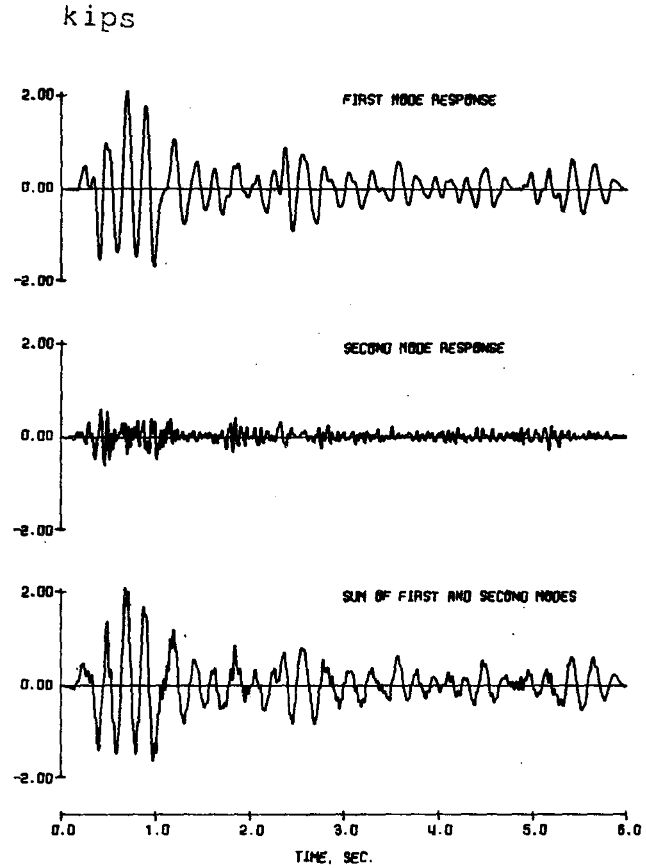
(b) Base Moment

Figure 7.17 Calculated Response Histories. Analysis 1. Test Run D1-4. Early Frequency. $\beta_1 = \beta_2 = 0.02$



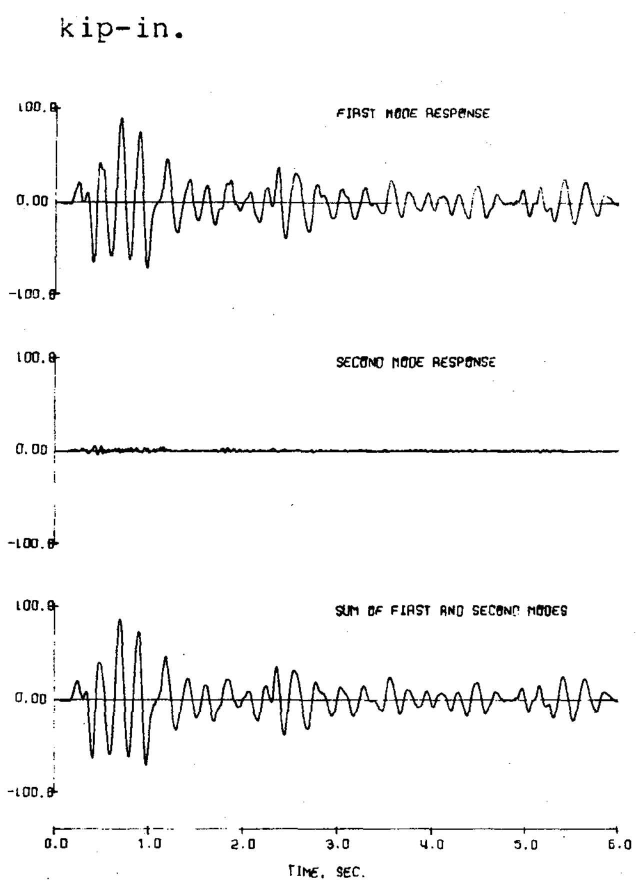
(c) Top Level Deflection

Figure 7.17 (contd.) Calculated Response Histories. Analysis 1. Test Run D1-4. Early Frequency. $\beta_1 = \beta_2 = 0.02$

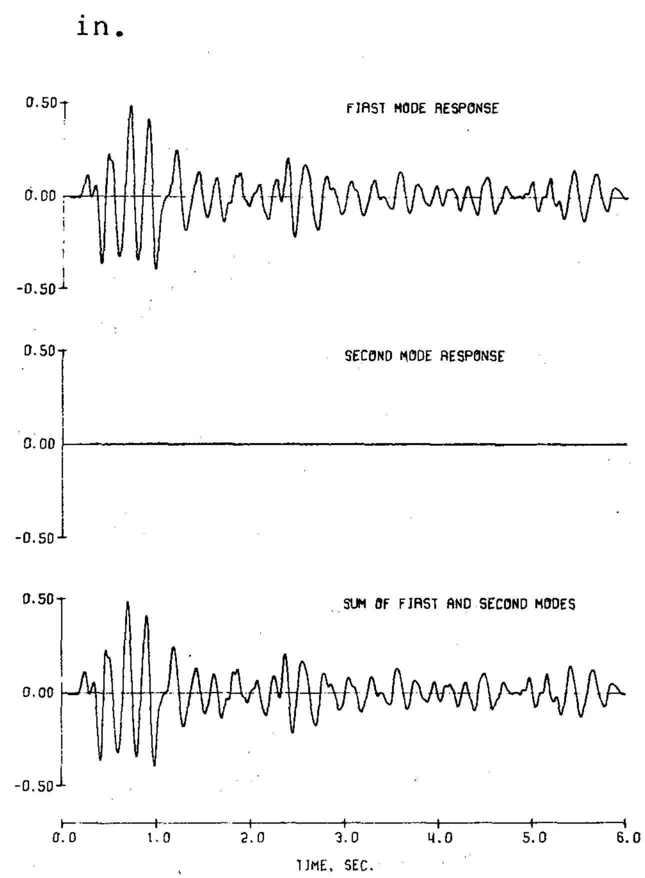


(a) Base Shear

Figure 7.18 Calculated Response Histories. Analysis 2. Test Run D1-4. Early Frequency. $\beta_1 = \beta_2 = 0.10$

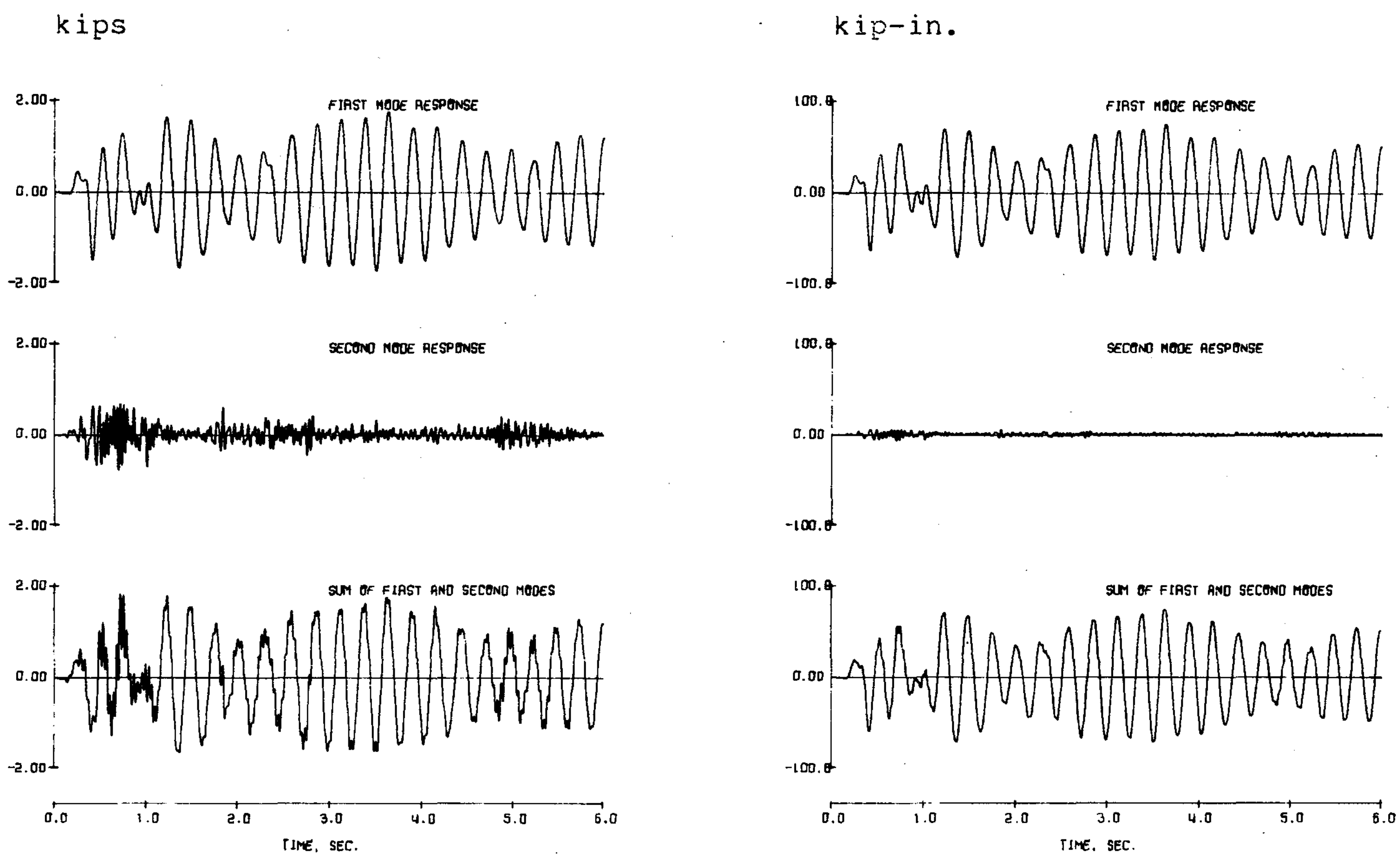


(b) Base Moment



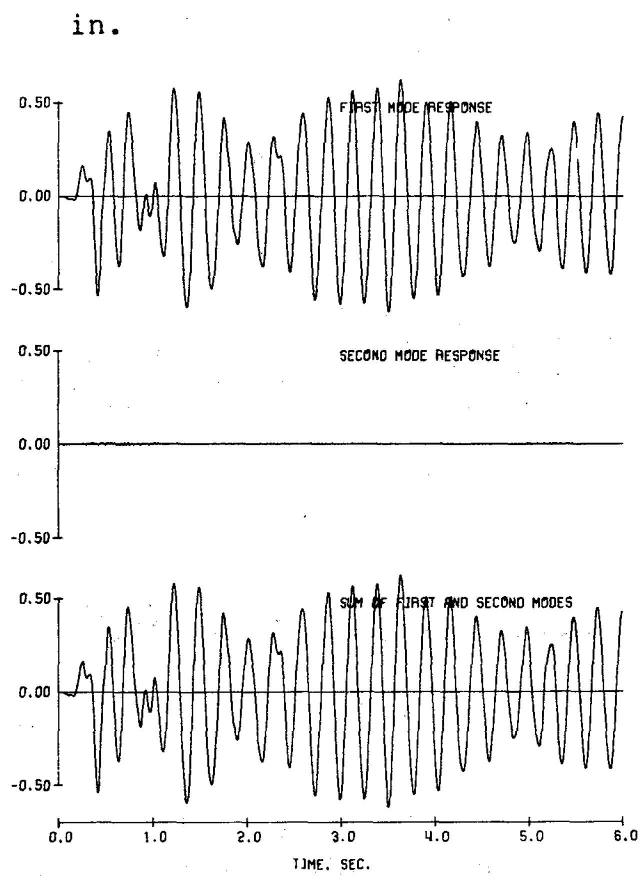
(c) Top Level Deflection

Figure 7.18(contd.) Calculated Response Histories. Analysis 2. Test Run D1-4. Early Frequency. $\beta_1 = \beta_2 = 0.10$



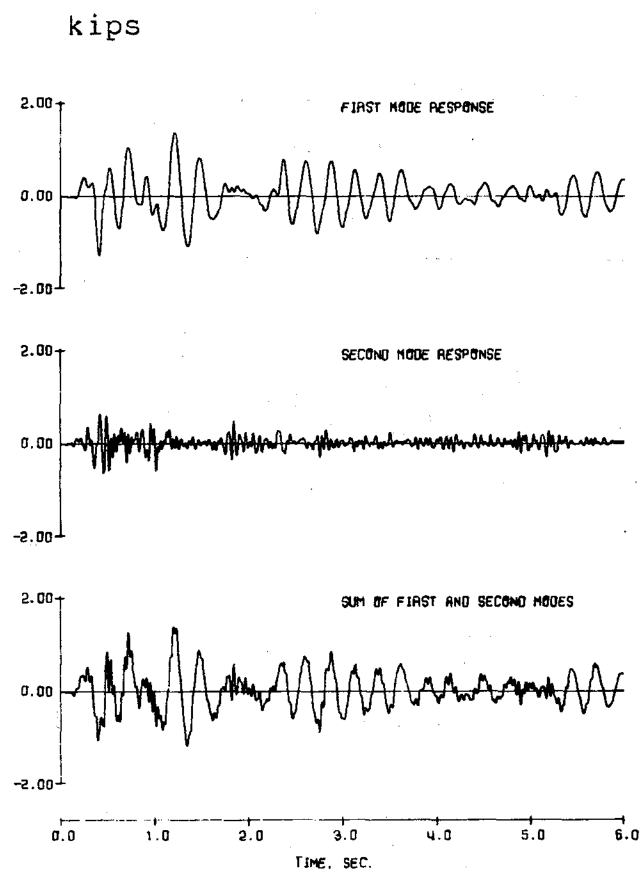
(a) Base Shear (b) Base Moment

Figure 7.19 Calculated Response Histories. Analysis 3. Test Run D1-4. Late Frequency. $\beta_1 = \beta_2 = 0.02$



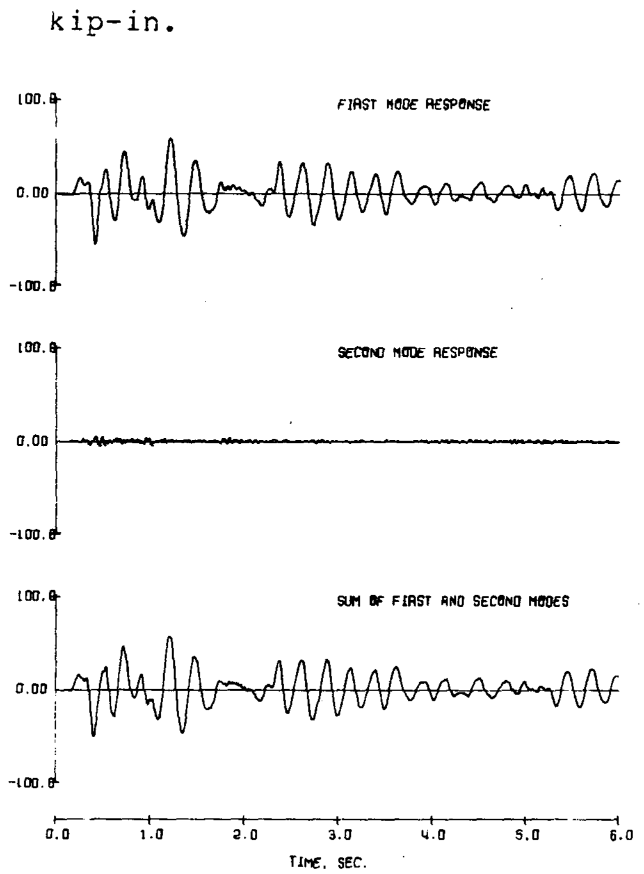
(c) Top Level Deflection

Figure 7.19 (contd.) Calculated Response Histories. Analysis 3. Test Run D1-4. Late Frequency. $\beta_1 = \beta_2 = 0.02$

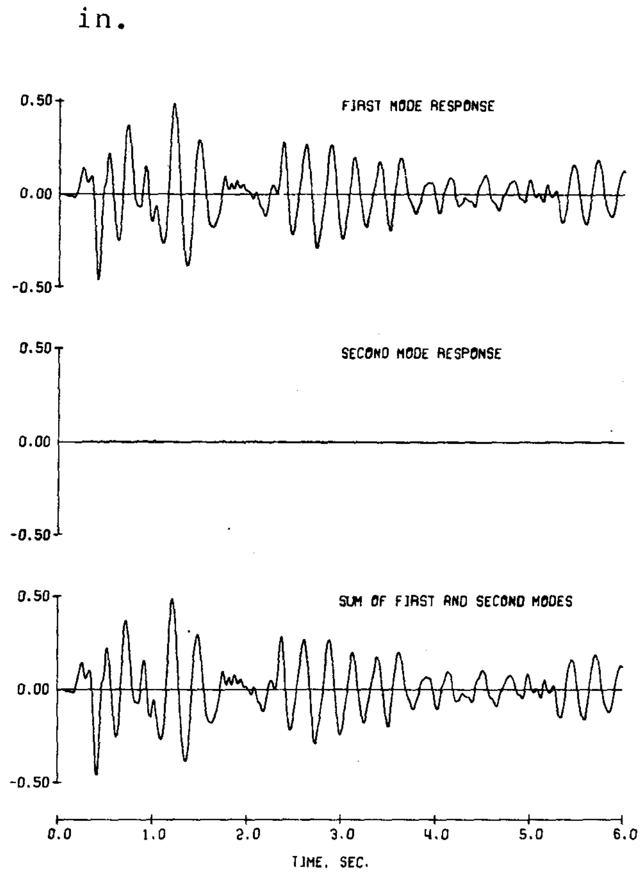


(a) Base Shear

Figure 7.20 Calculated Response Histories. Analysis 4. Test Run D1-4. Late Frequency. $\beta_1 = \beta_2 = 0.10$

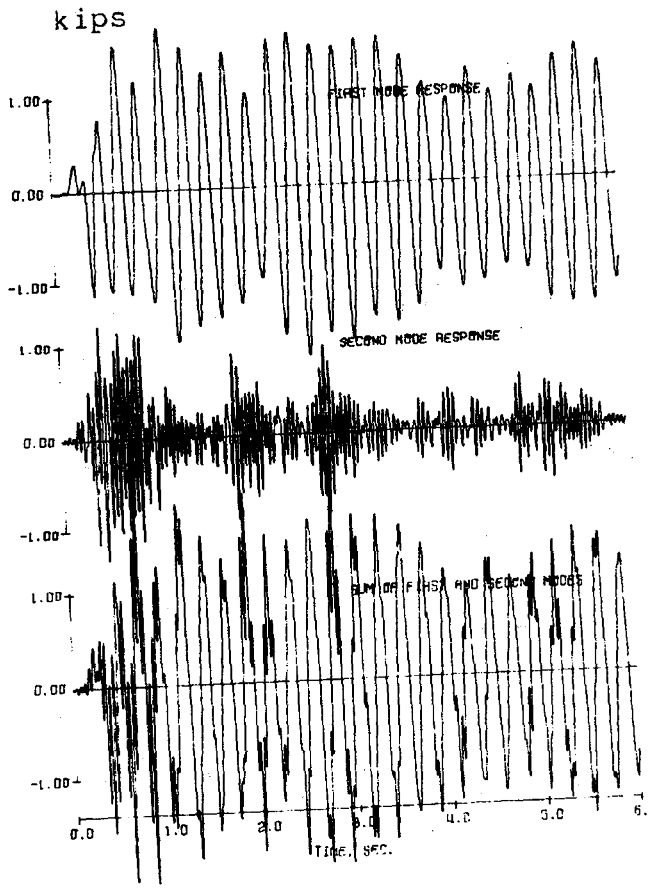


(b) Base Moment

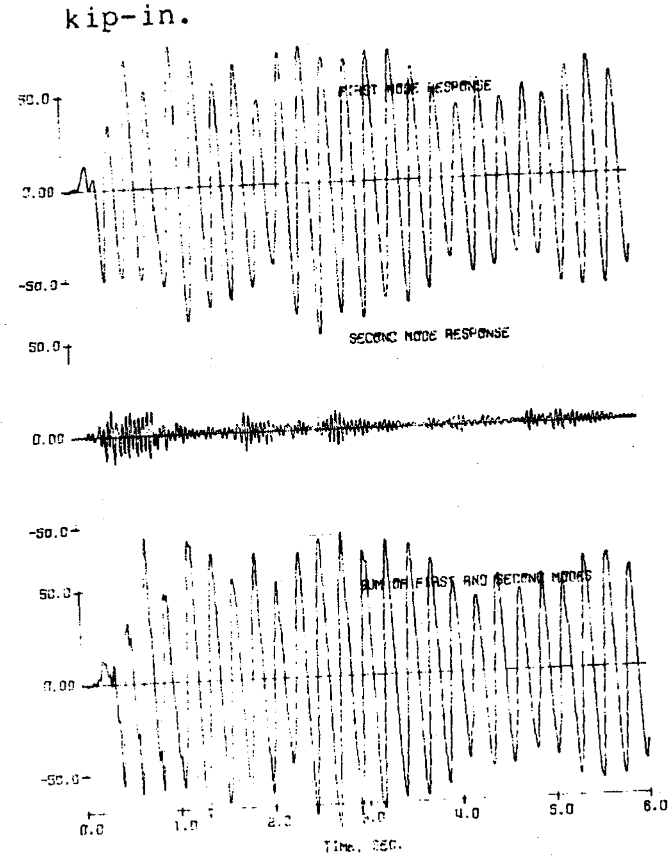


(c) Top Level Deflection

7.20 (contd.) Calculated Response Histories. Analysis 4. Test Run D1-4. Late Frequency. $\beta_1 = \beta_2 = 0.10$

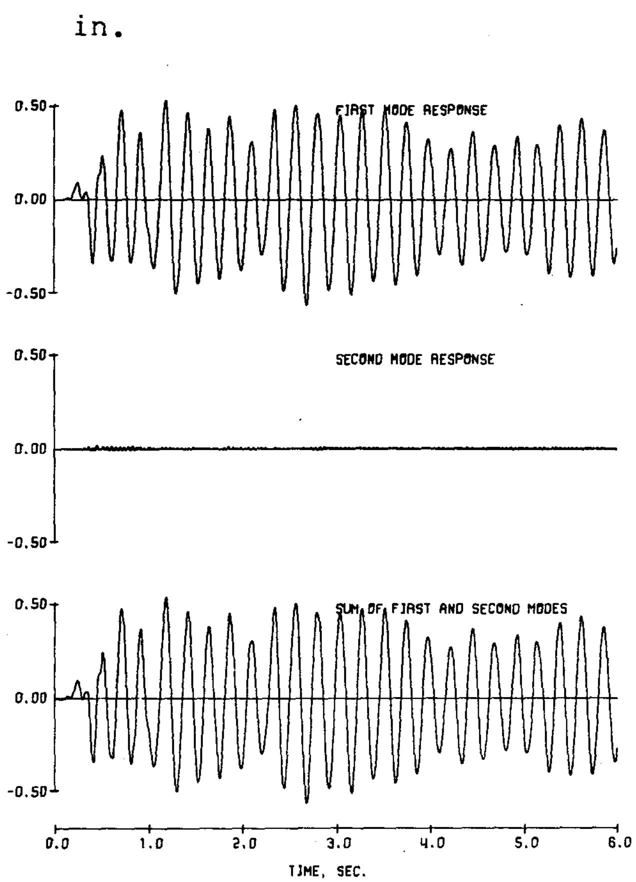


(a) Base Shear



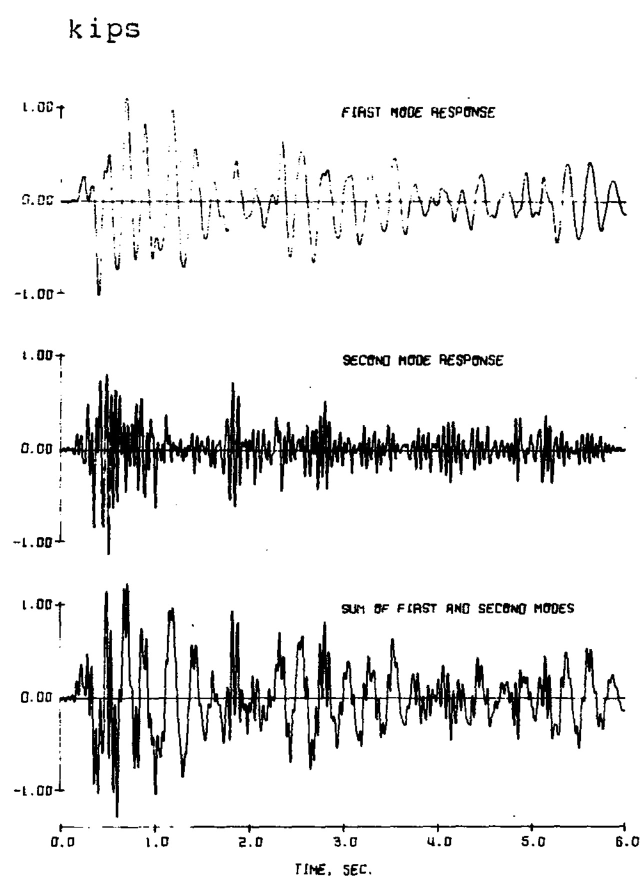
(b) Base Moment

Figure 7.21 Calculated Response Histories. Analysis 5. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$



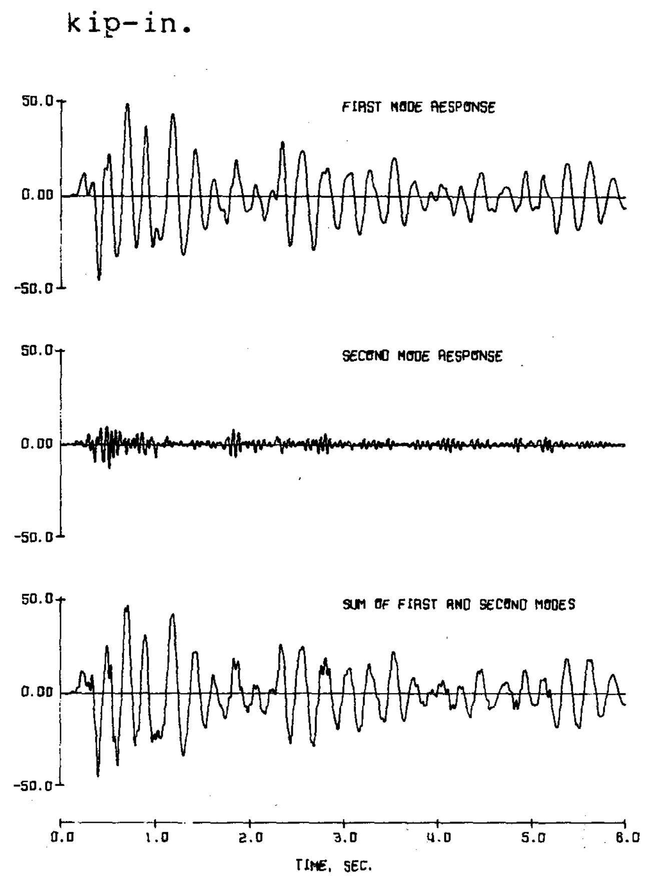
(c) Top Level Deflection

Figure 7.21 (contd.) Calculated Response Histories. Analysis 5. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$

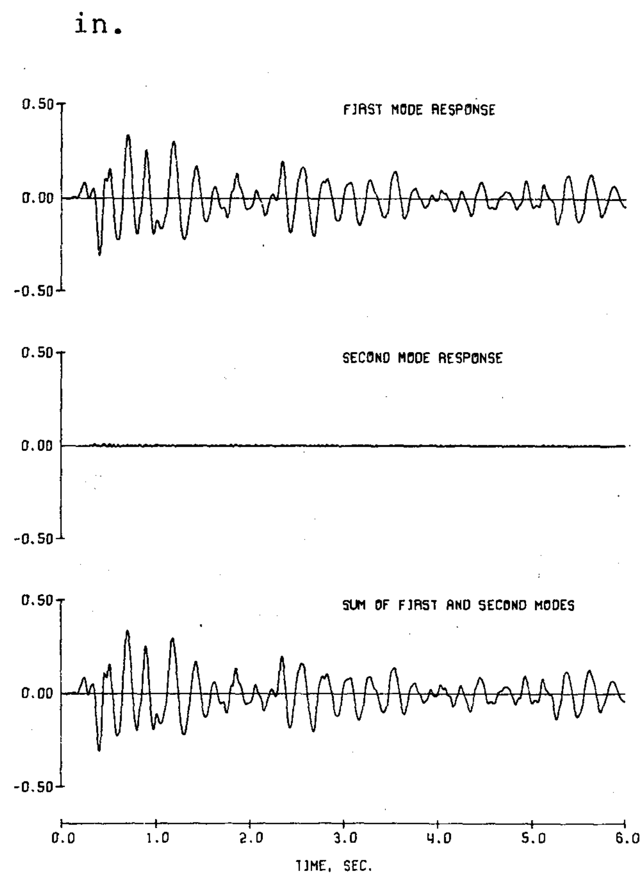


(a) Base Shear

Figure 7.22 Calculated Response Histories. Analysis 6. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$

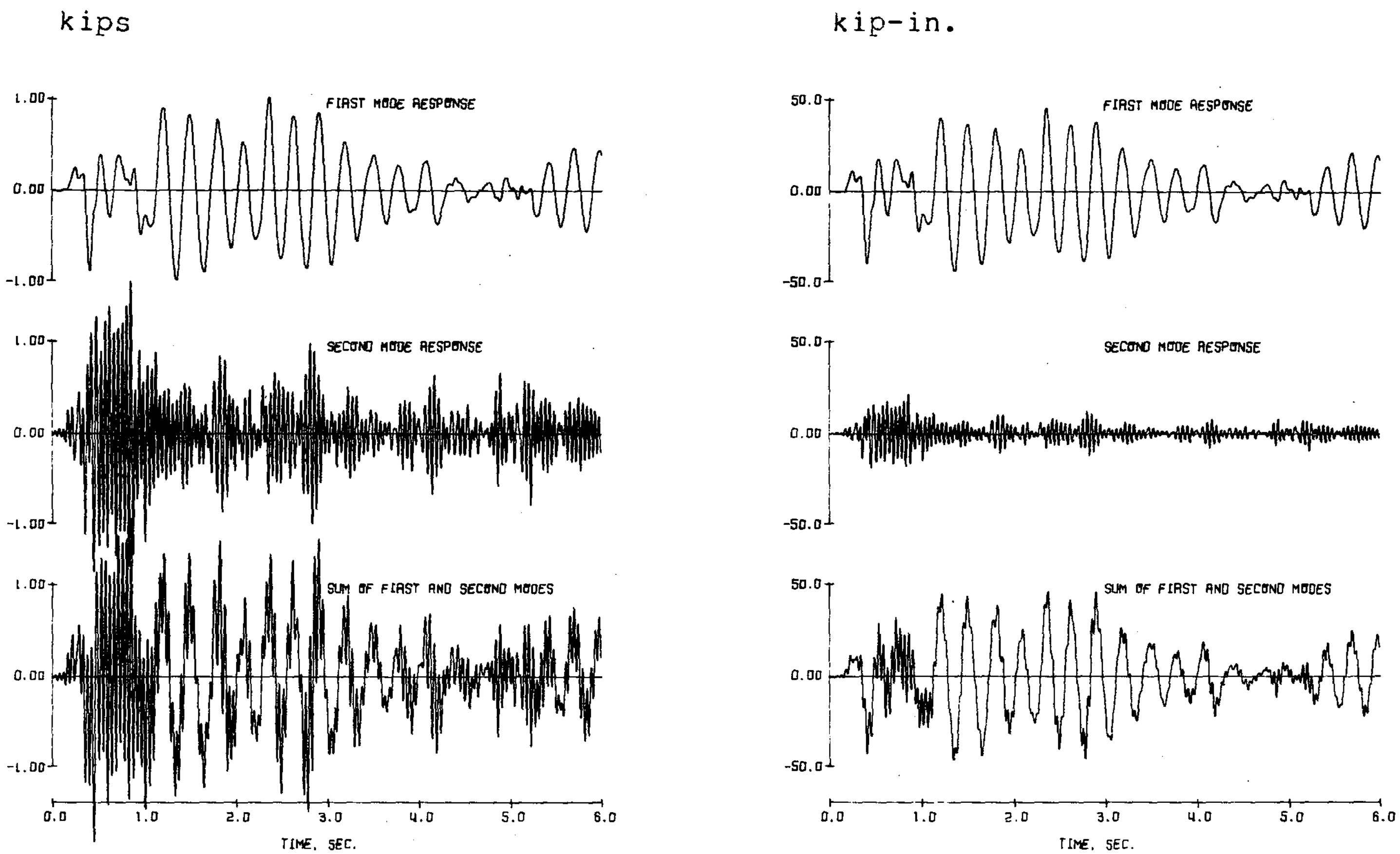


(b) Base Moment



(c) Top Level Deflection

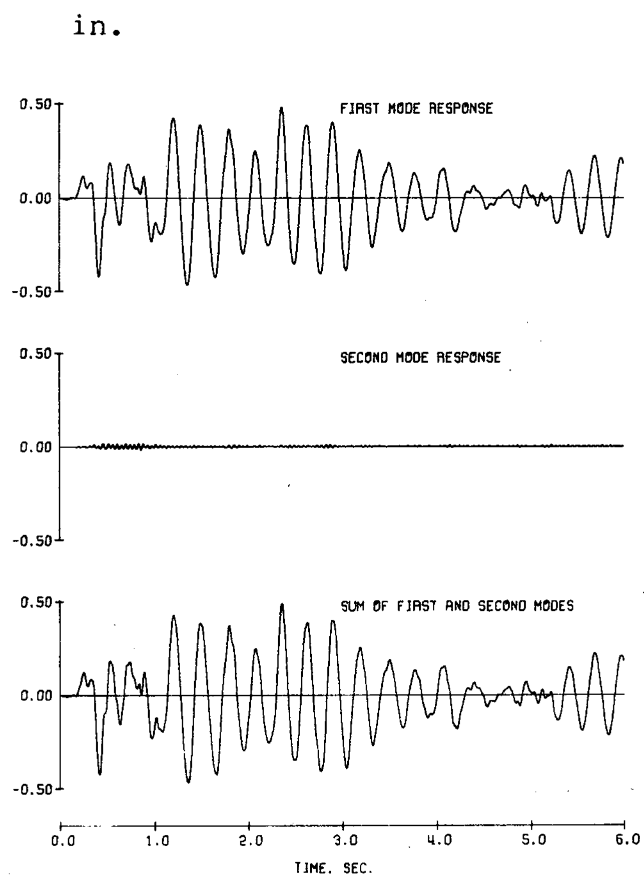
Figure 7.22 (contd.) Calculated Response Histories. Analysis 6. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$



(a) Base Shear

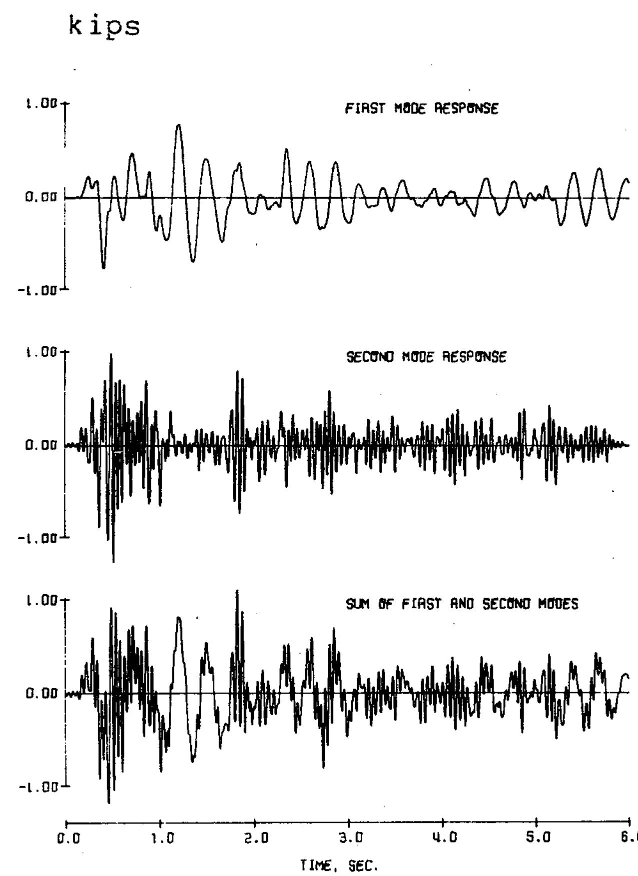
(b) Base Moment

Figure 7.23 Calculated Response Histories. Analysis 7. Test Run D4-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$



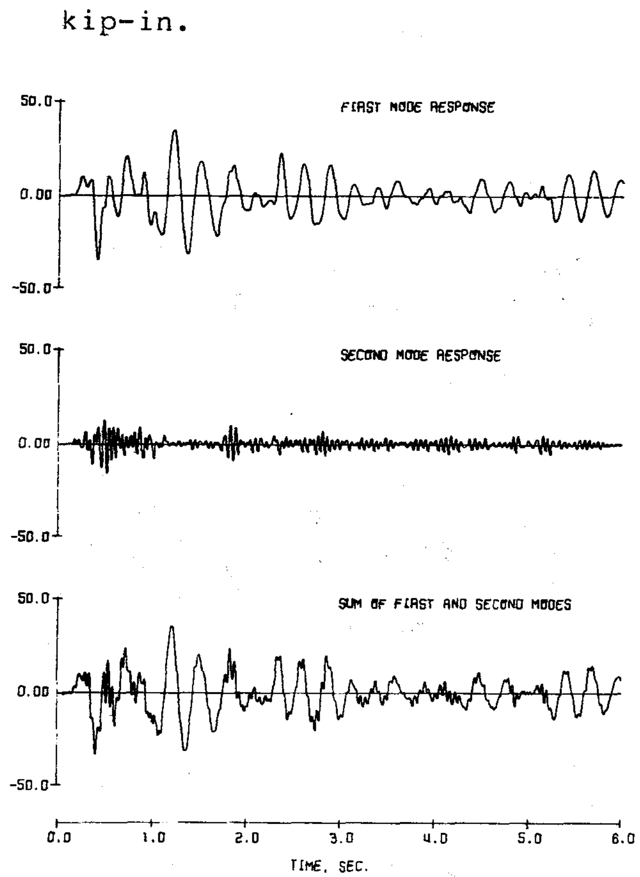
(c) Top Level Deflection

Figure 7.23 (contd.) Calculated Response Histories. Analysis 7. Test Run D4-1. Late Frequency $\beta_1 = \beta_2 = 0.02$

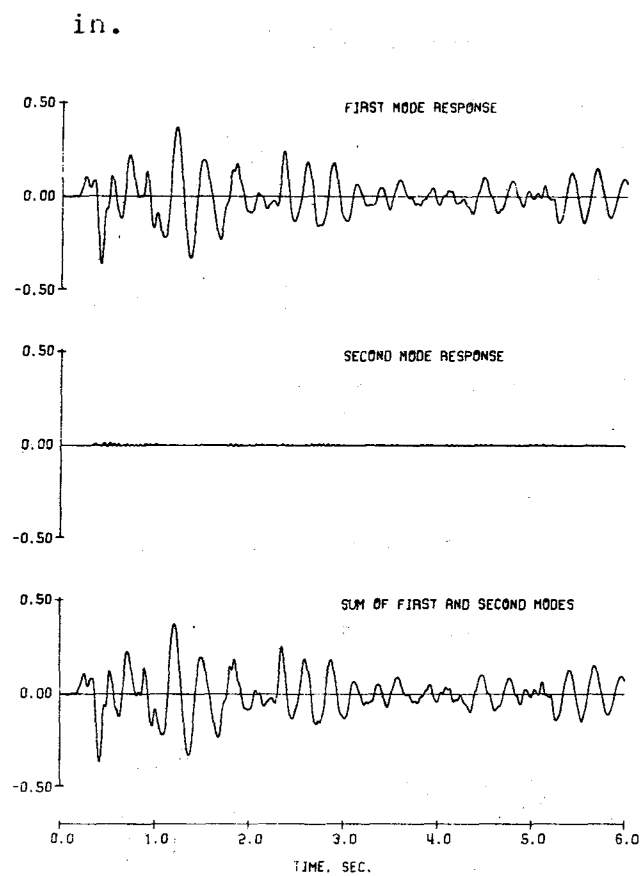


(a) Base Shear

Figure 7.24 Calculated Response Histories. Analysis 8. Test Run D4-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$

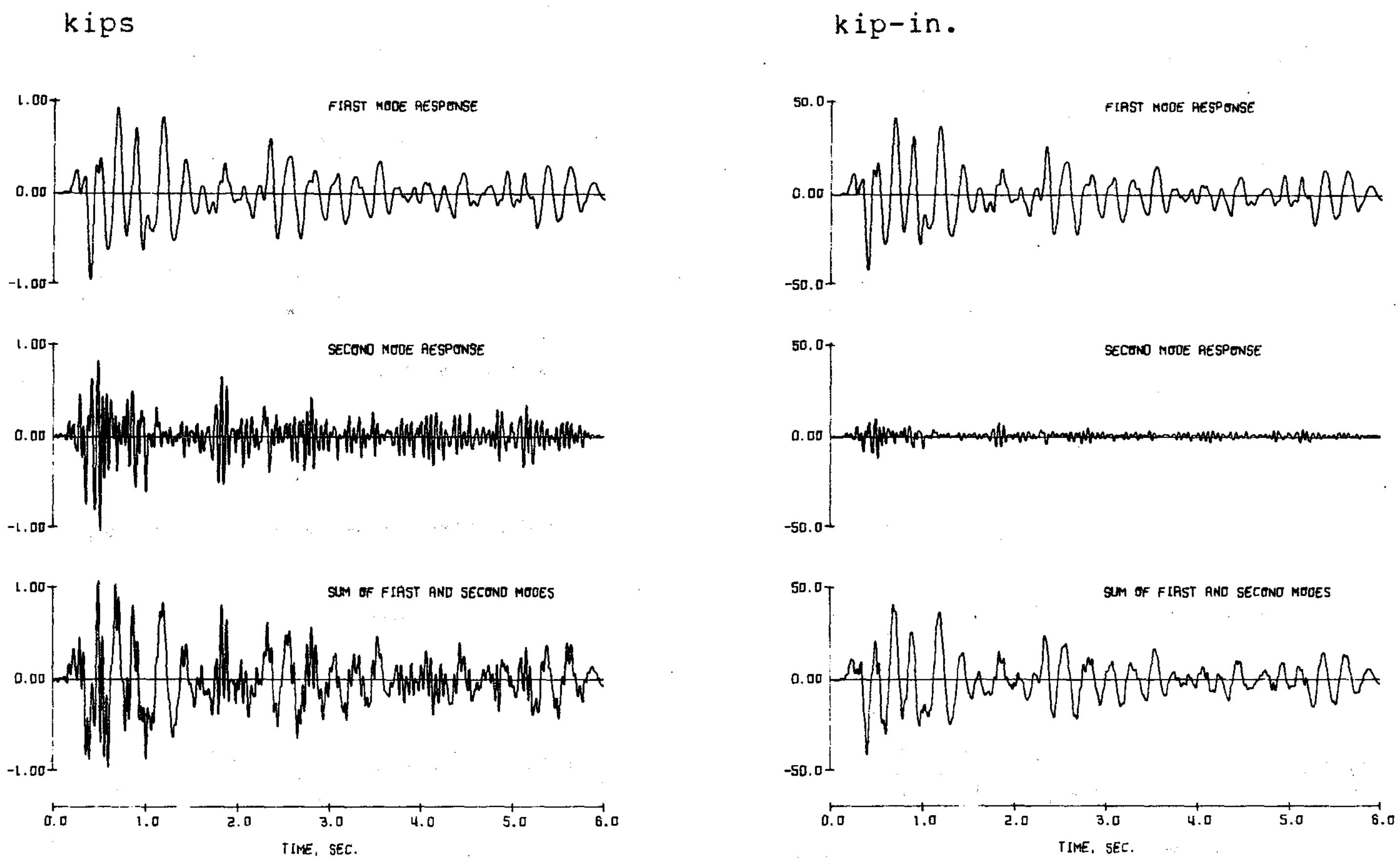


(b) Base Moment



(c) Top Level Deflection

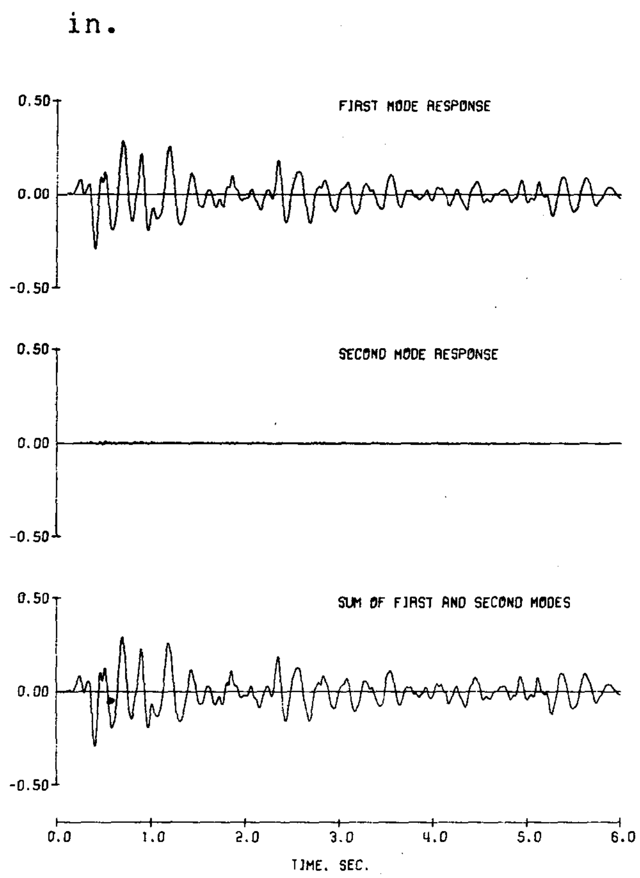
Figure 7.24 (contd.) Calculated Response Histories. Analysis 8. Test Run D4-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$



(a) Base Shear

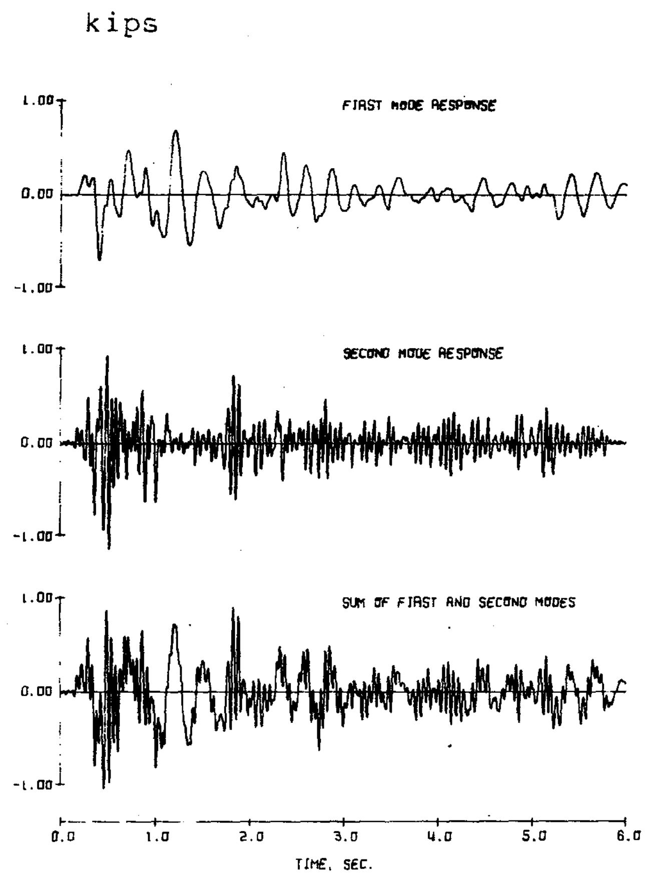
(b) Base Moment

Figure 7.25 Calculated Response Histories. Analysis 9. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.15$



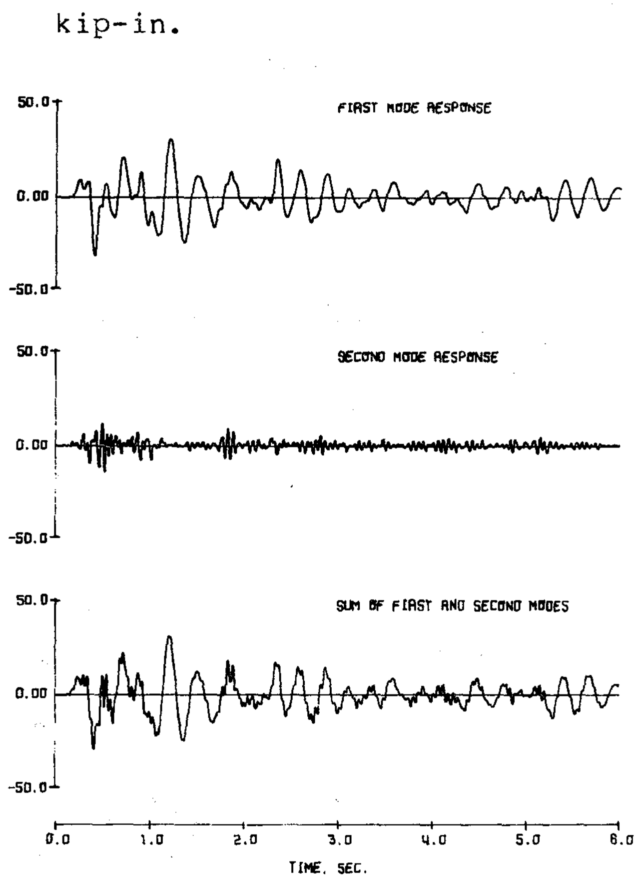
(c) Top Level Deflection

Figure 7.25 (contd.) Calculated Response Histories. Analysis 9. Test Run D4-1. Early Frequency. $\beta_1 = \beta_2 = 0.15$

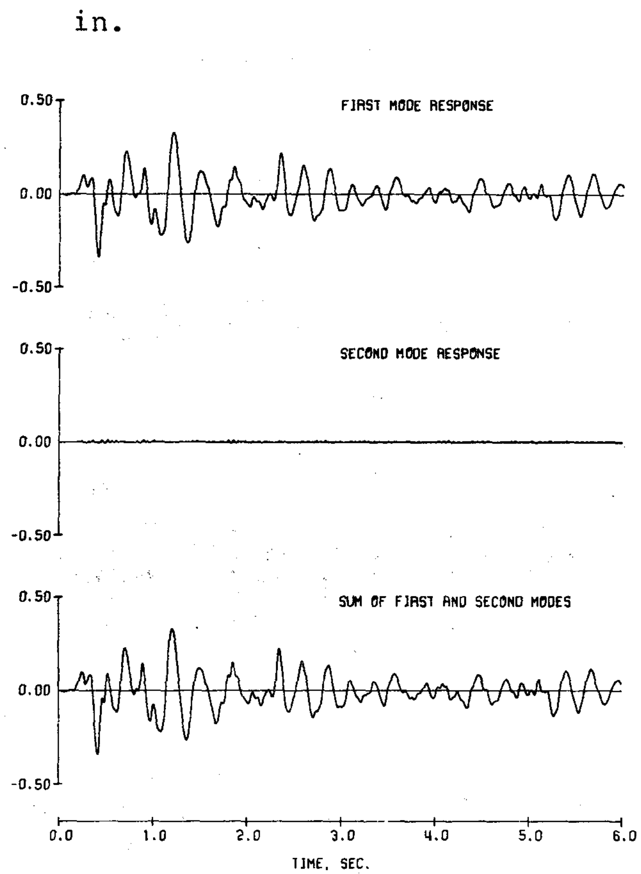


(a) Base Shear

Figure 7.26 Calculated Response Histories. Analysis 10. Test Run D4-1. Late Frequency. $\beta_1 = \beta_2 = 0.15$

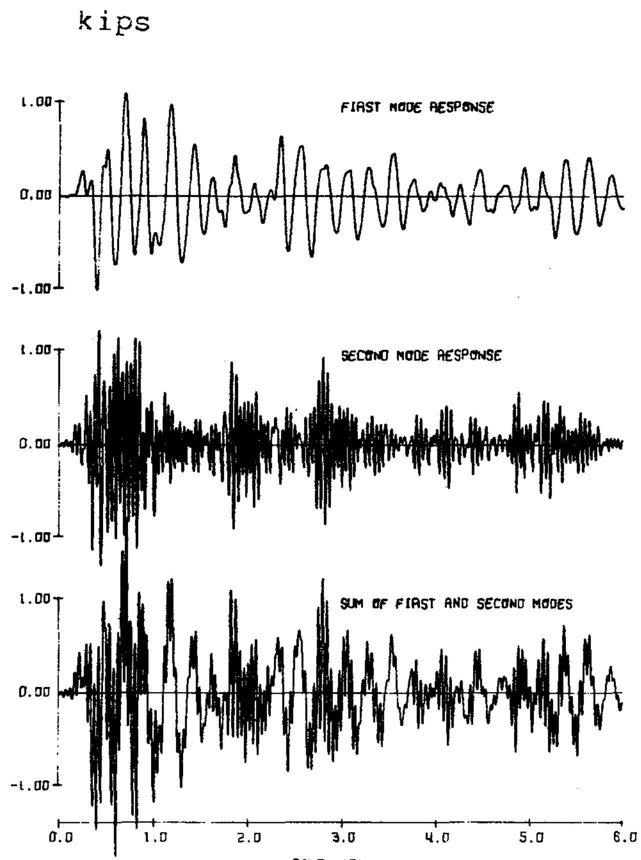


(b) Base Moment

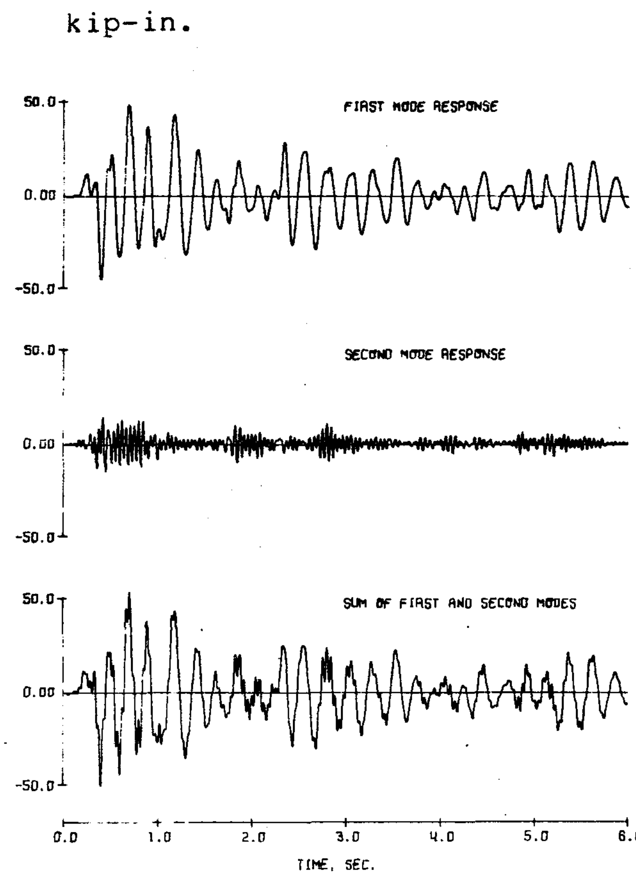


(c) Top Level Deflection

Figure 7.26 (contd.) Calculated Response Histories. Analysis 10. Test Run D4-1. Late Frequency. $\beta_1 = \beta_2 = 0.15$

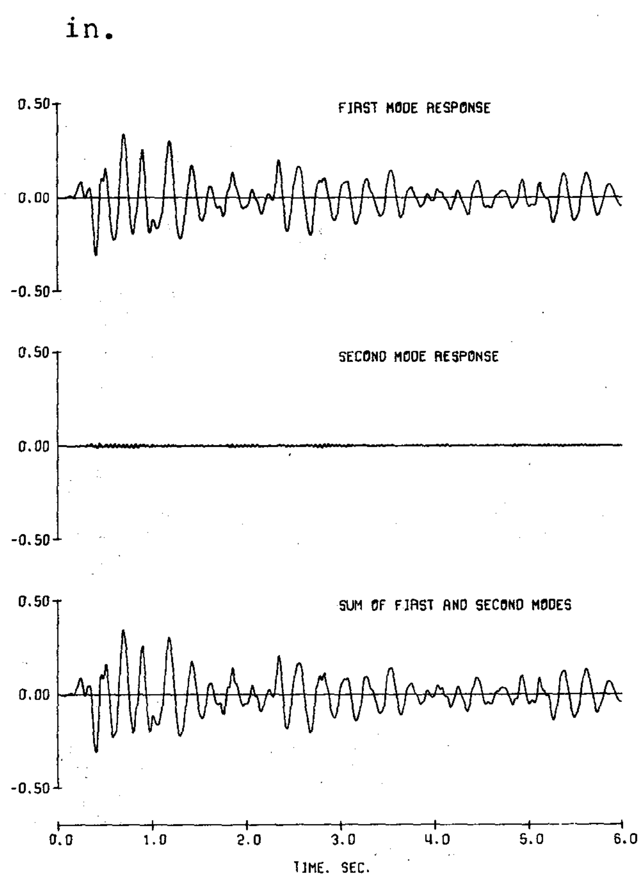


(a) Base Shear



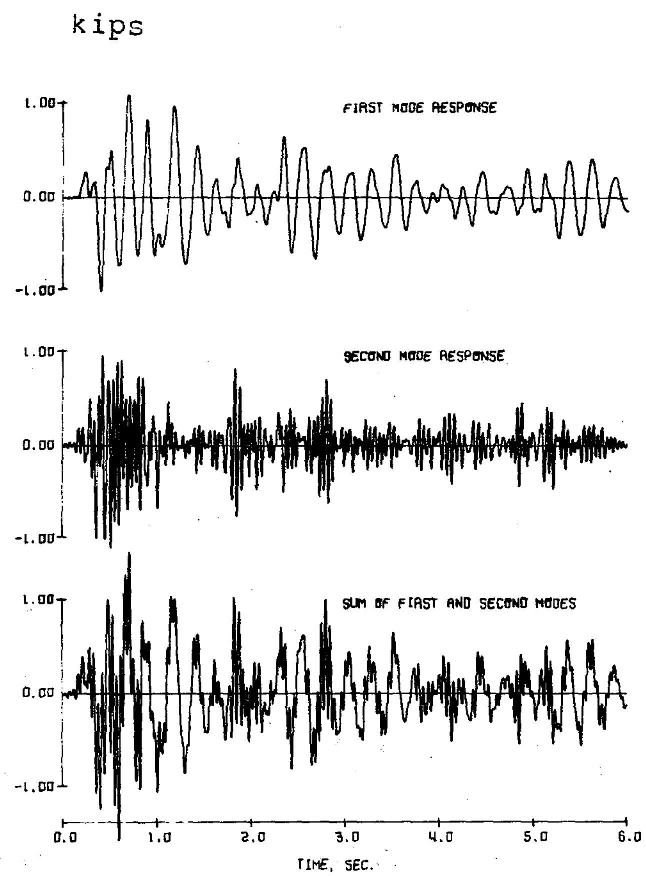
(b) Base Moment

Figure 7.27 Calculated Response Histories. Analysis 11. Test Run D4-1. Early Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.02$



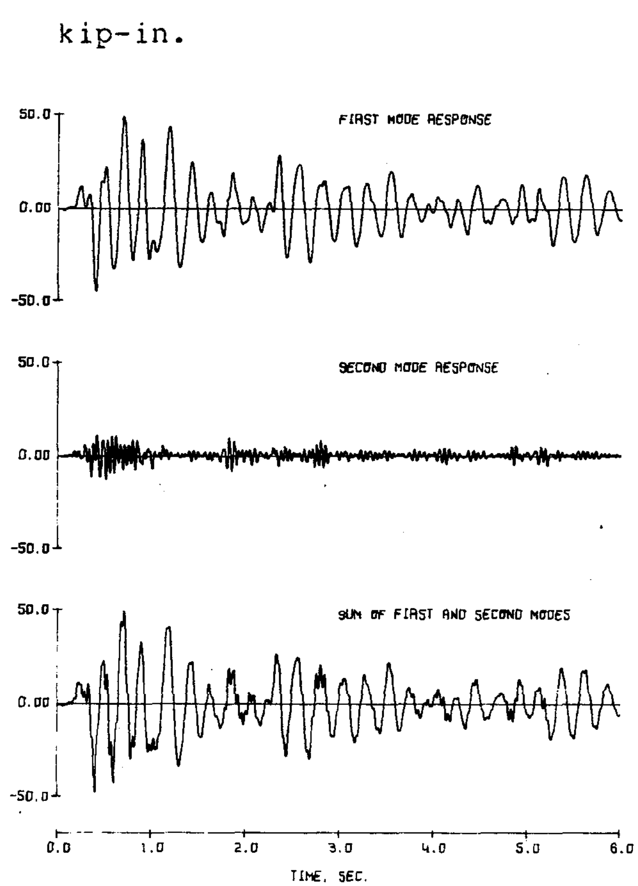
(c) Top Level Deflection

Figure 7.27 (contd.) Calculated Response Histories. Analysis 11. Test Run D4-1. Early Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.02$

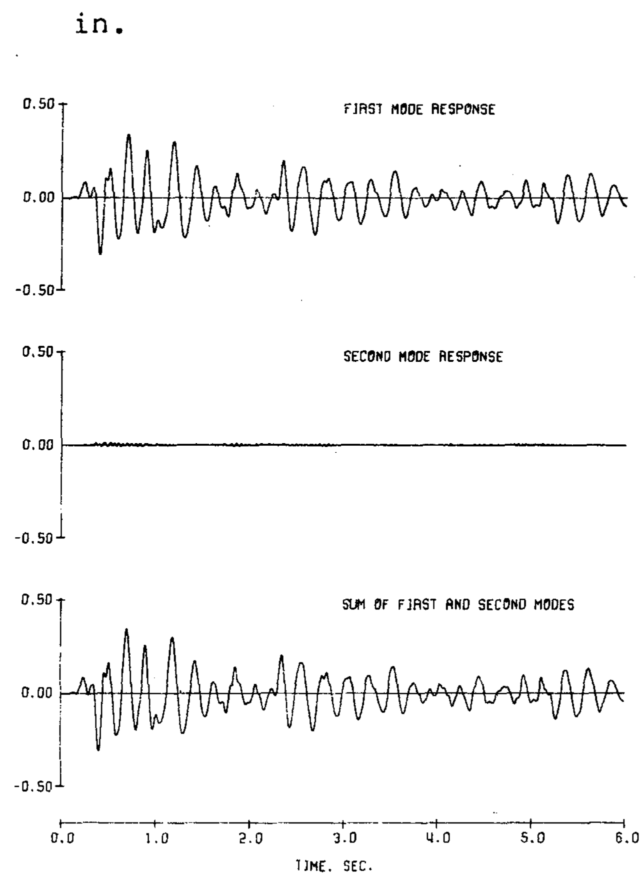


(a) Base Shear

Figure 7.28 Calculated Response Histories. Analysis 12. Test Run D4-1. Early Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.05$

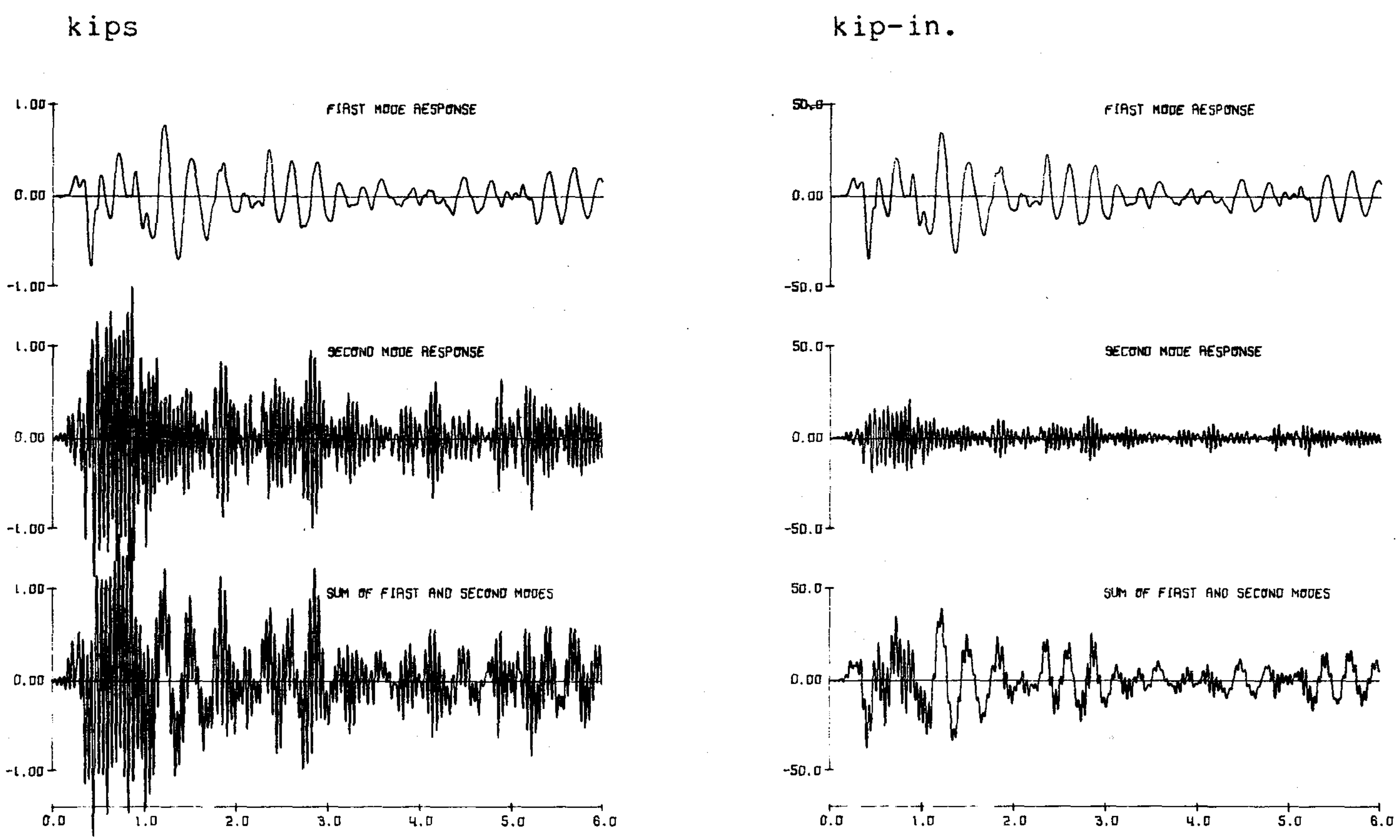


(b) Base Moment



(c) Top Level Deflection

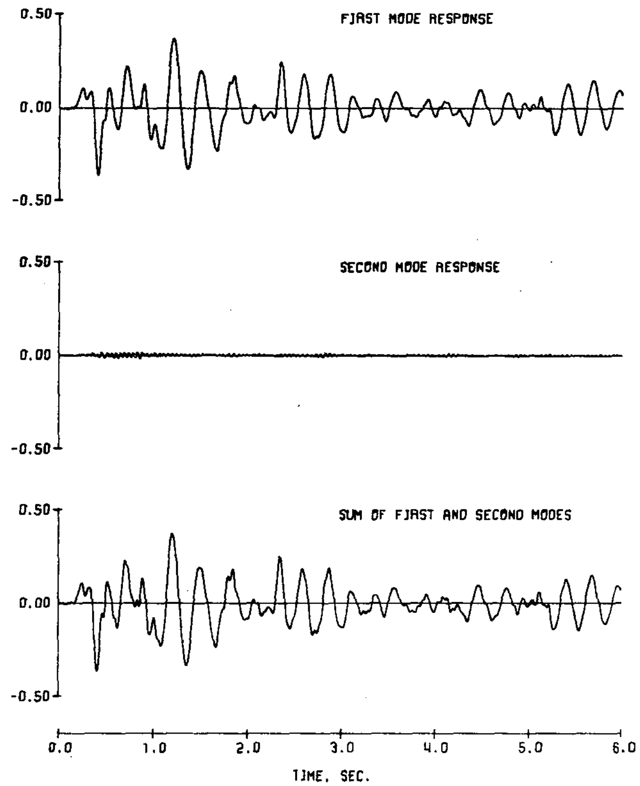
Figure 7.28 (contd.) Calculated Response Histories. Analysis 12. Test Run D4-1. Early Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.05$



(a) Base Shear

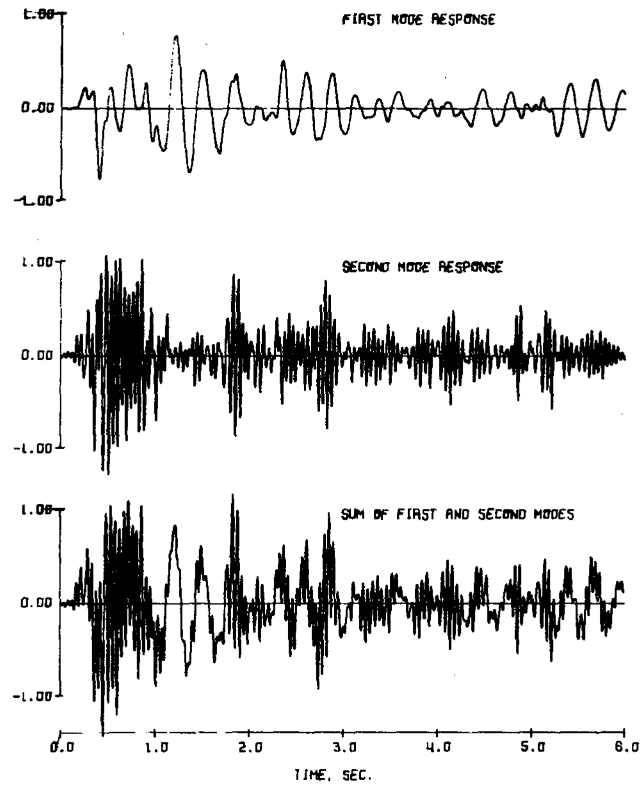
(b) Base Moment

Figure 7.29 Calculated Response Histories. Analysis 13. Test Run D4-1. Late Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.02$



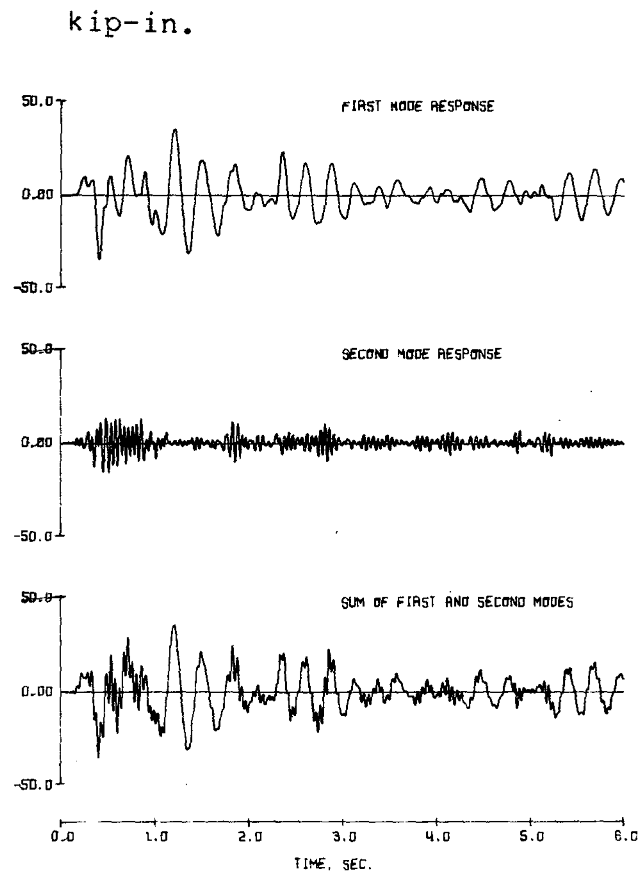
(c) Top Level Deflection

Figure 7.29 (contd.) Calculated Response Histories. Analysis 13. Test Run D4-1. Late Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.02$

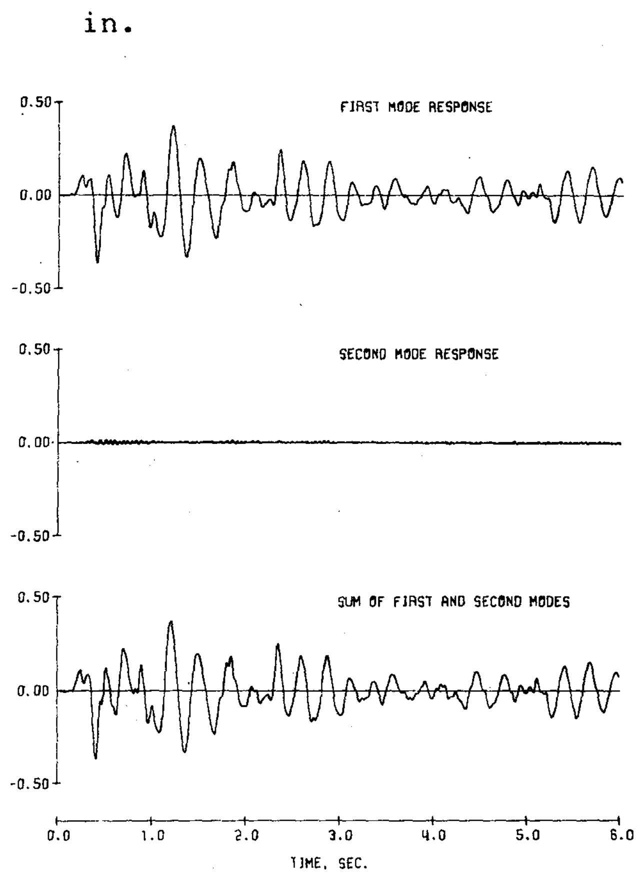


(a) Base Shear

Figure 7.30 Calculated Response Histories. Analysis 14. Test Run D4-1. Late Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.05$

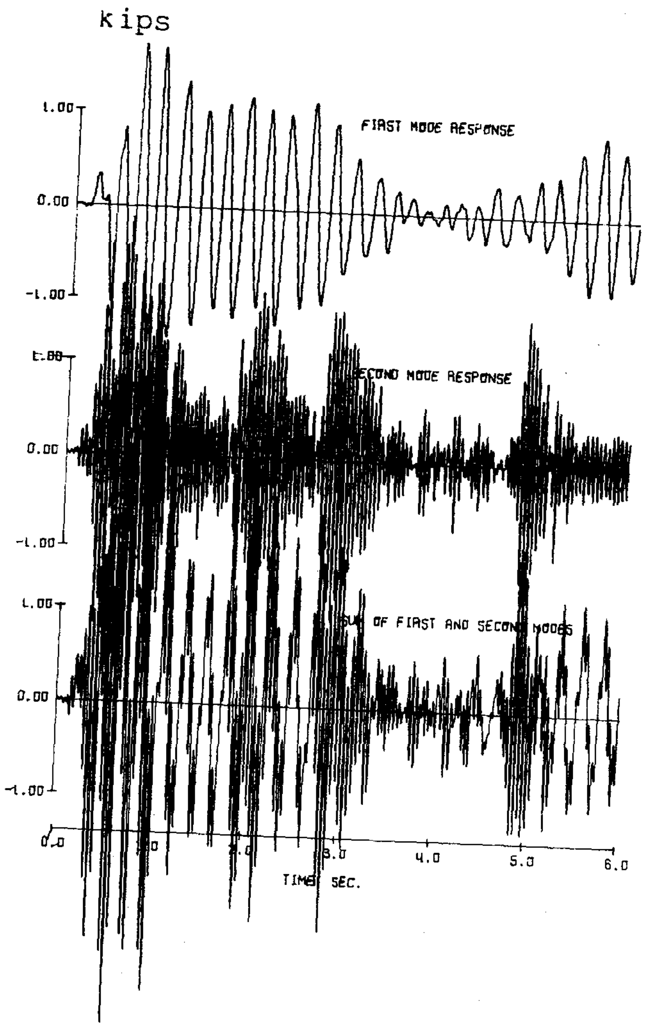


(b) Base Moment

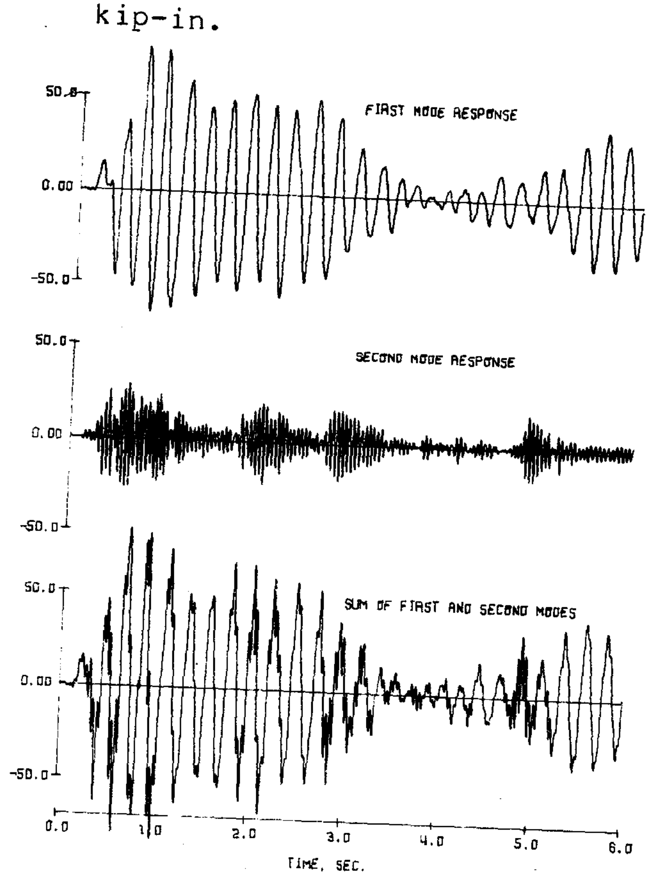


(c) Top Level Deflection

Figure 7.30 (contd.) Calculated Response Histories. Analysis 14. Test Run D4-1. Late Frequency. $\beta_1 = 0.10$, $\beta_2 = 0.05$

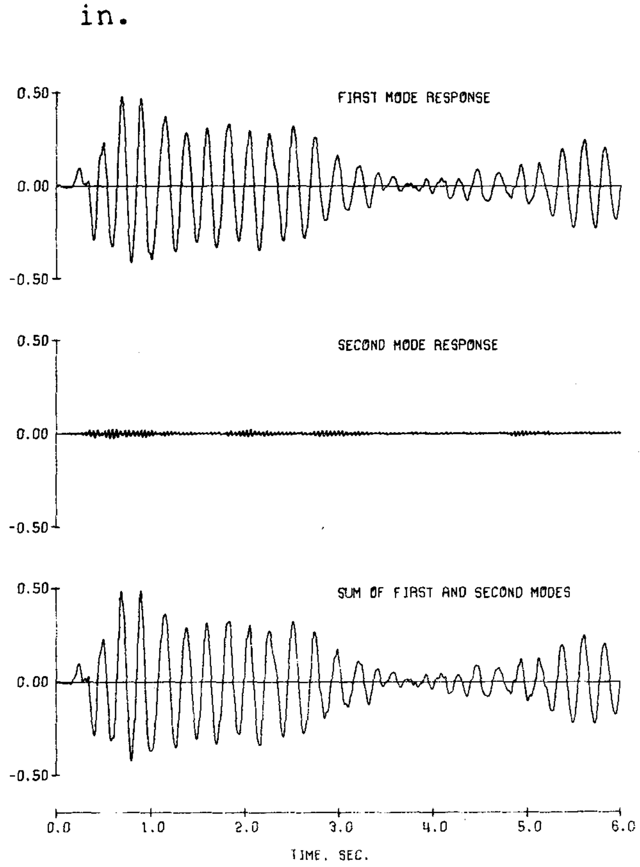


(a) Base Shear



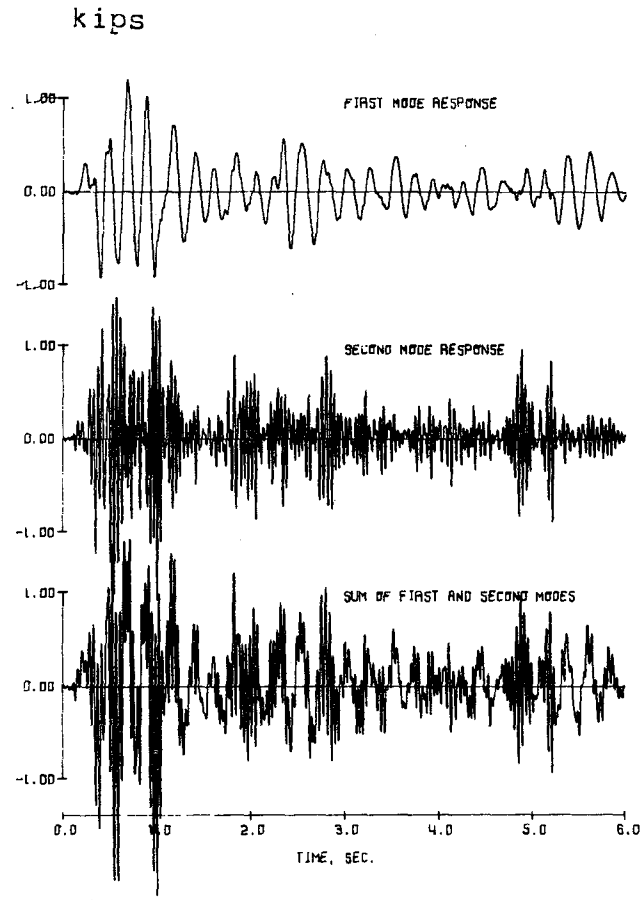
(b) Base Moment

Figure 7.31 Calculated Response Histories. Analysis 15. Test Run D2-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$



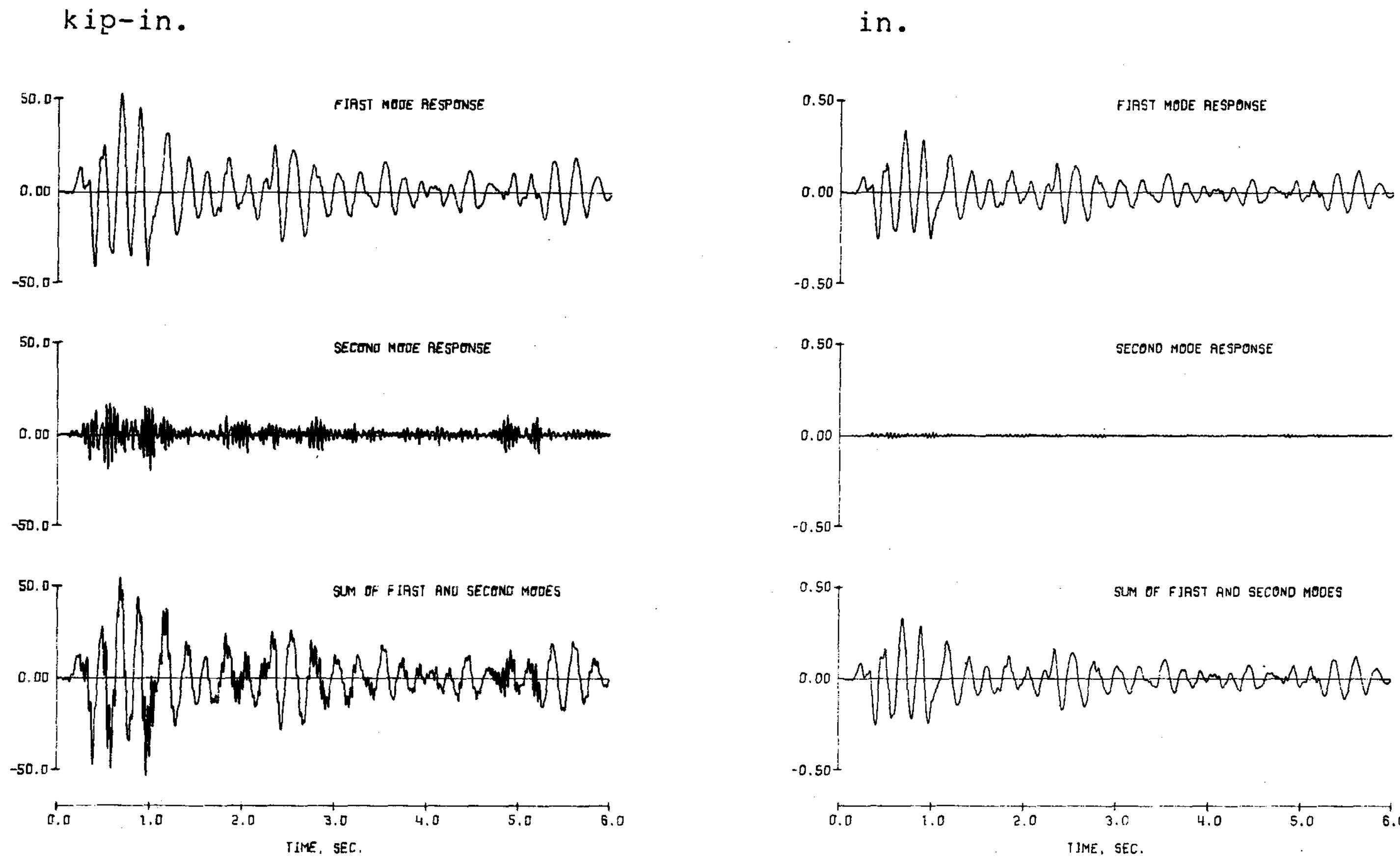
(c) Top Level Deflection

Figure 7.31 (contd.) Calculated Response Histories. Analysis 15. Test Run D2-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$



(a) Base Shear

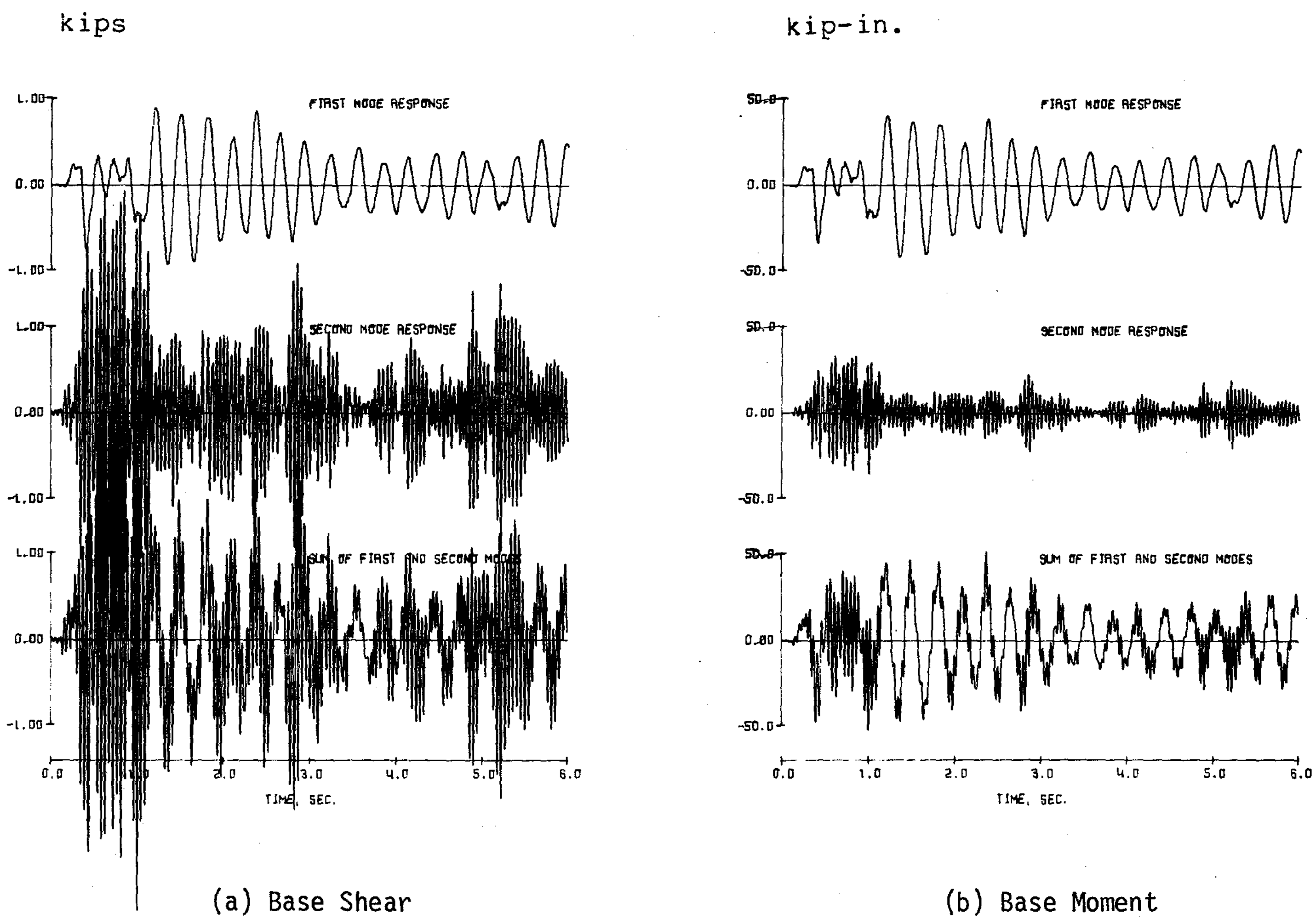
Figure 7.32 Calculated Response Histories. Analysis 16. Test Run D2-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$



(b) Base Moment

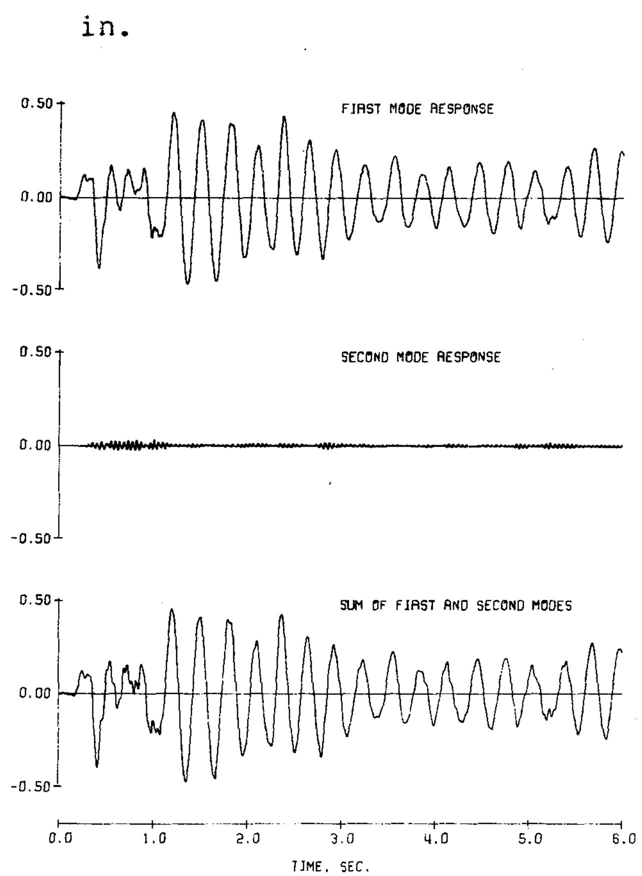
(c) Top Level Deflection

Figure 7.32 (contd.) Calculated Response Histories. Analysis 16. Test Run D2-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$



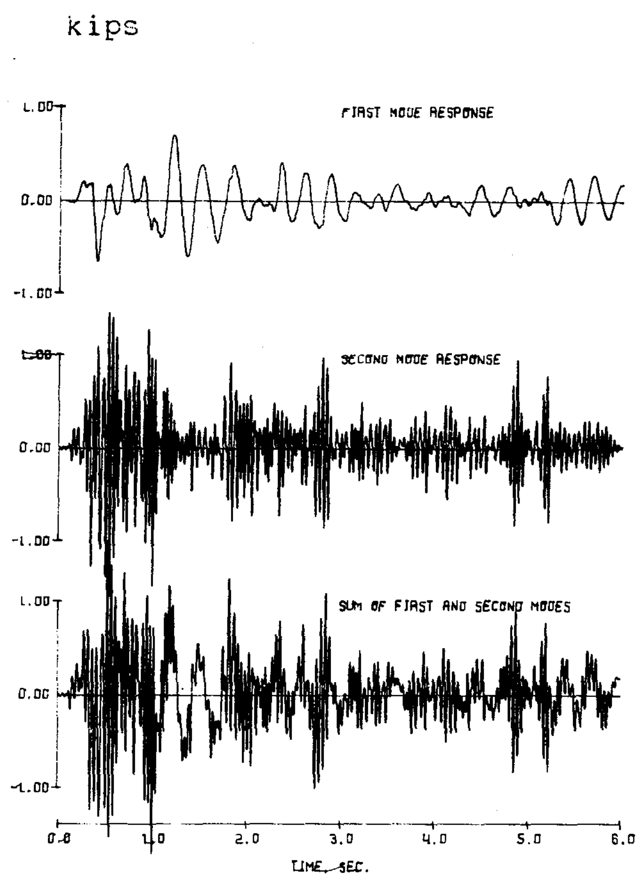
(a) Base Shear (b) Base Moment

Figure 7.33 Calculated Response Histories. Analysis 17. Test Run D2-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$



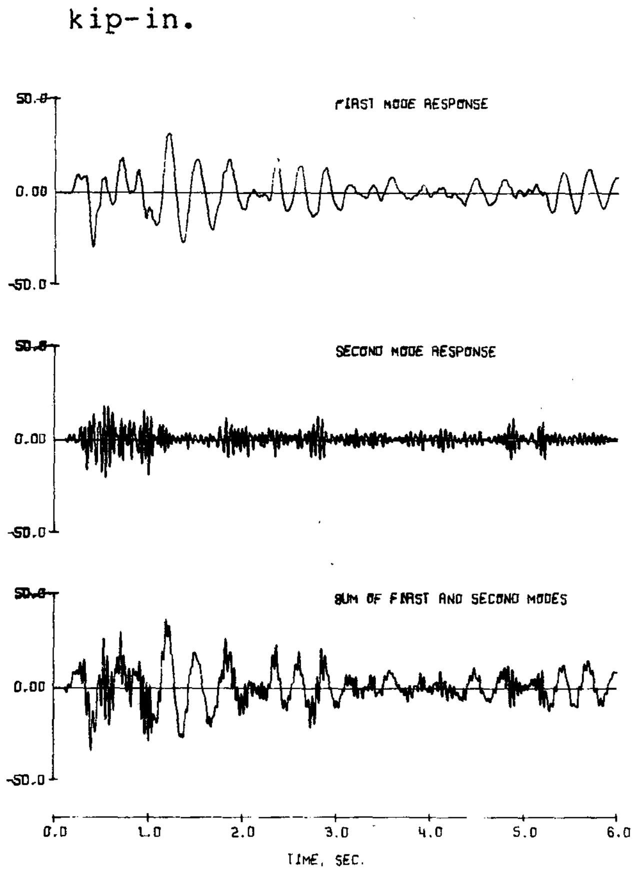
(c) Top Level Deflection

Figure 7.33 (contd.) Calculated Response Histories. Analysis 17. Test Run D2-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$

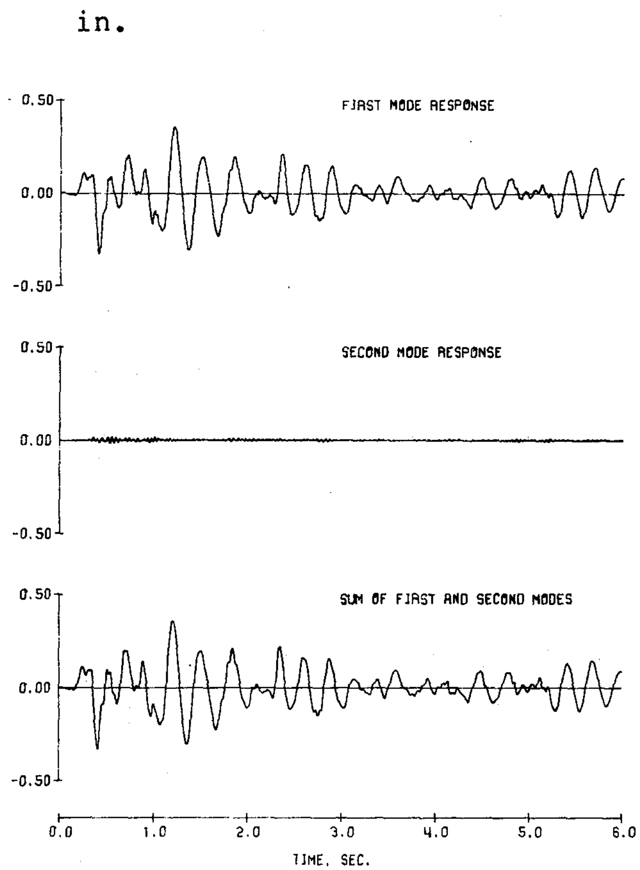


(a) Base Shear

Figure 7.34 Calculated Response Histories. Analysis 18. Test Run D2-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$

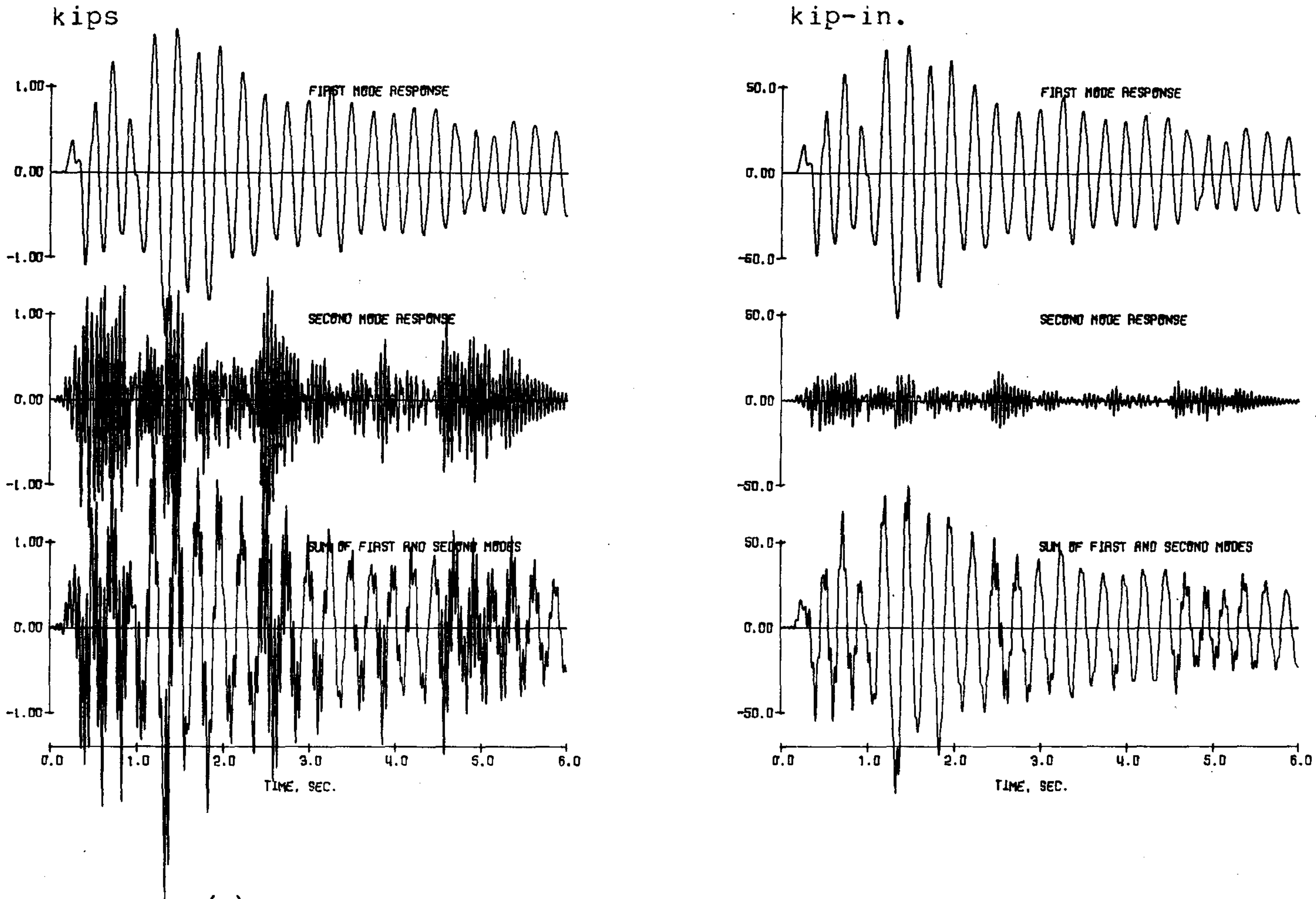


(b) Base Moment



(c) Top Level Deflection

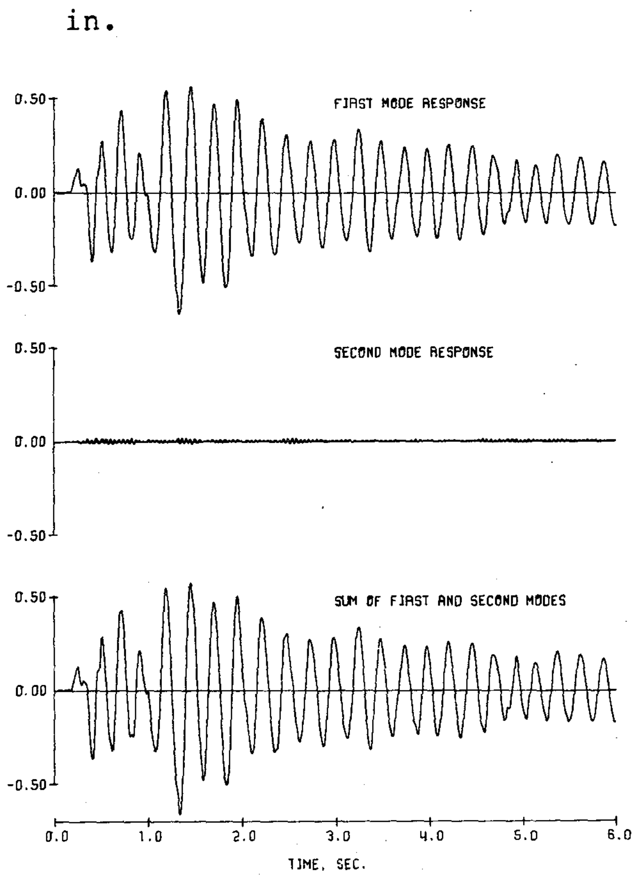
Figure 7.34 (contd.) Calculated Response Histories. Analysis 18. Test Run D2-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$



(a) Base Shear

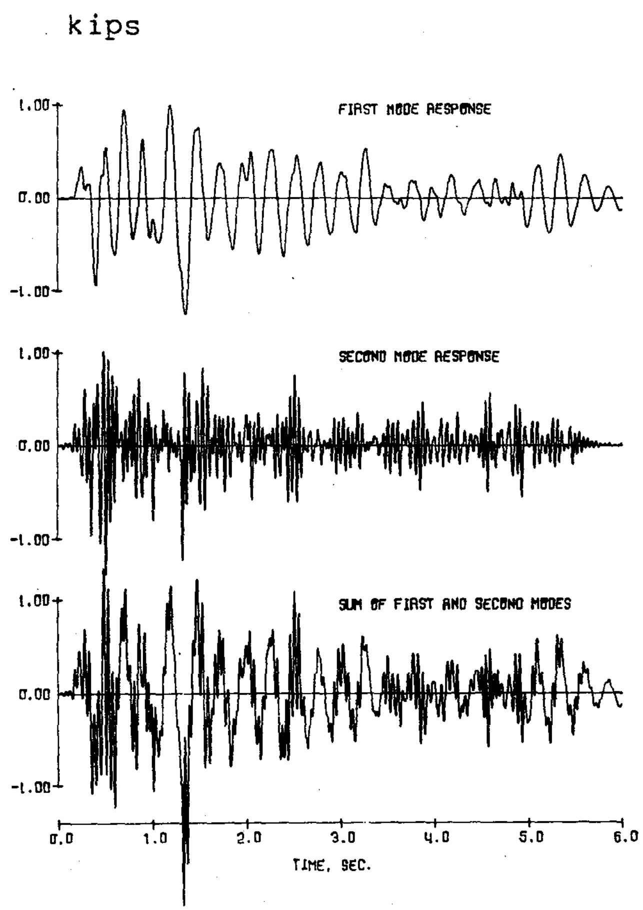
(b) Base Moment

Figure 7.35 Calculated Response Histories. Analysis 19. Test Run D3-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$



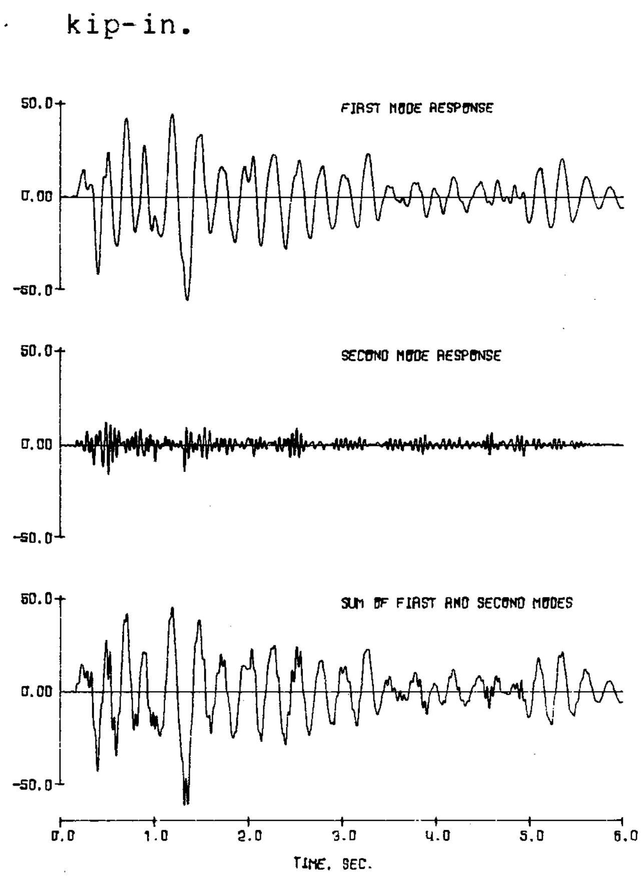
(c) Top Level Deflection

Figure 7.35 (contd.) Calculated Response Histories. Analysis 19. Test Run D3-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$

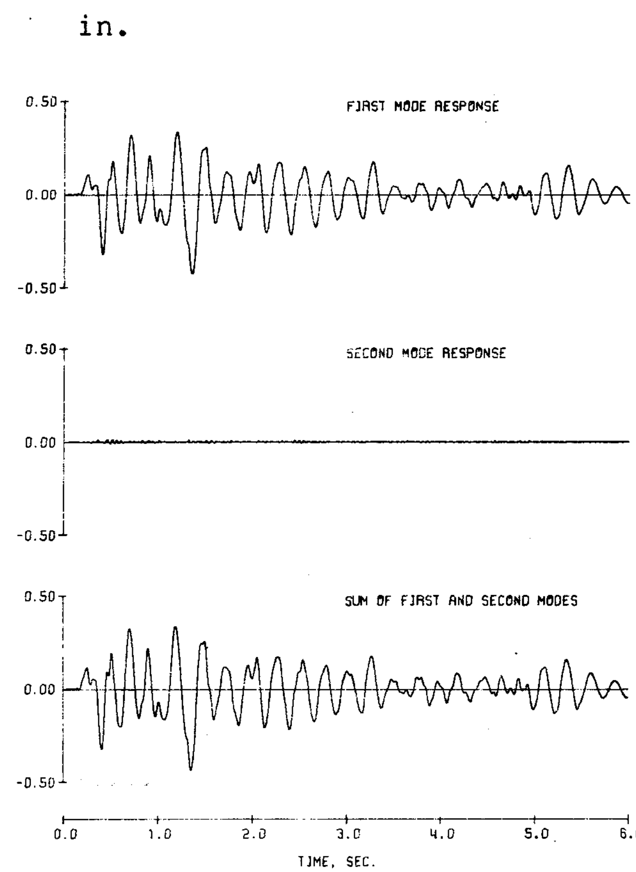


(a) Base Shear

Figure 7.36 Calculated Response Histories. Analysis 20. Test Run D3-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$

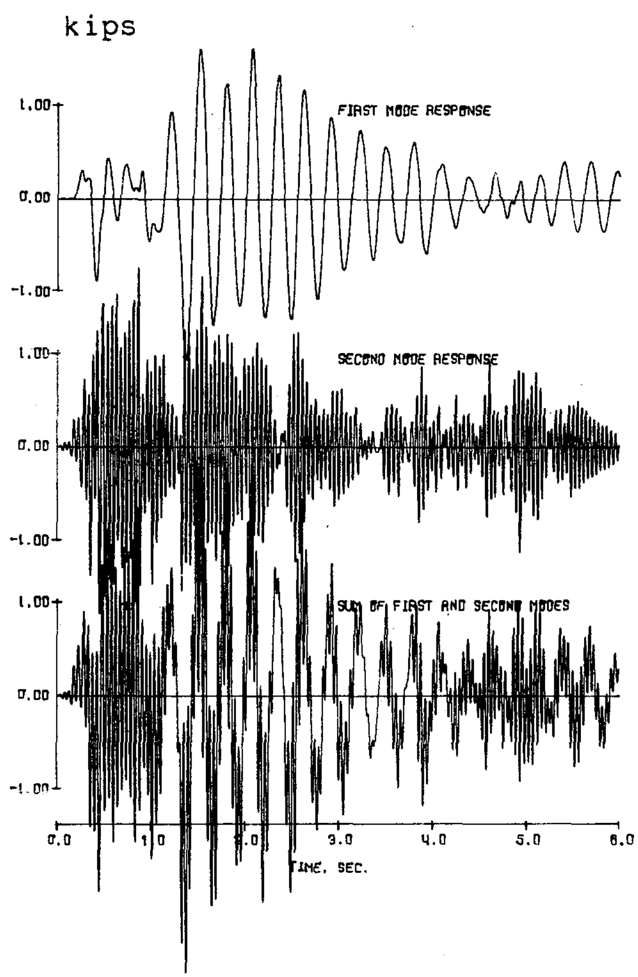


(b) Base Moment

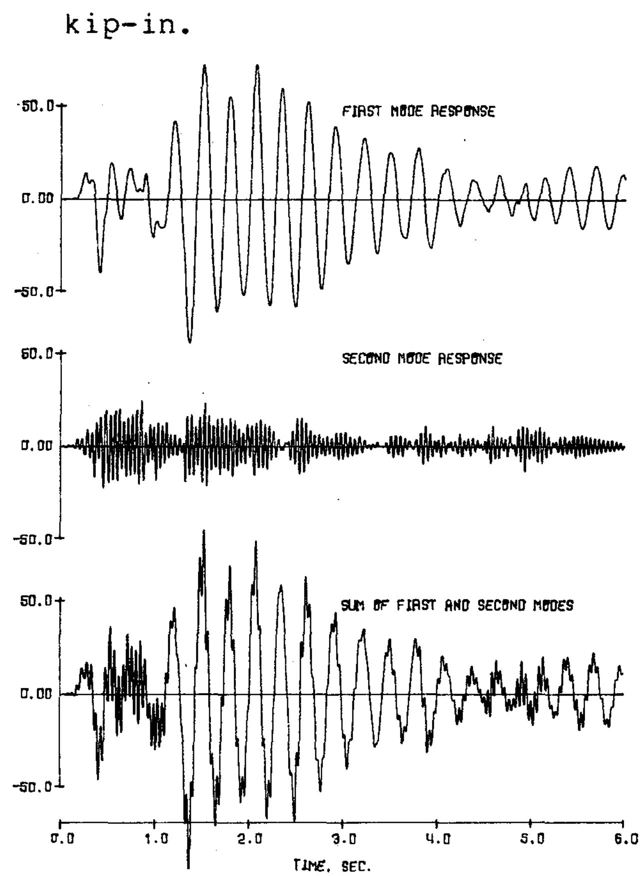


(c) Top Level Deflection

Figure 7.36 (contd.) Calculated Response Histories. Analysis 20. Test Run D3-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$

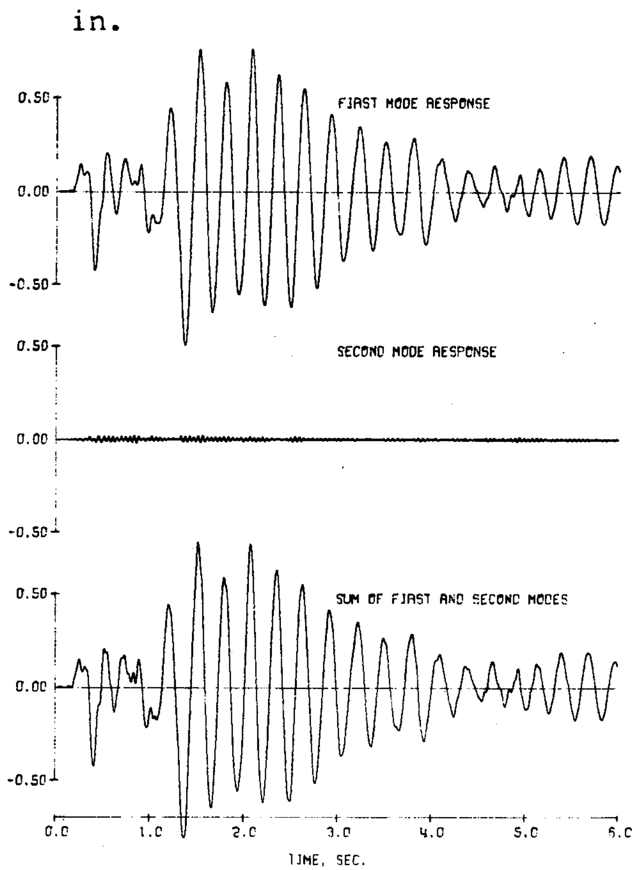


(a) Base Shear



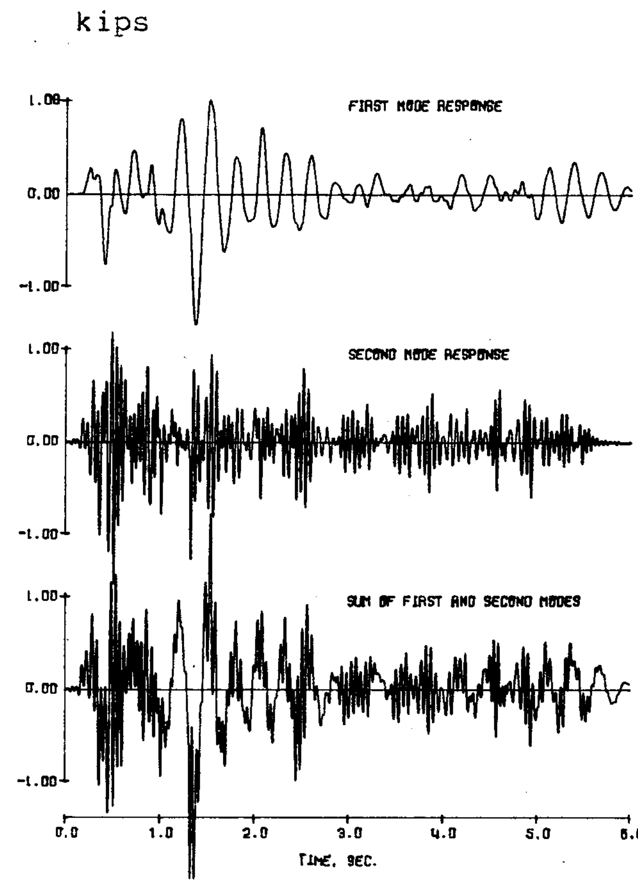
(b) Base Moment

Figure 7.37 Calculated Response Histories. Analysis 21. Test Run D3-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$



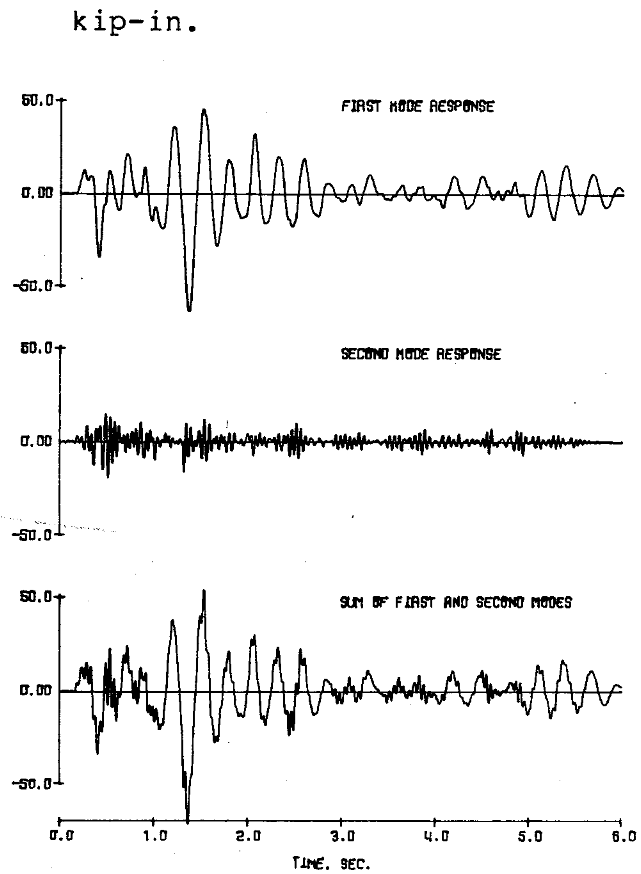
(c) Top Level Deflection

Figure 7.37 (contd.) Calculated Response Histories. Analysis 21. Test Run D3-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$

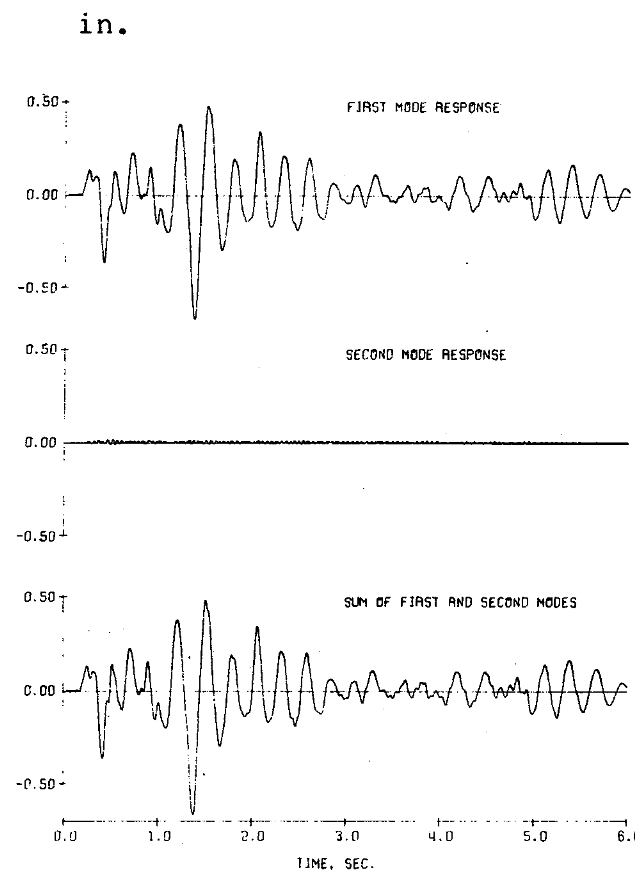


(a) Base Shear

Figure 7.38 Calculated Response Histories. Analysis 22. Test Run D3-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$

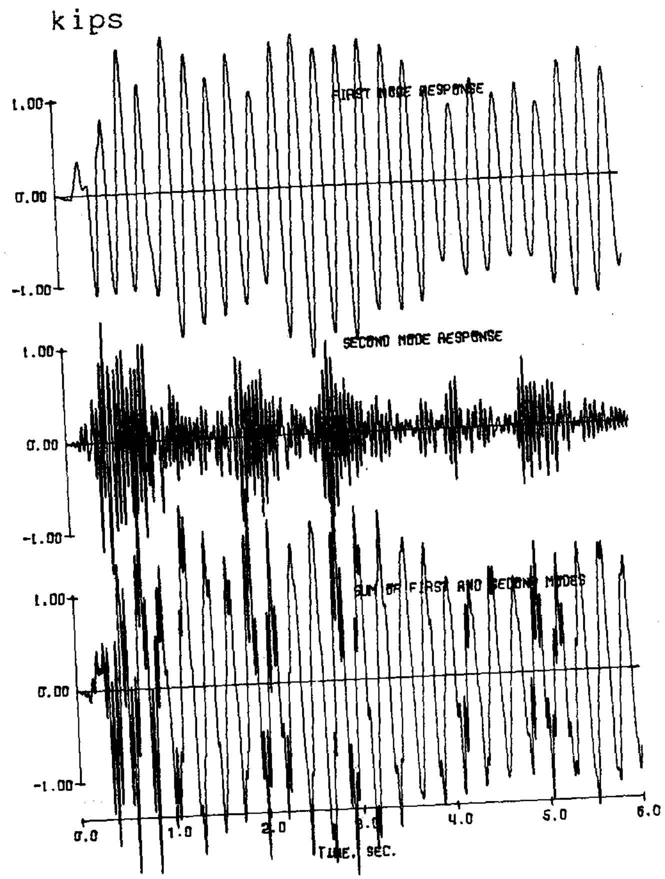


(b) Base Moment

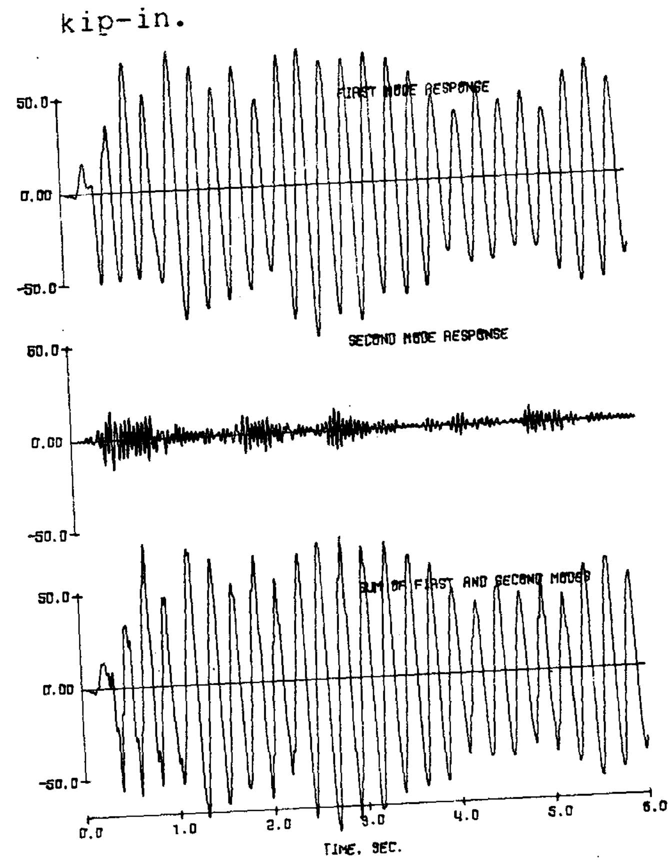


(c) Top Level Deflection

Figure 7.38 (contd.) Calculated Response Histories. Analysis 22. Test Run D3-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$

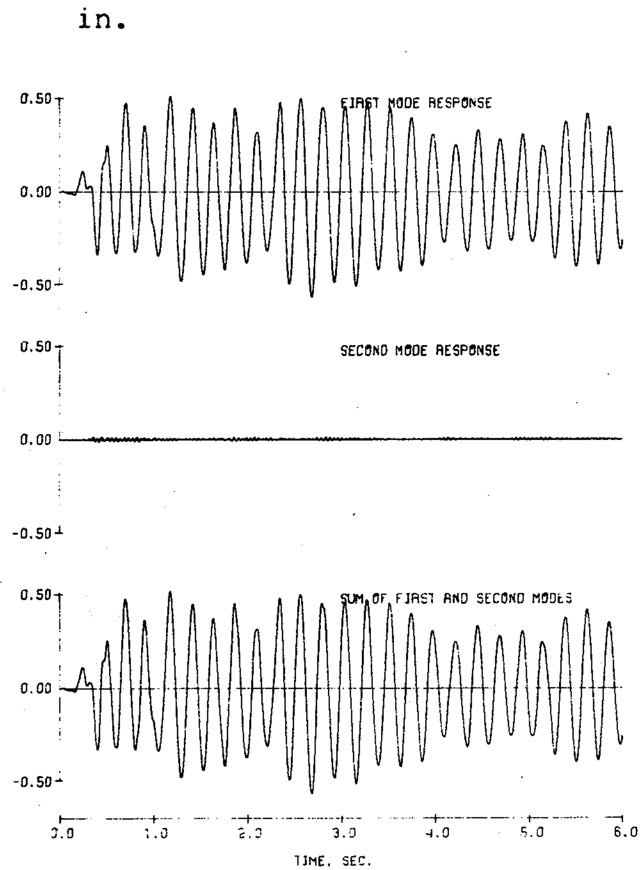


(a) Base Shear



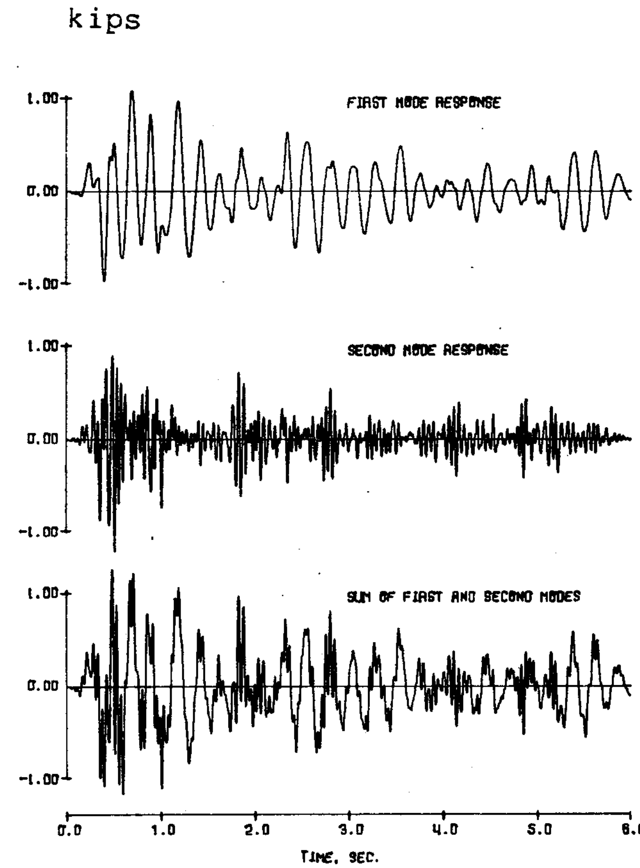
(b) Base Moment

Figure 7.39 Calculated Response Histories. Analysis 23. Test Run D5-1. Early Frequency.
$\beta_1 = \beta_2 = 0.02$



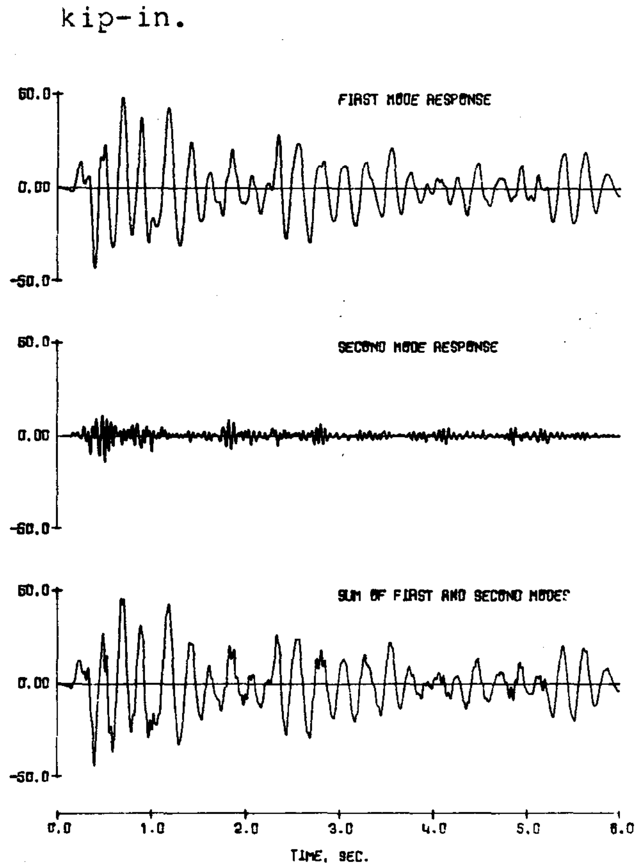
(c) Top Level Deflection

Figure 7.39 (contd.) Calculated Response Histories. Analysis 23. Test Run D5-1. Early Frequency. $\beta_1 = \beta_2 = 0.02$

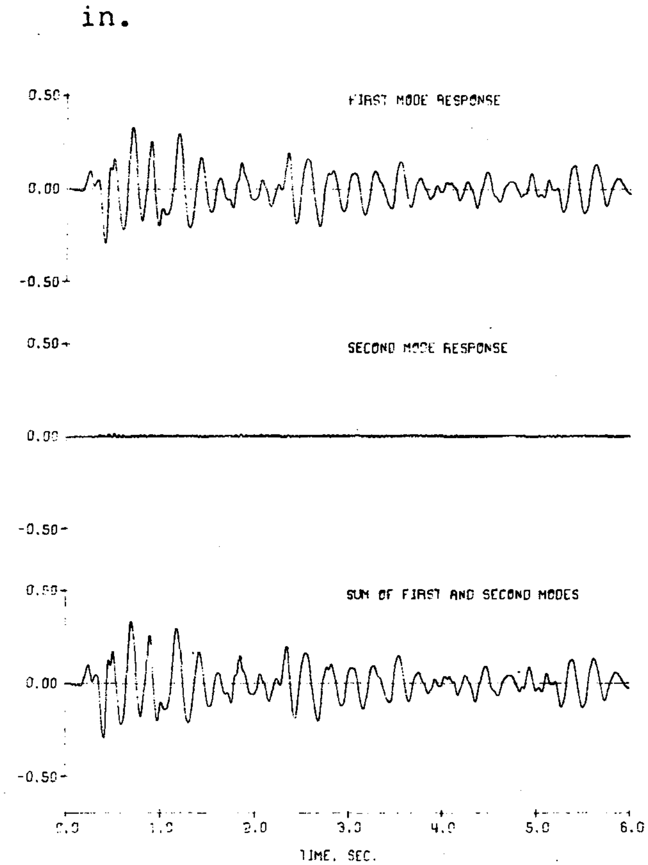


(a) Base Shear

Figure 7.40 Calculated Response Histories. Analysis 24. Test Run D5-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$.



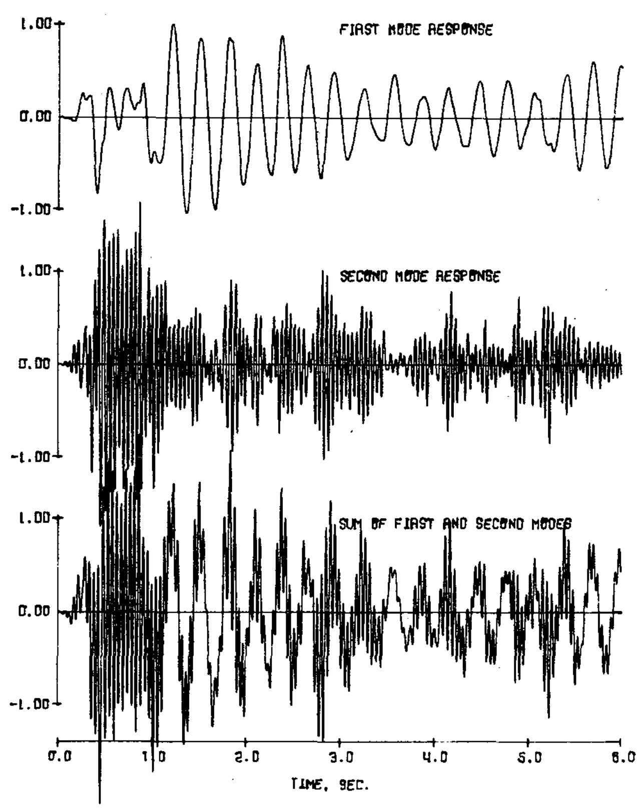
(b) Base Moment



(c) Top Level Deflection

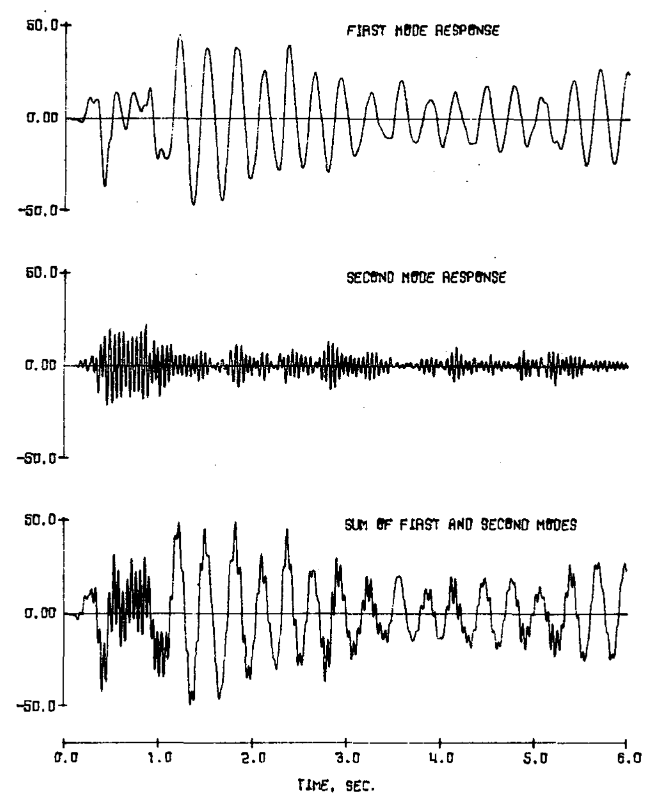
Figure 7.40 (contd.) Calculated Response Histories. Analysis 24. Test Run D5-1. Early Frequency. $\beta_1 = \beta_2 = 0.10$

kips



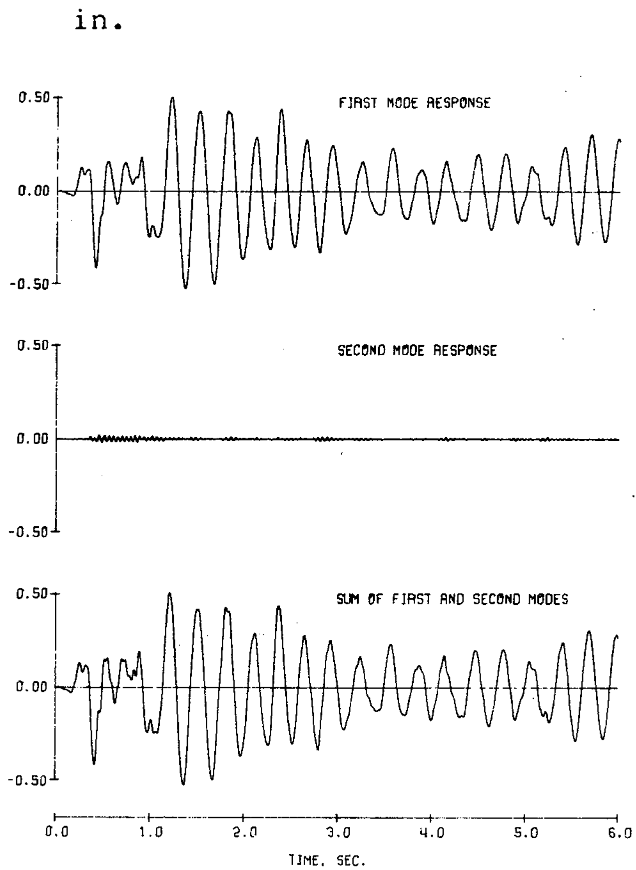
(a) Base Shear

kip-in.



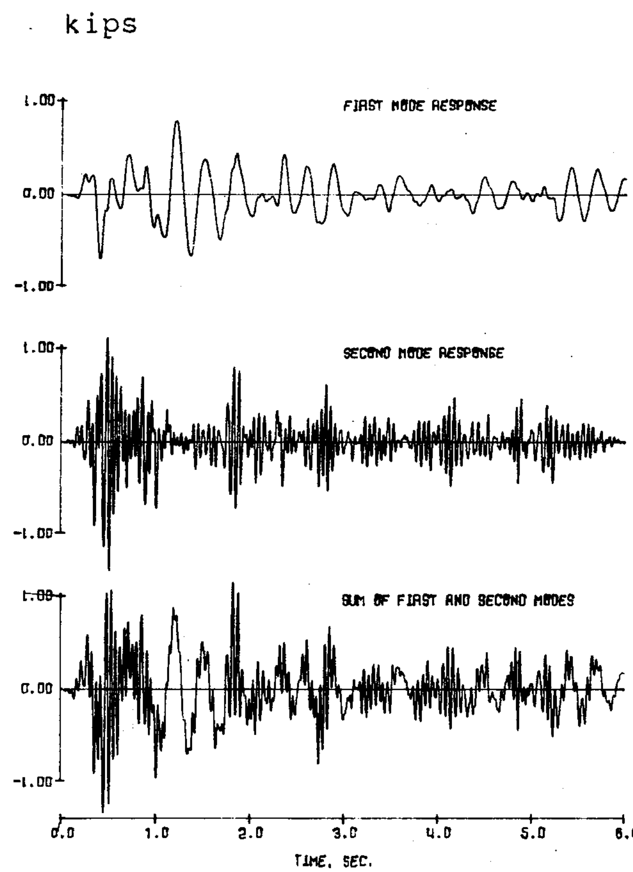
(b) Base Moment

Figure 7.41 Calculated Response Histories. Analysis 25. Test Run D5-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$



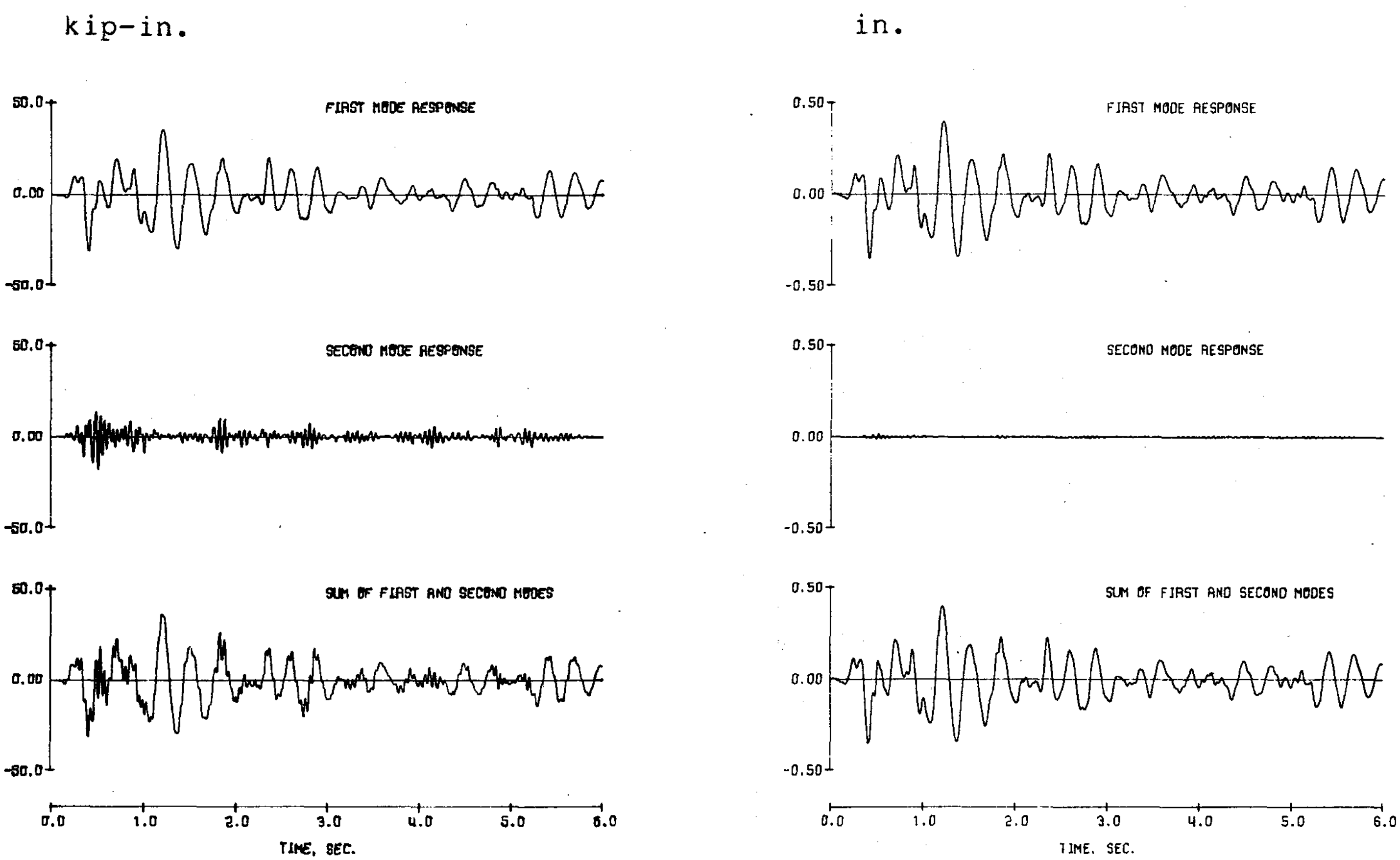
(c) Top Level Deflection

Figure 7.41 (contd.) Calculated Response Histories. Analysis 25. Test Run D5-1. Late Frequency. $\beta_1 = \beta_2 = 0.02$



(a) Base Shear

Figure 7.42 Calculated Response Histories. Analysis 26. Test Run D5-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$



(b) Base Moment

(c) Top Level Deflection

Figure 7.42 (contd.) Calculated Response Histories. Analysis 26. Test Run D5-1. Late Frequency. $\beta_1 = \beta_2 = 0.10$

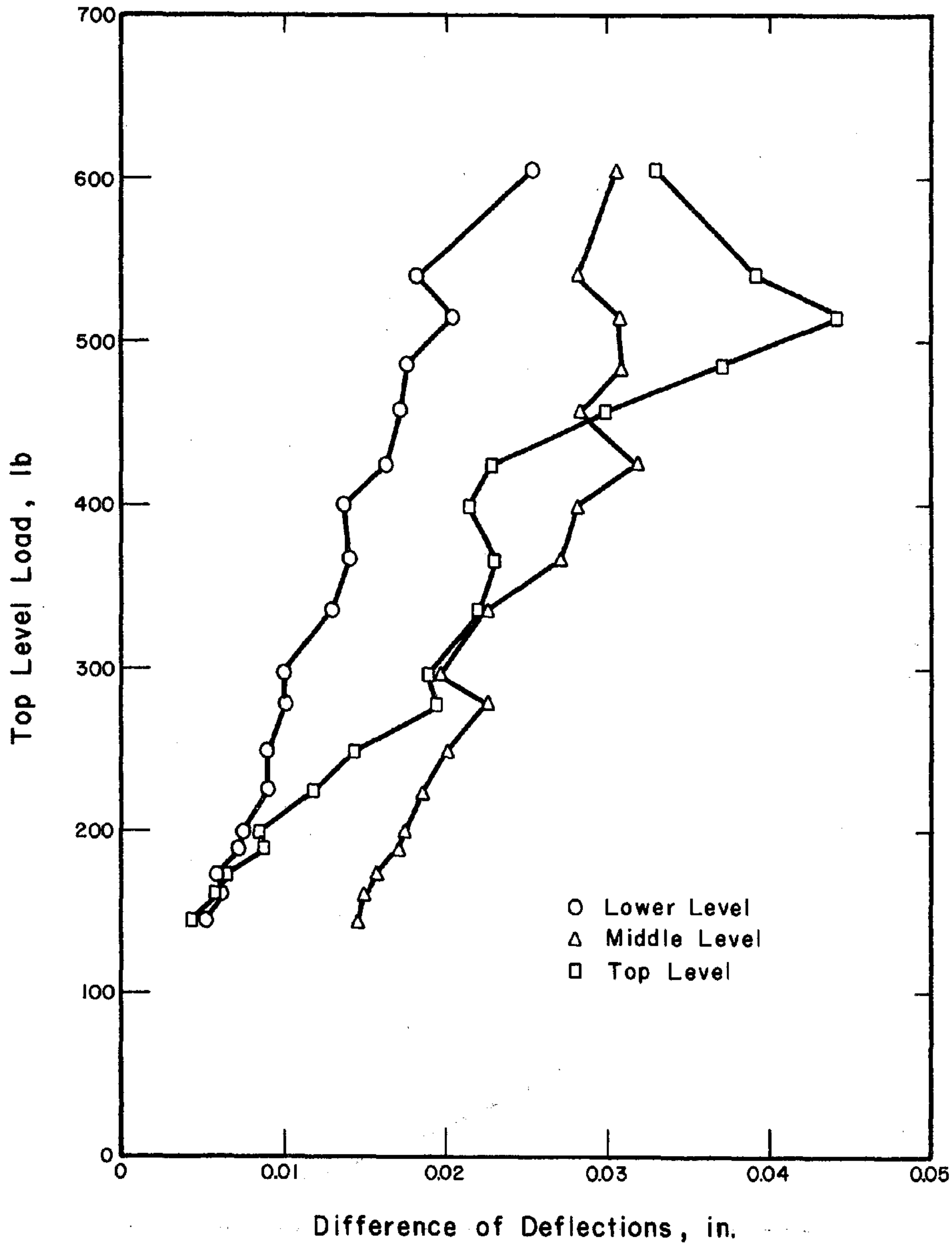


Figure 8.1 Variation with Top Level Load for One Wall of the Difference Between Horizontal Deflection Measured by Differential Transformers and by Mechanical Dial Gages Uncorrected for Base Movement

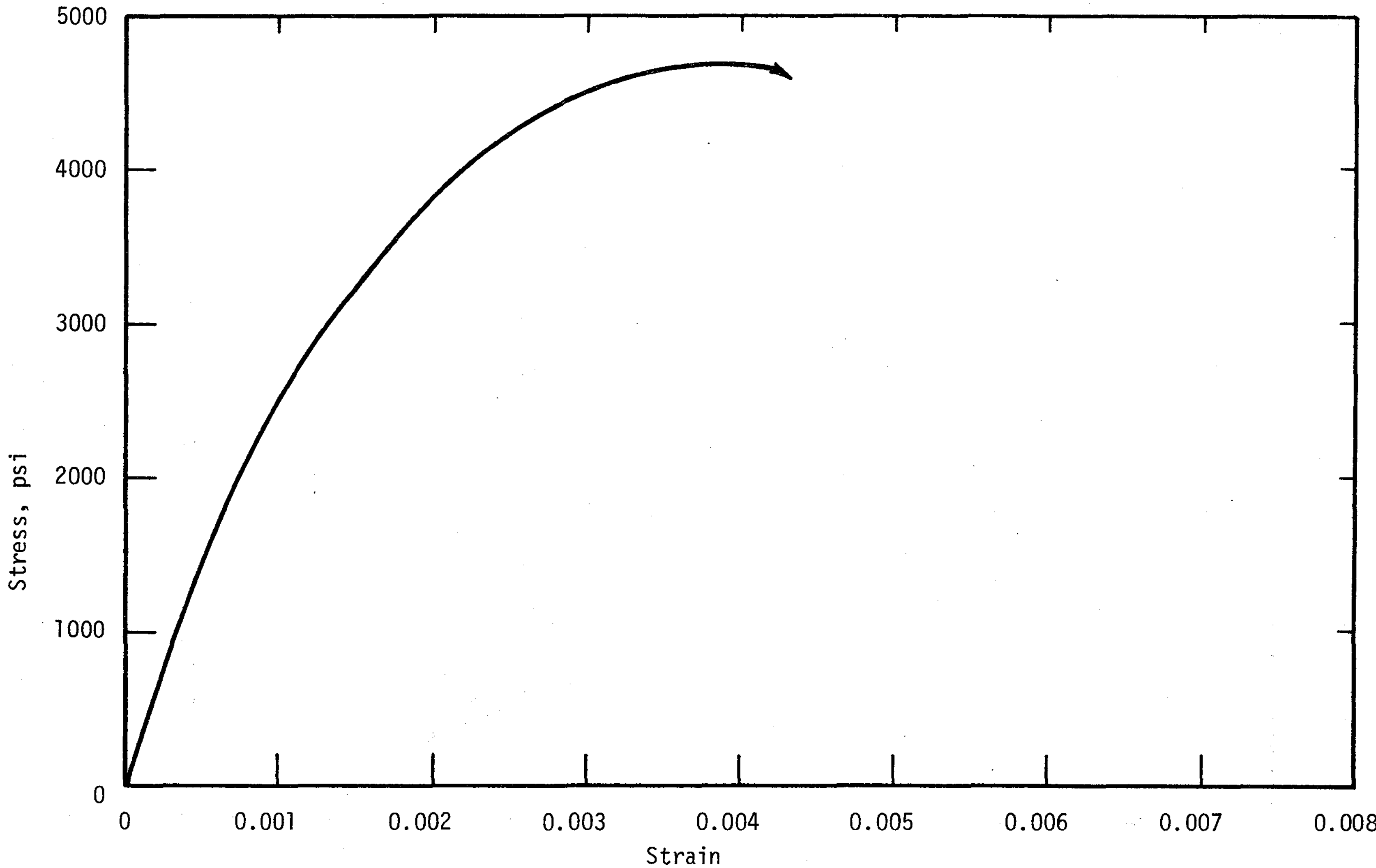


Figure A.1 Representative Stress-Strain Relation for the Concrete

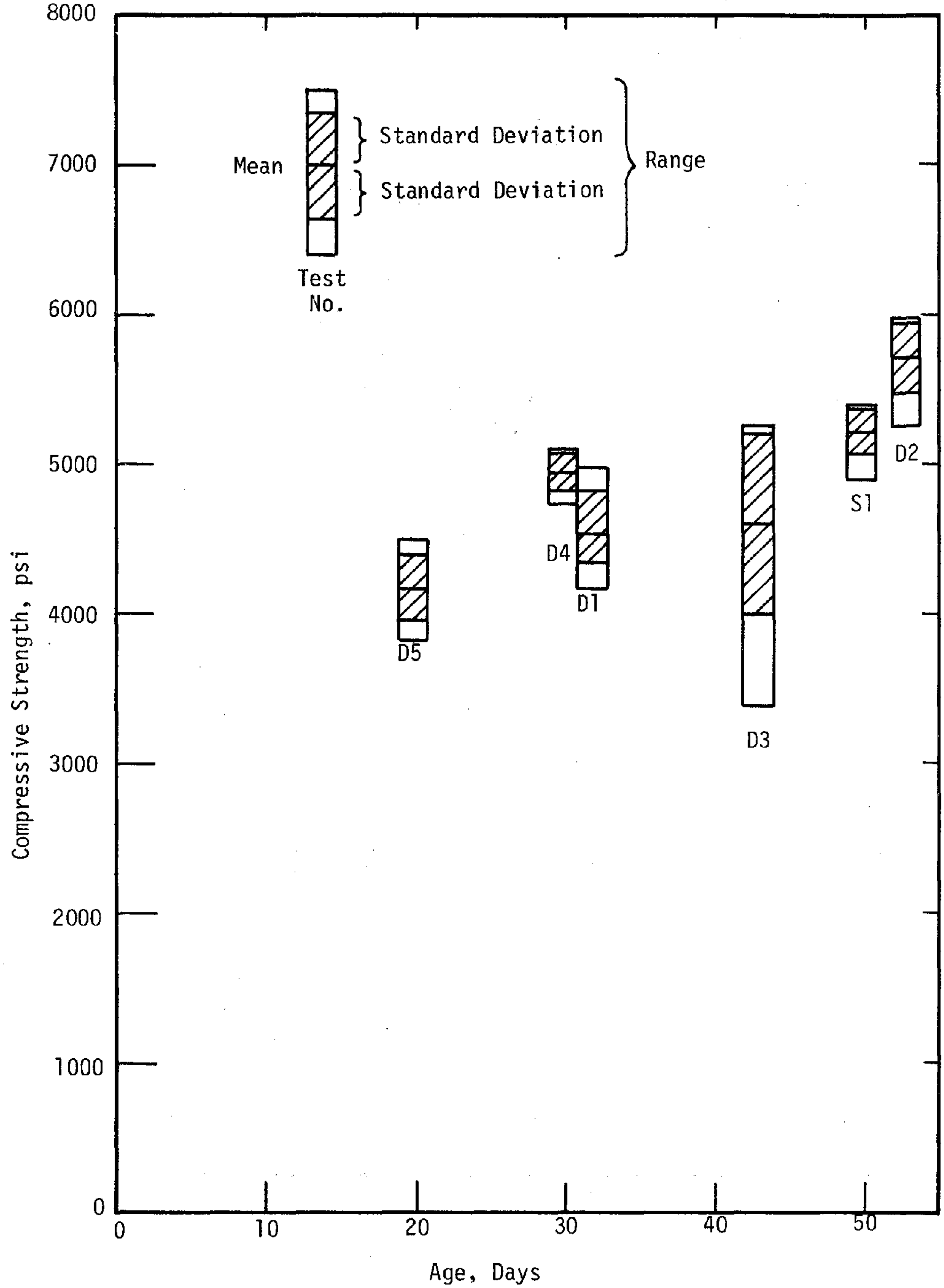


Figure A.2 Variation of Compressive Strength of Concrete with Age

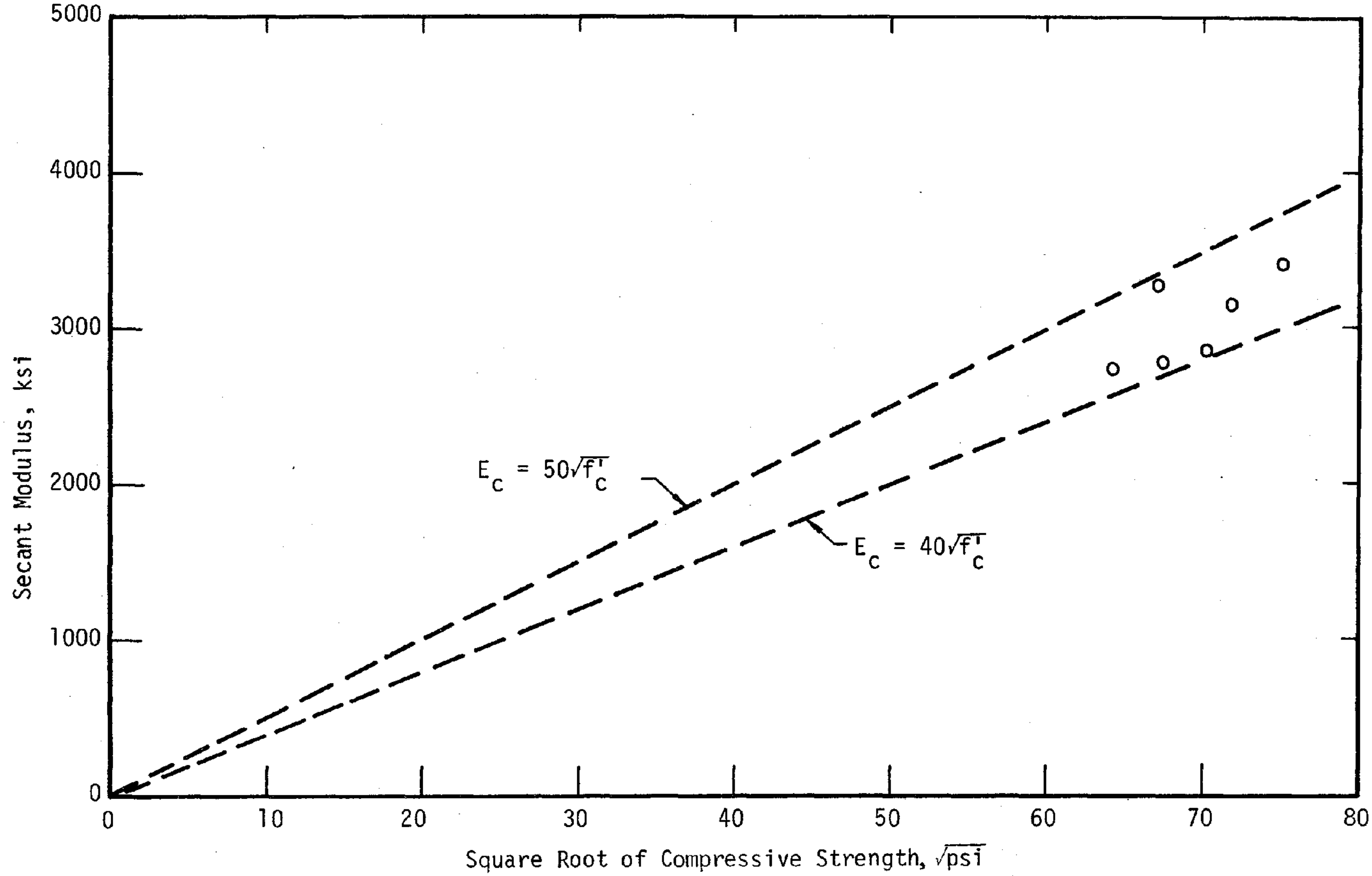


Figure A.3 Variation of Initial Modulus of Concrete with Square Root of Compressive Strength of Concrete

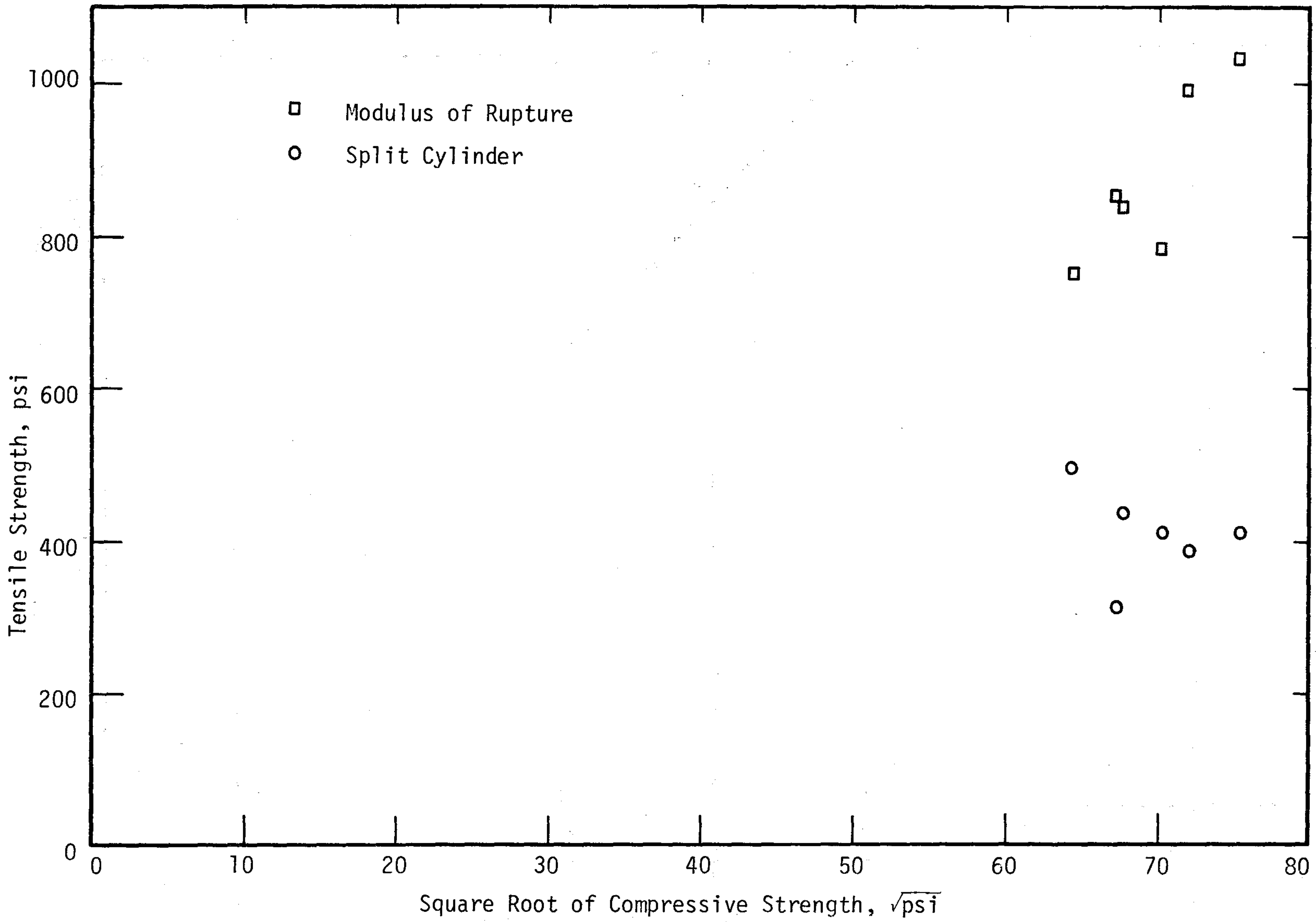


Figure A.4 Variation of Tensile Strength of Concrete with Square Root of Compressive Strength of Concrete

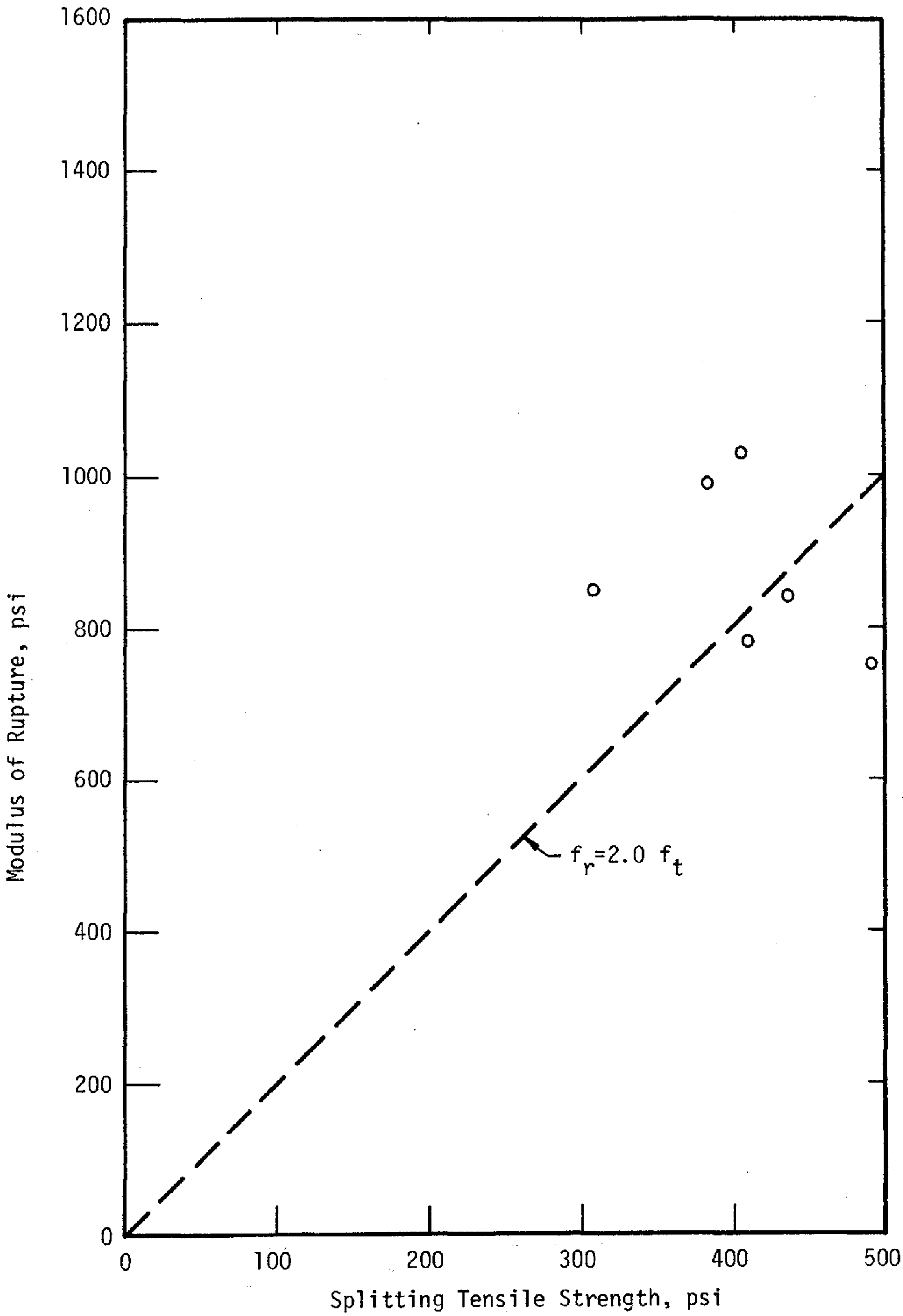


Figure A.5 Relation between Modulus of Rupture of Concrete and Splitting Strength of Concrete

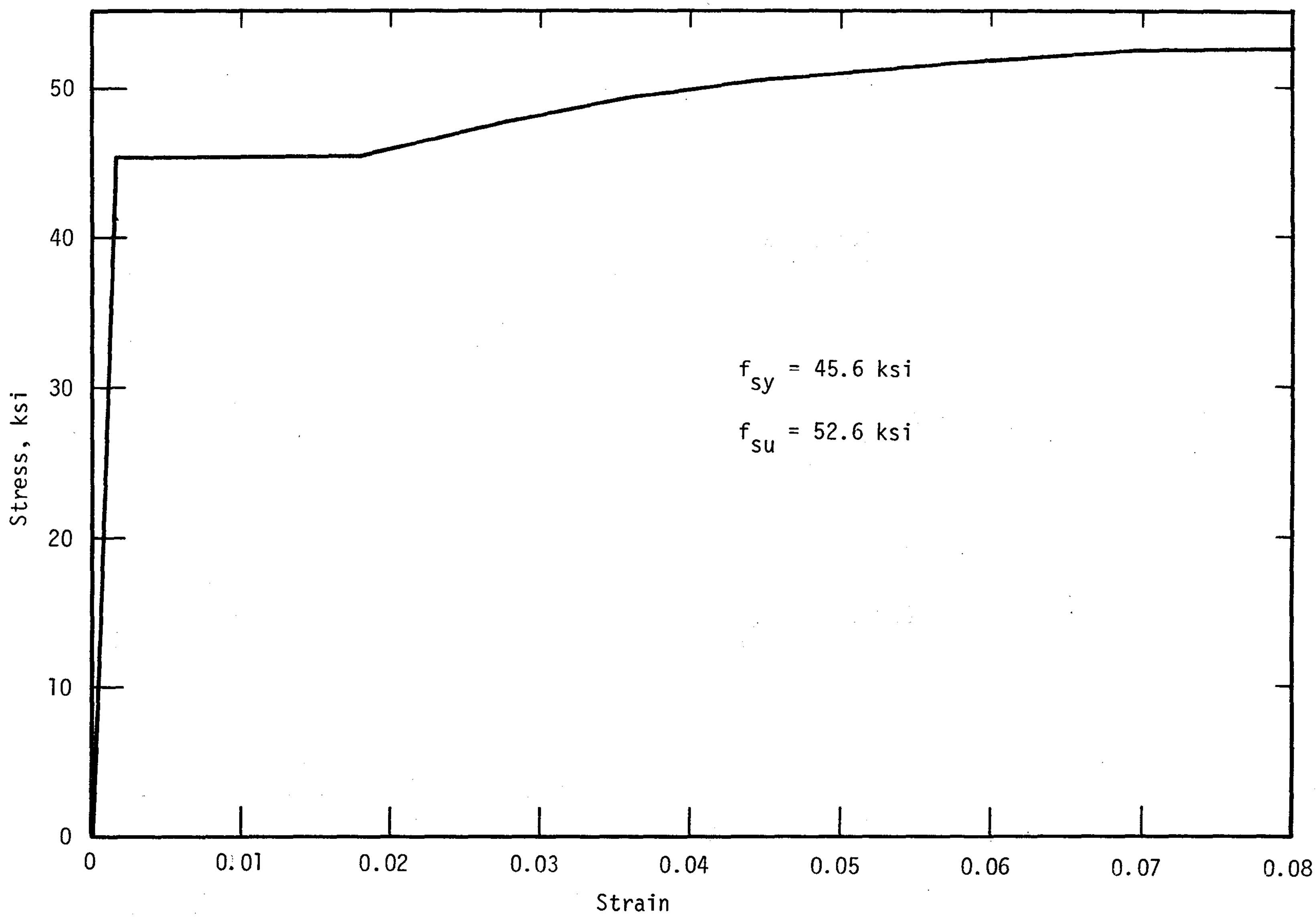


Figure A.6 Representative Stress-Strain Relation for Steel Before Welding

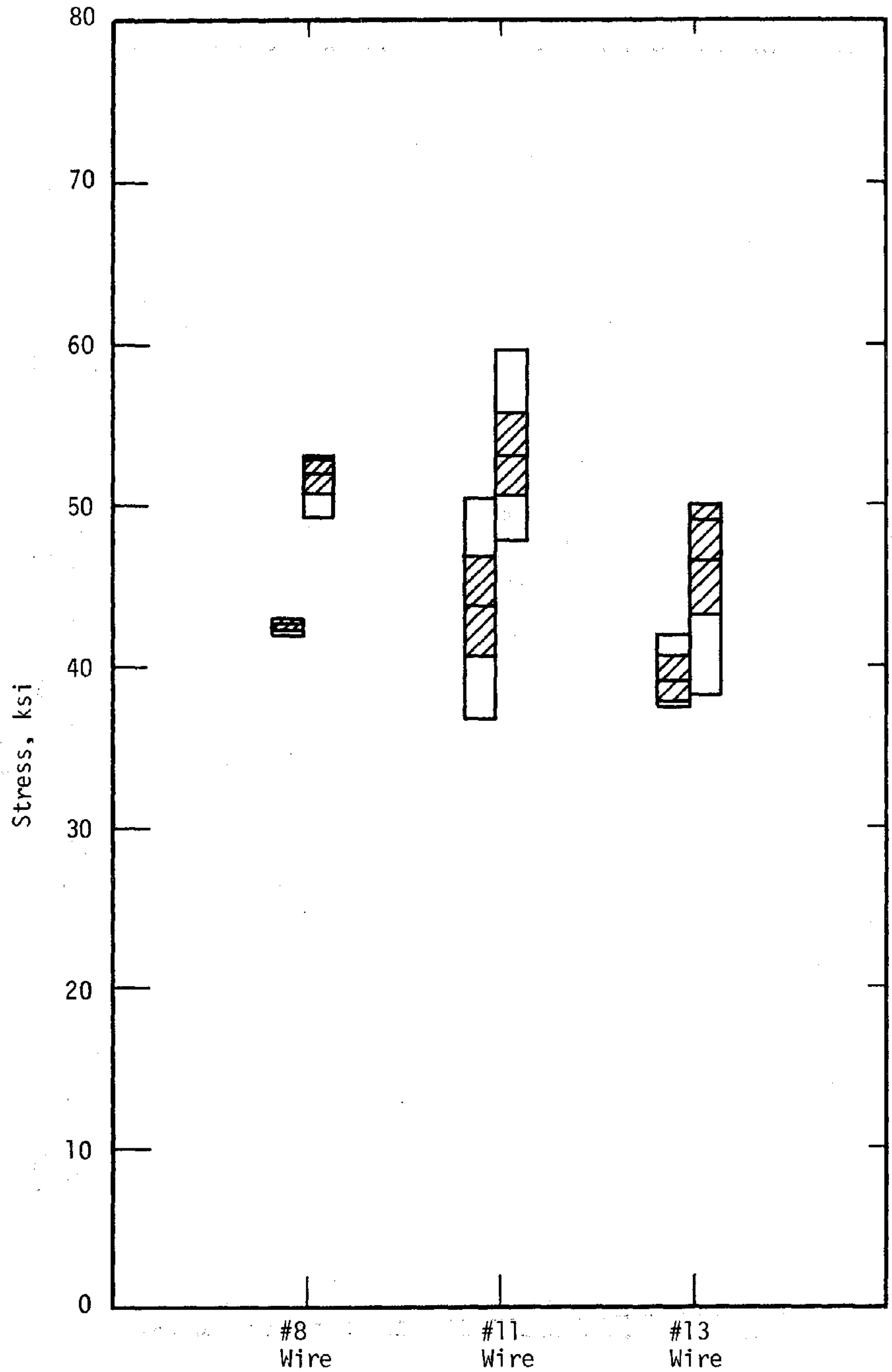


Figure A.7 Ultimate Stress and Yield Stress for Each Wire Size

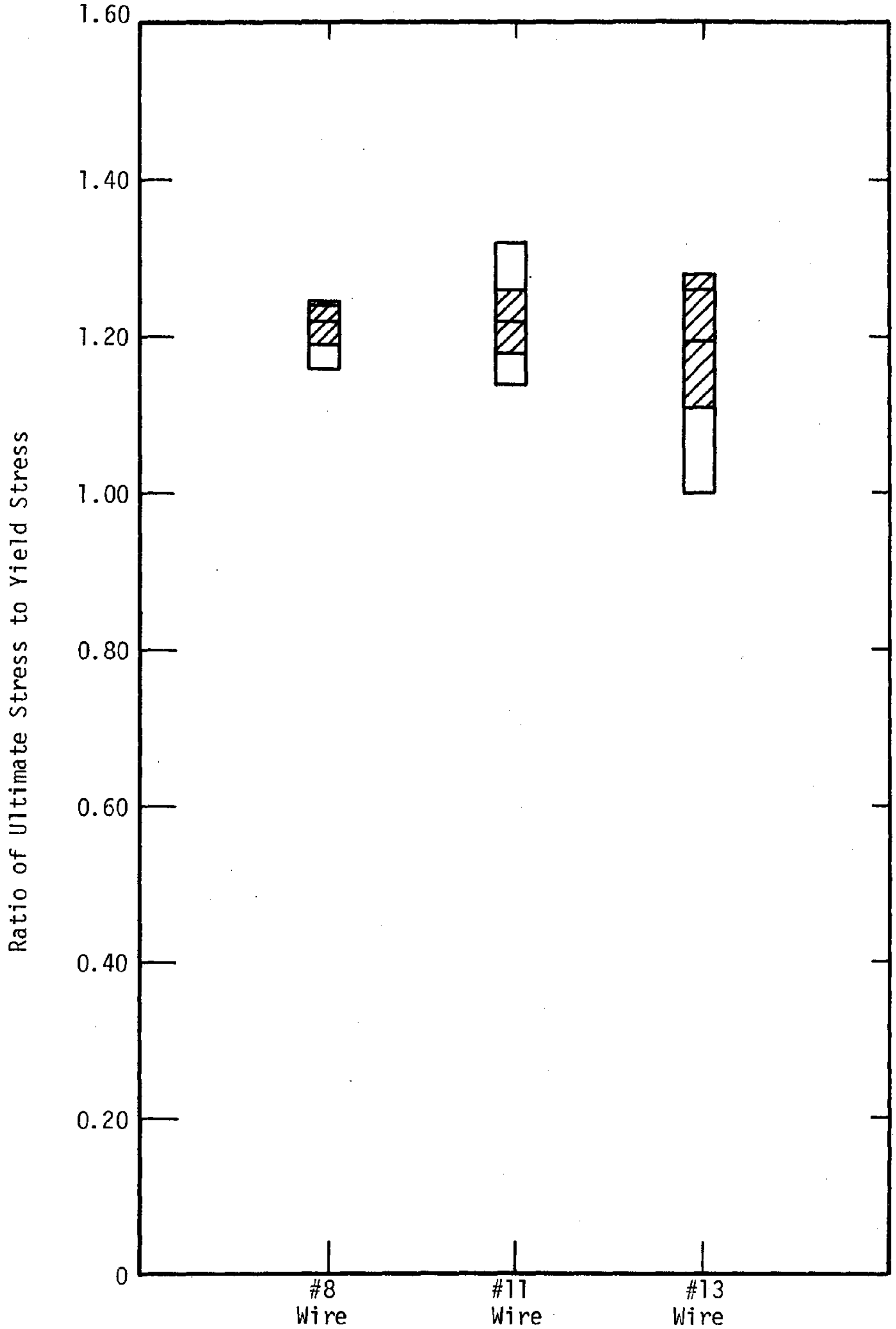


Figure A.8 Ratio of Ultimate Stress to Yield Stress for Each Wire Size

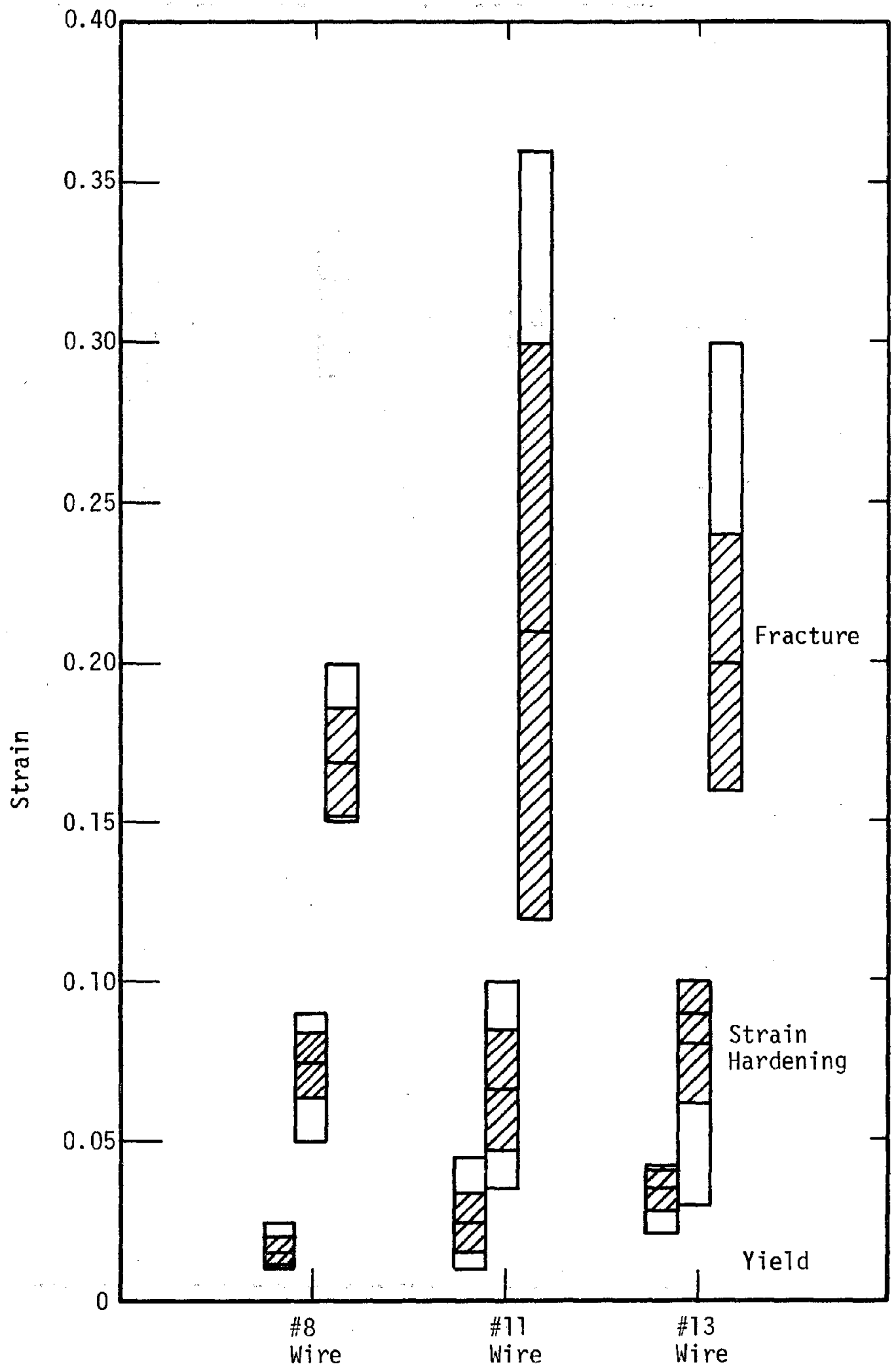


Figure A.9 Strain at Strain-Hardening, Attainment of Ultimate Stress and Fracture for Each Wire Size

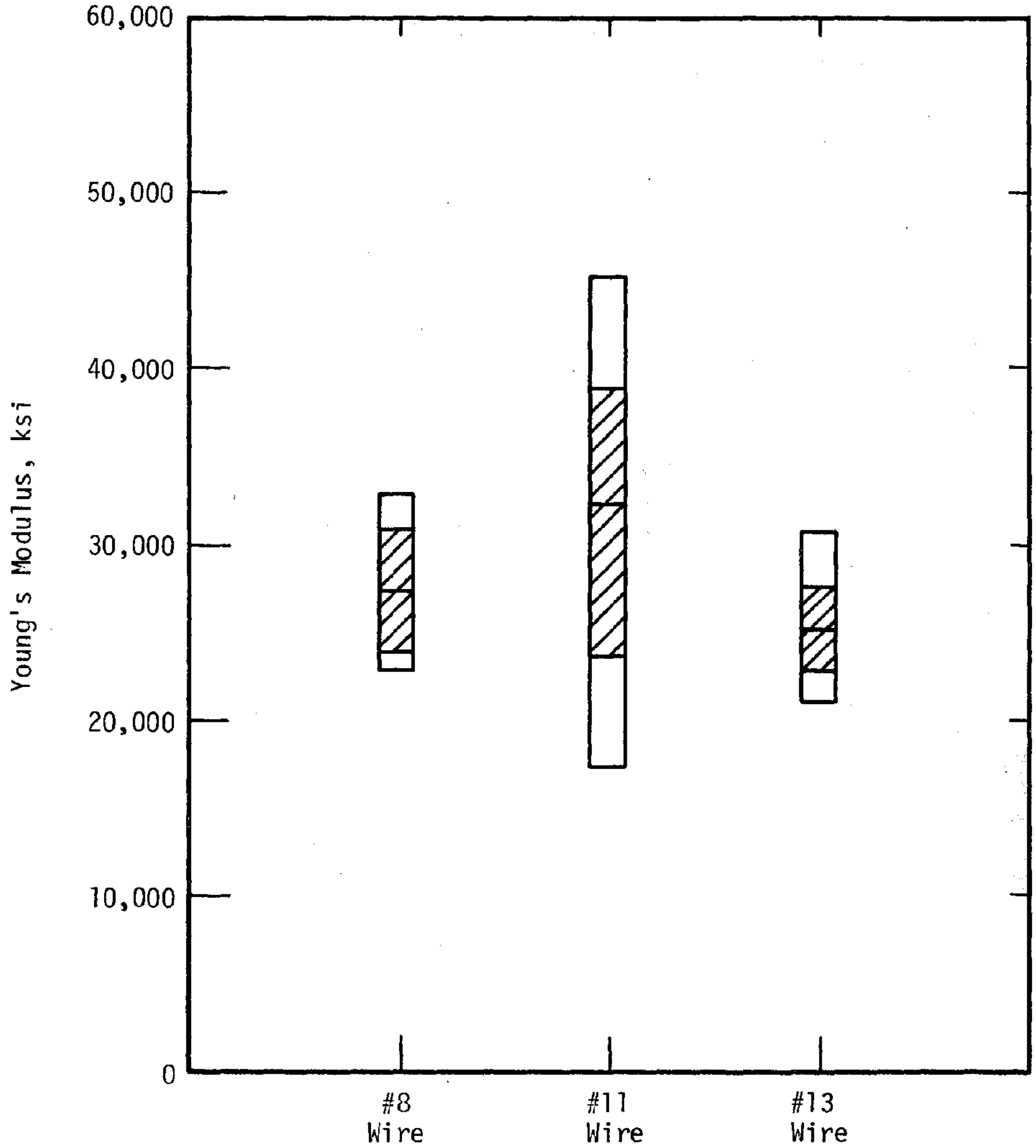


Figure A.10 Young's Modulus for Each Wire Size

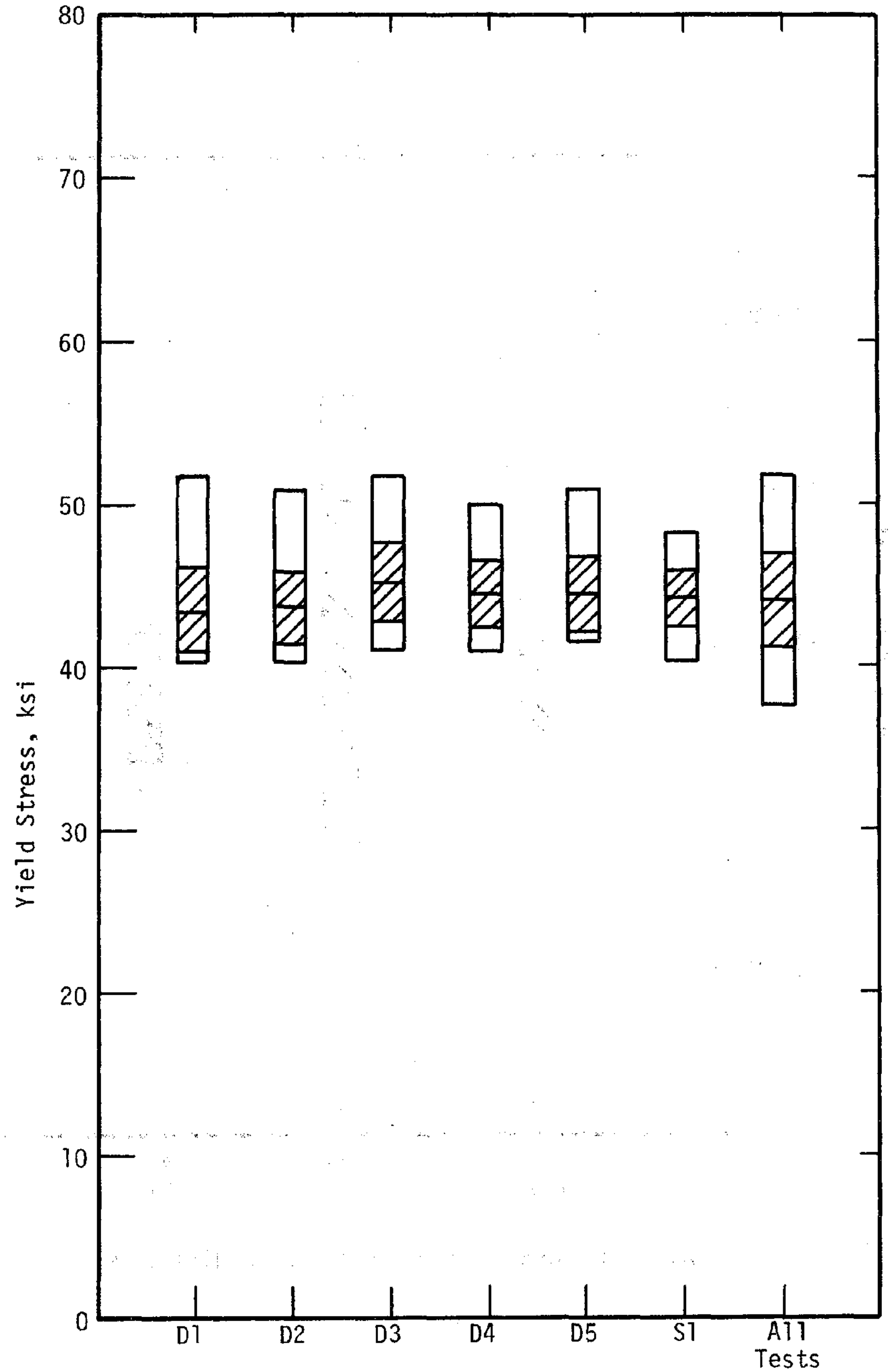


Figure A.11 Yield Stress of #11 Wire for Each Test

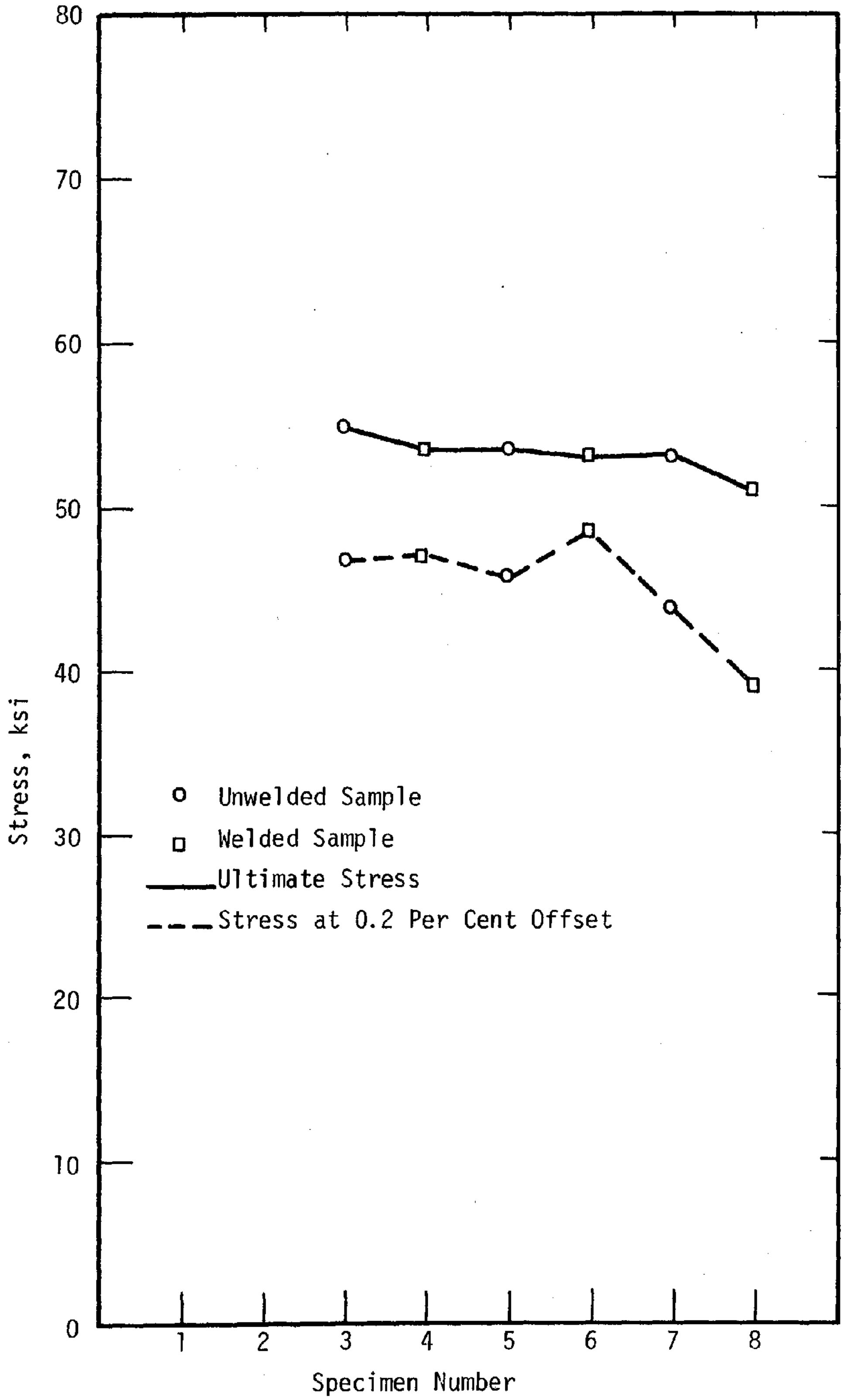


Figure A.12 Yield and Ultimate Stresses for Specimen Group No. 1

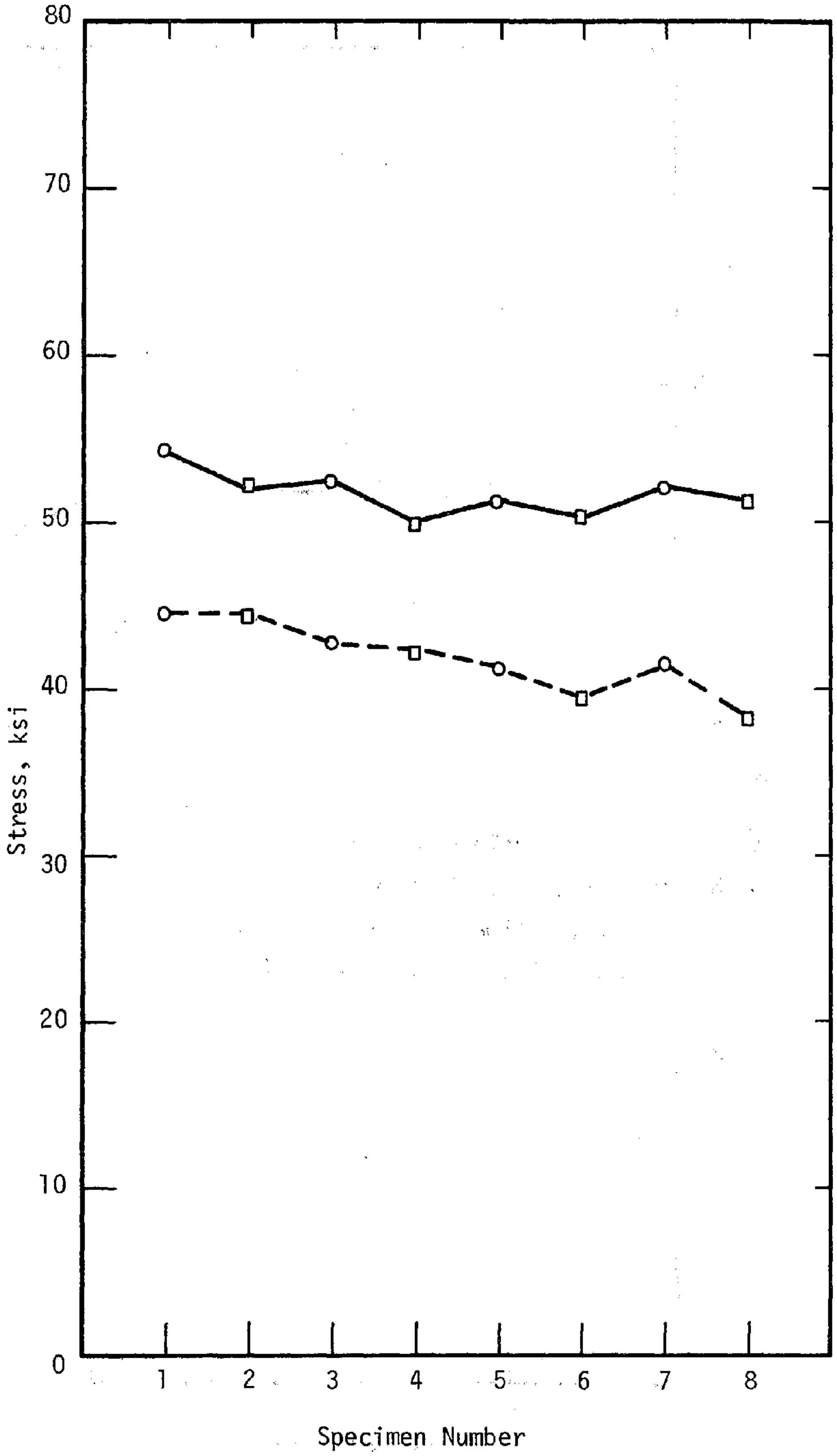


Figure A.13 Yield and Ultimate Stresses for Specimen Group No. 2

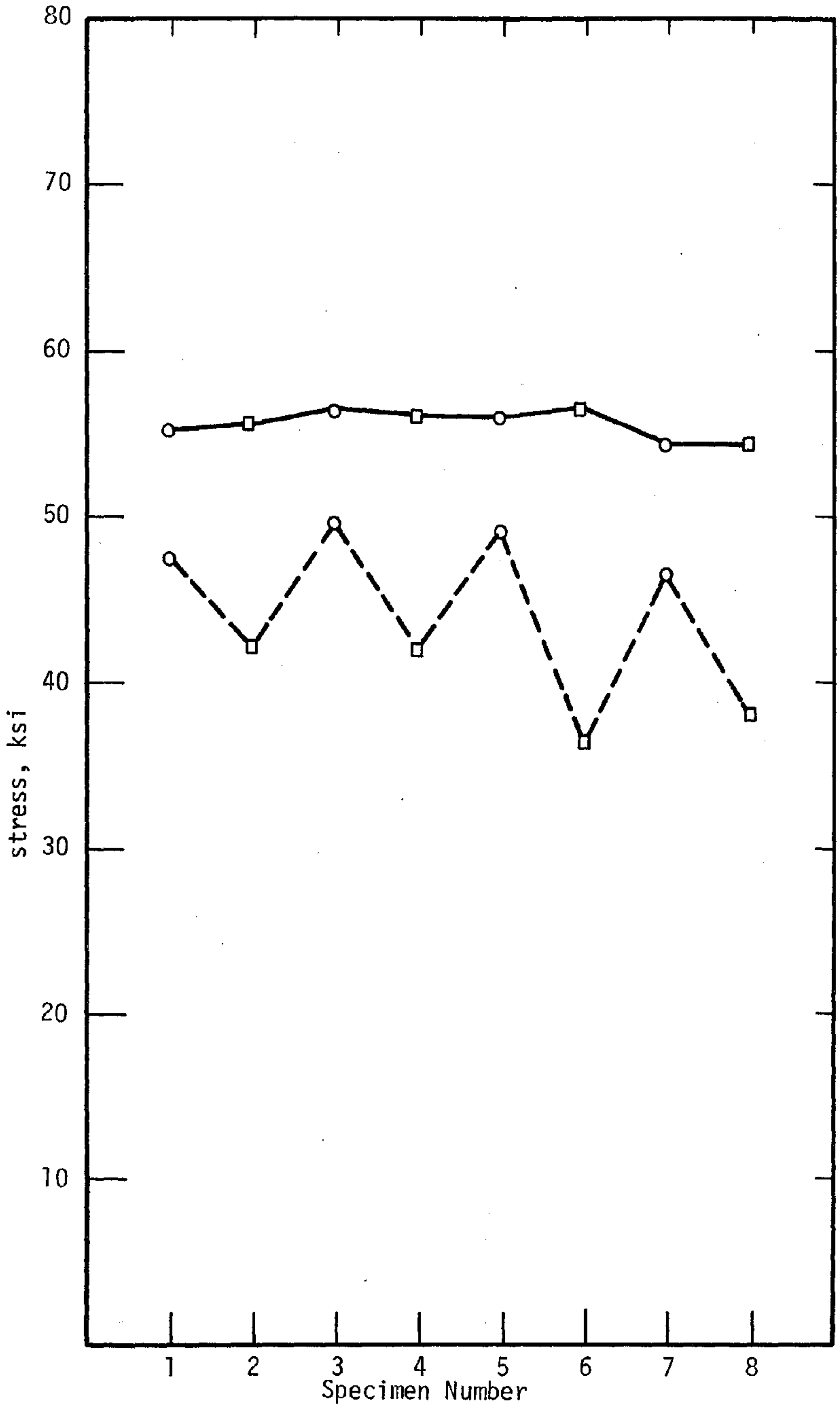


Figure A.14 Yield and Ultimate Stresses for Specimen Group No. 3

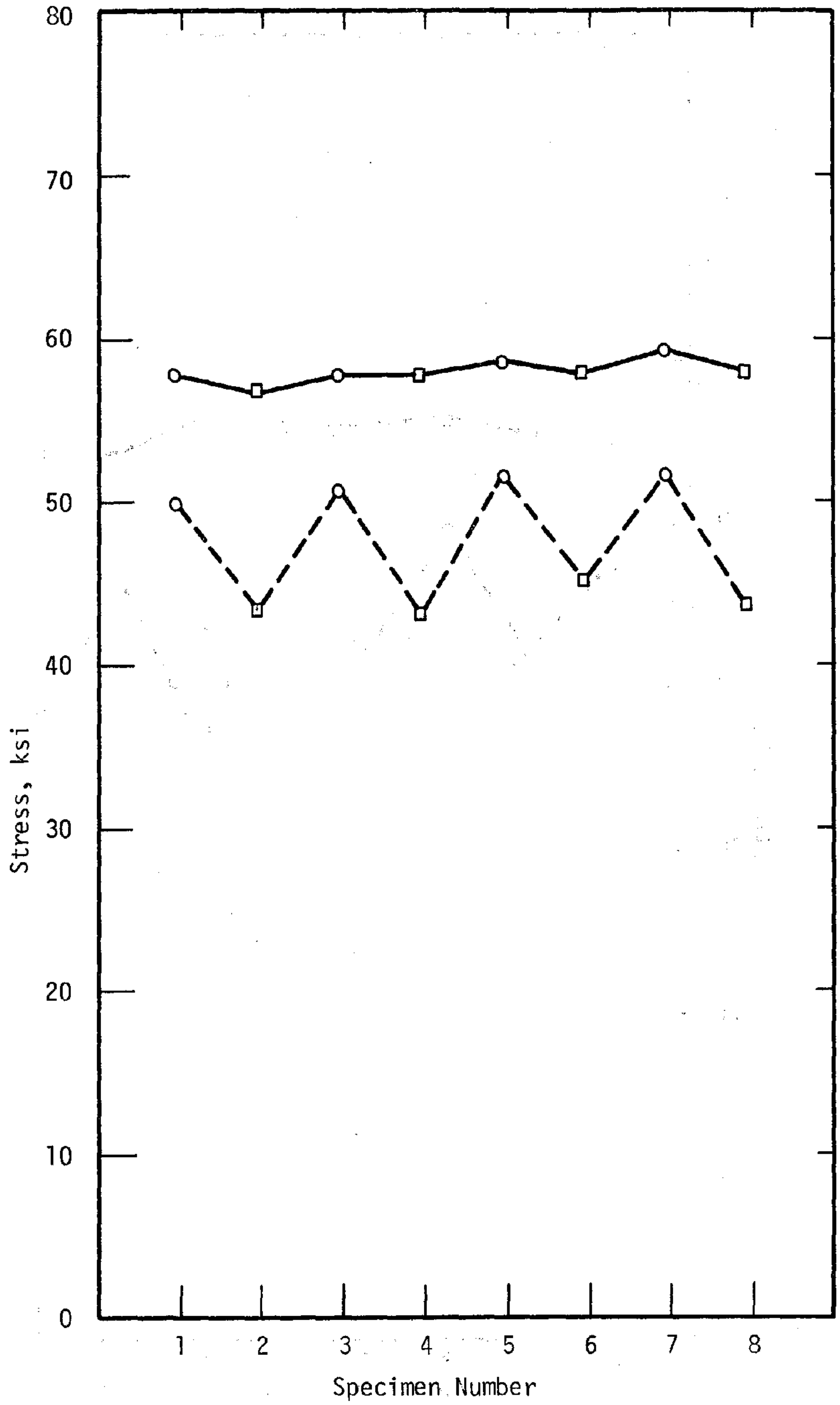


Figure A.15 Yield and Ultimate Stresses for Specimen Group No. 4

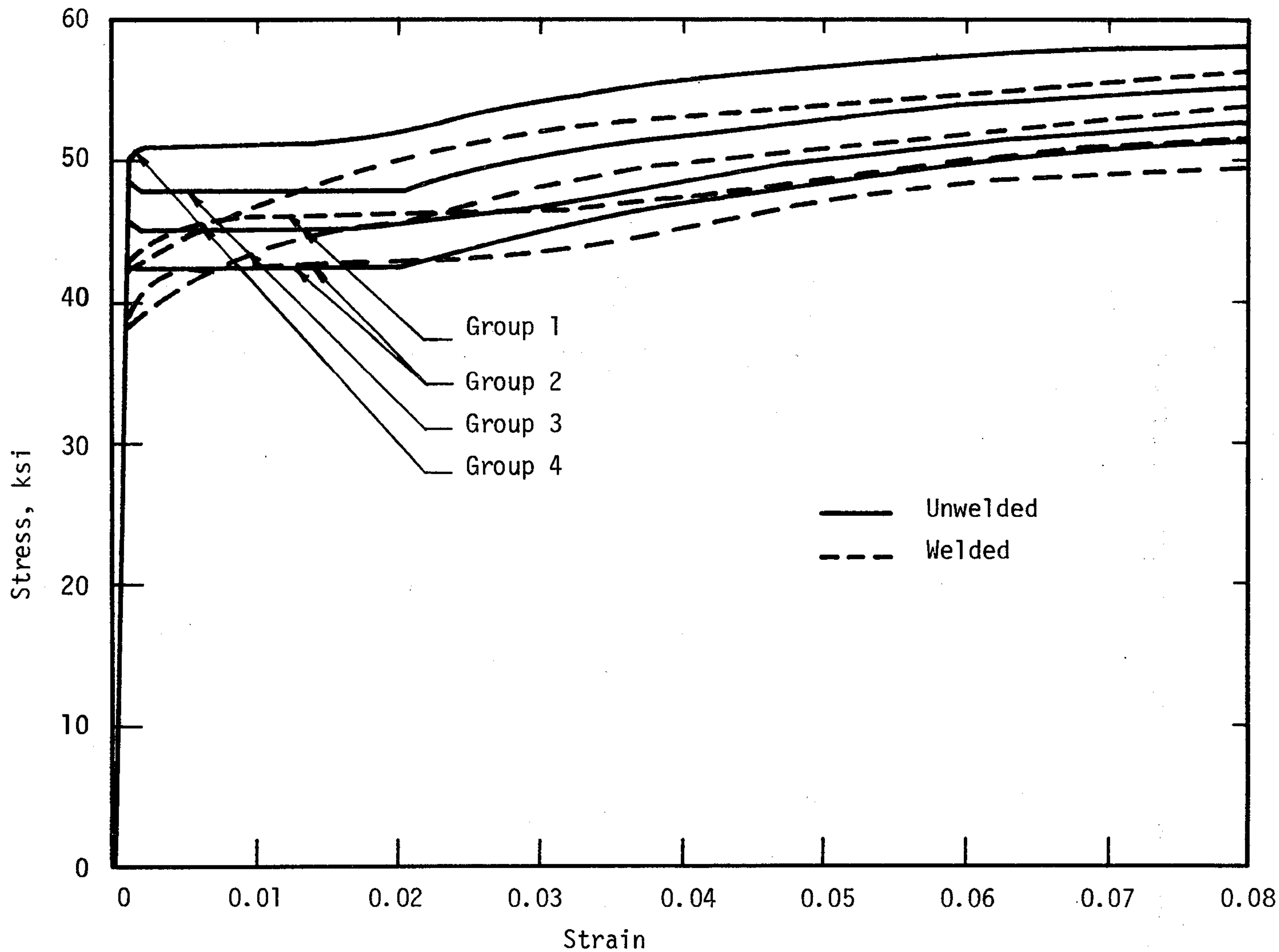


Figure A.16 Comparison of Stress-Strain Relations for Welded and Unwelded Samples

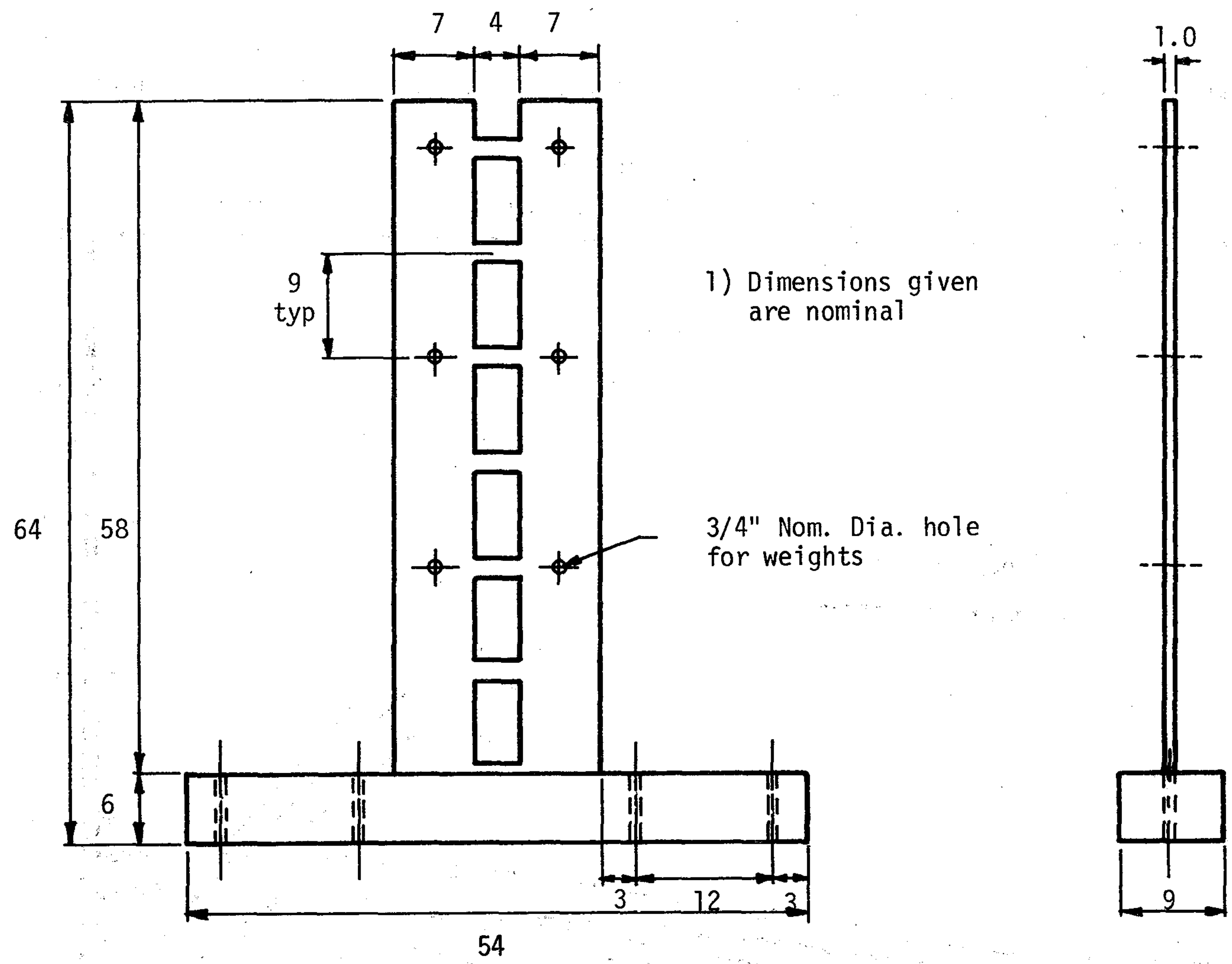


Figure A.17 General Configuration of Test Specimens

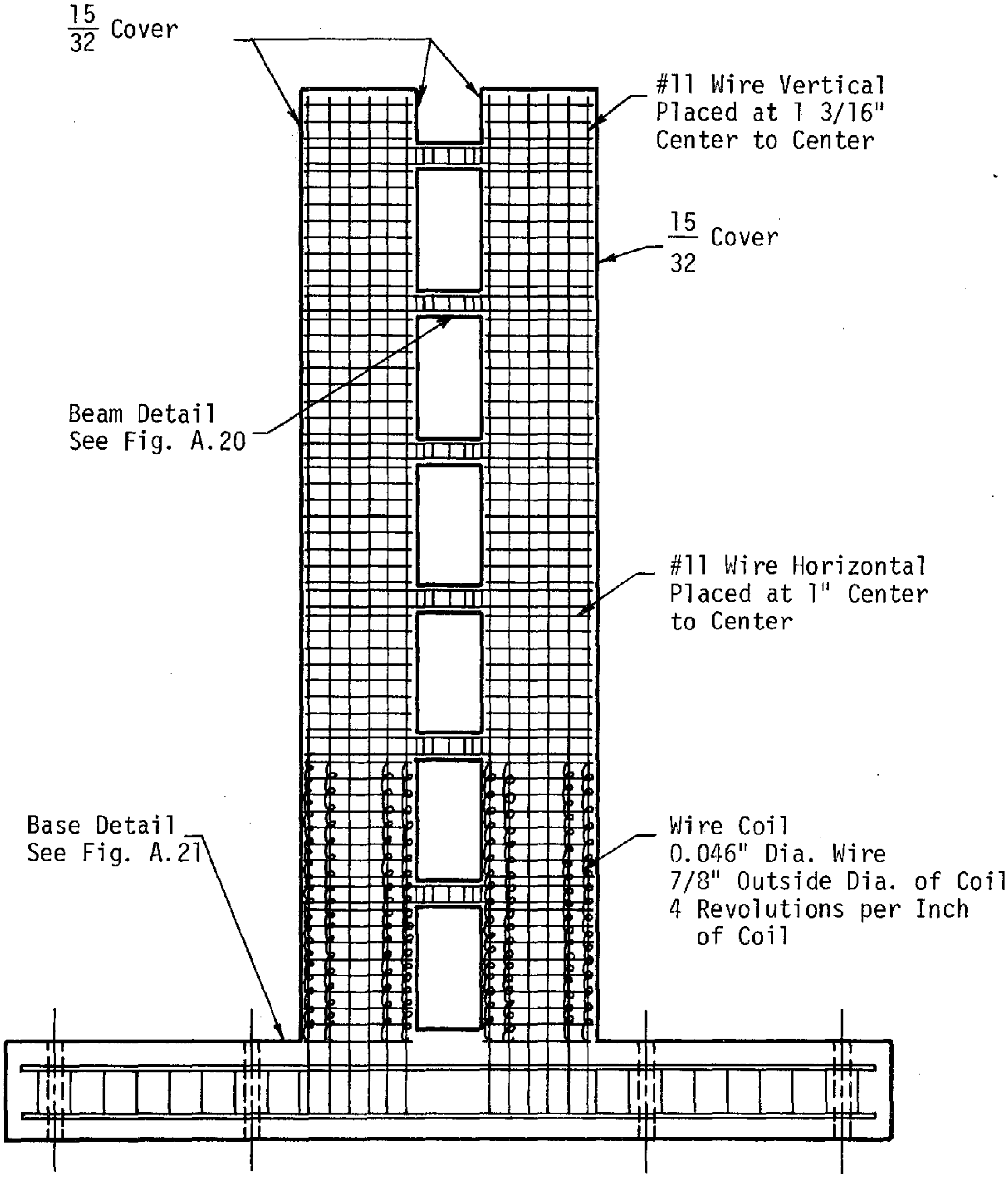


Figure A.18 General Reinforcing Scheme of Test Specimen

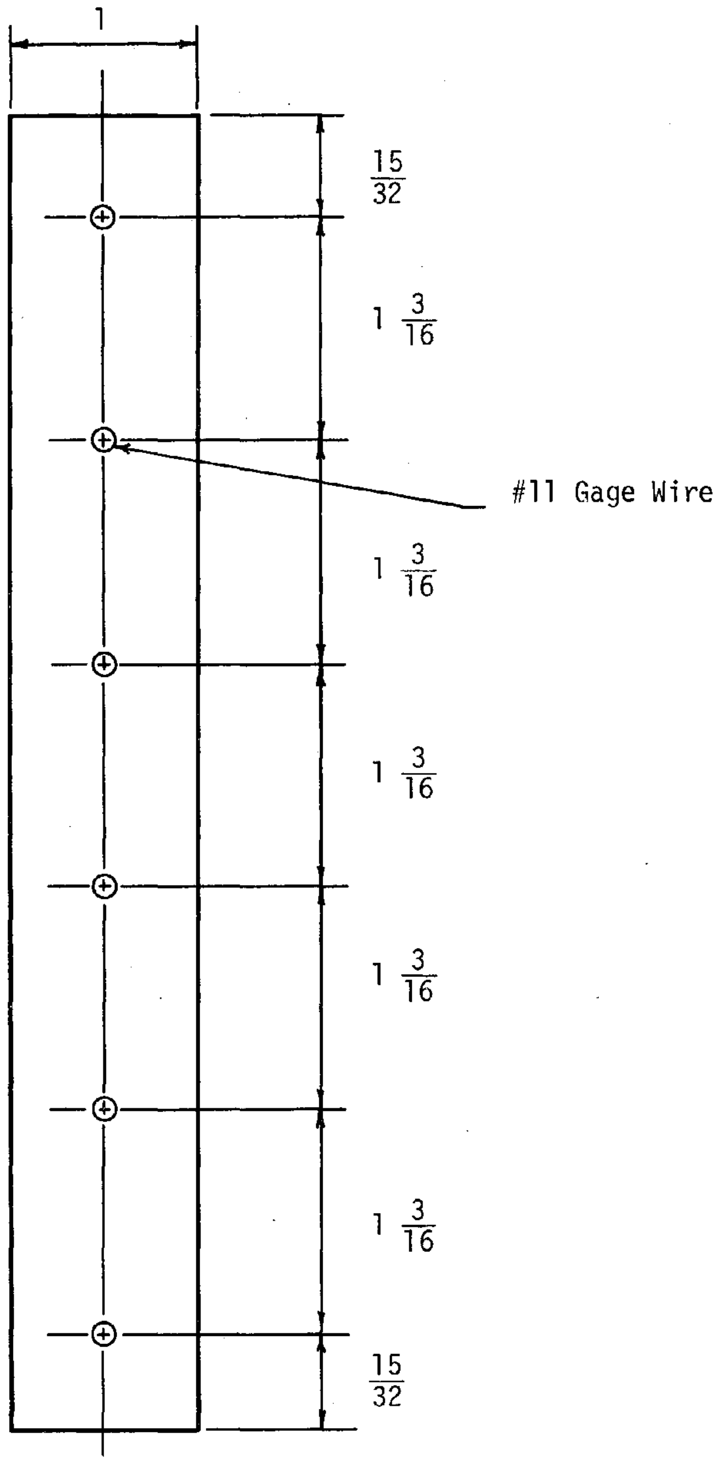


Figure A.19 Nominal Cross-Section of Pier

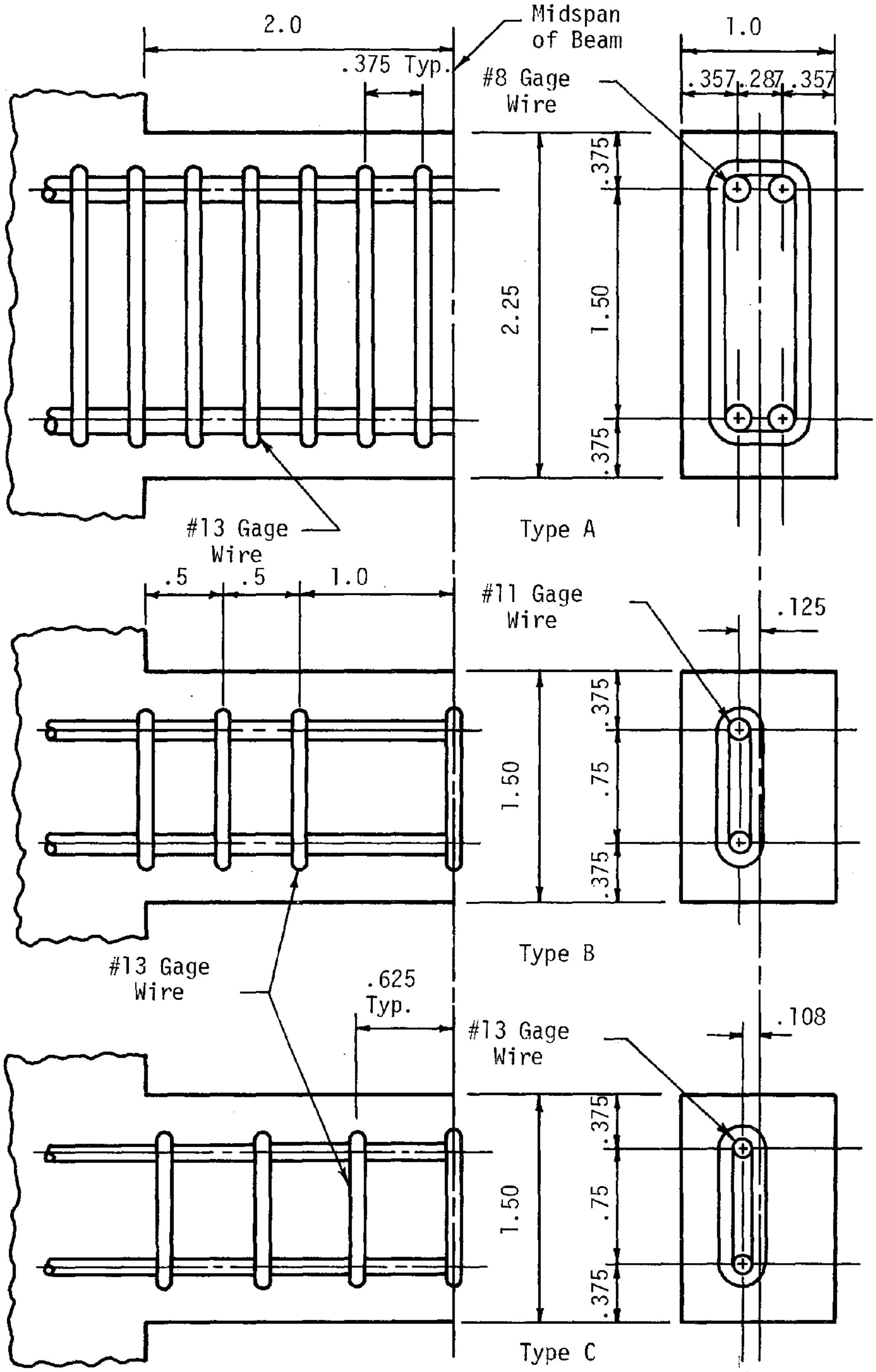


Figure A.20 Details of Connecting Beams

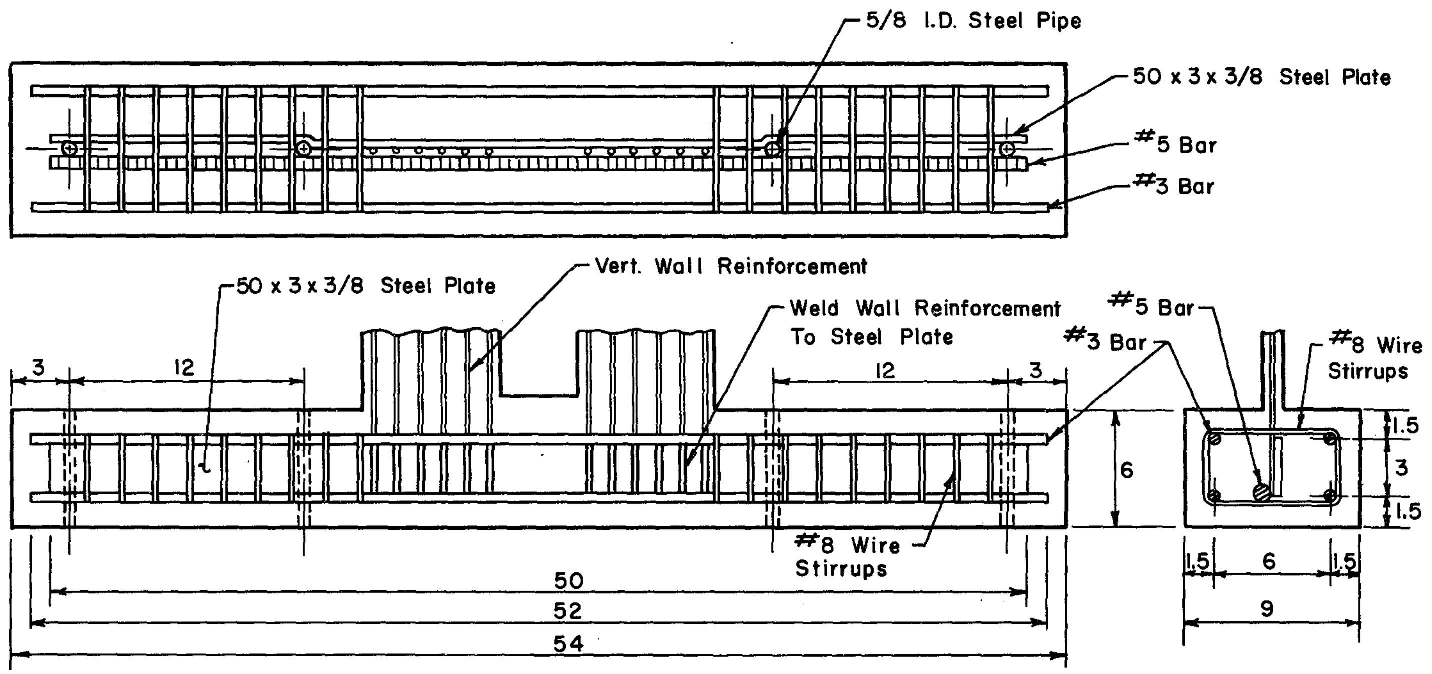
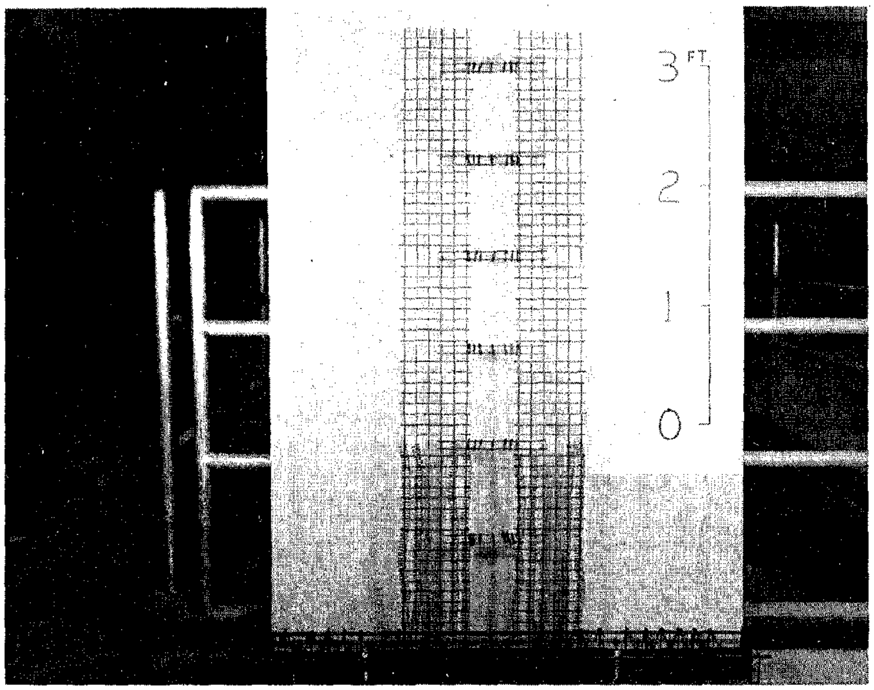


Figure A.21 Detail of Specimen Base



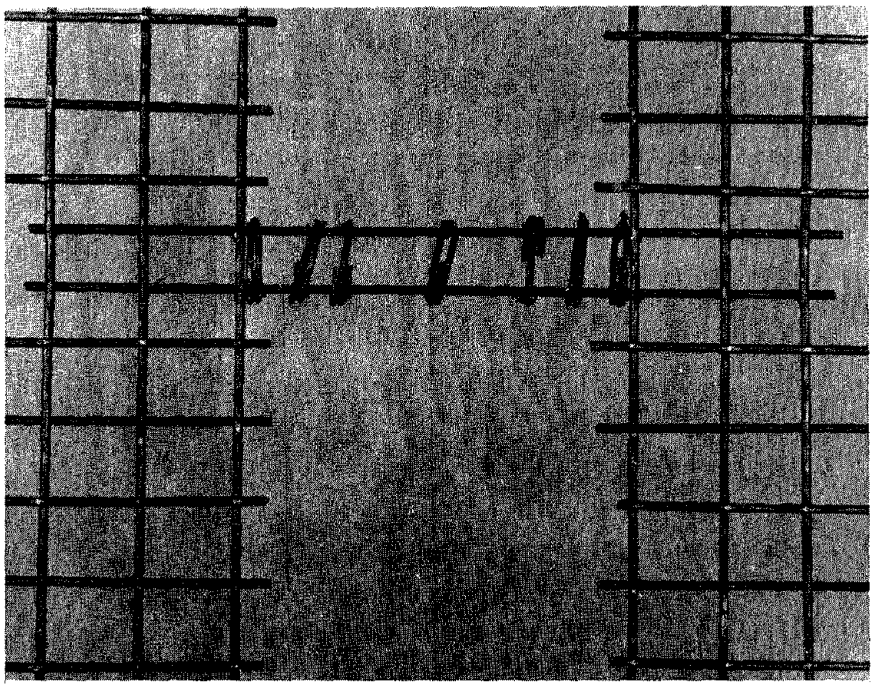
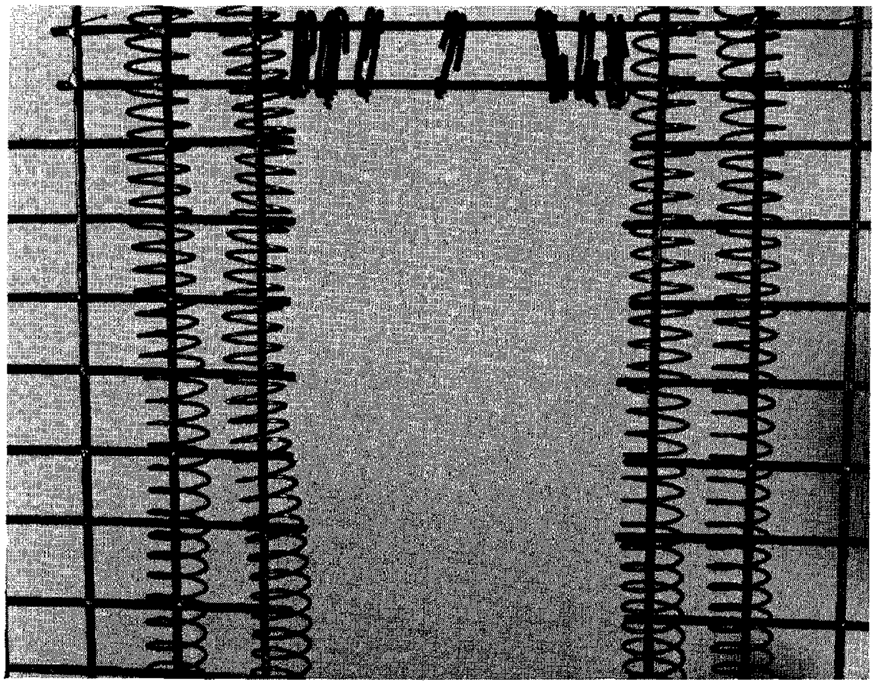


Figure A.22 Steel Cages



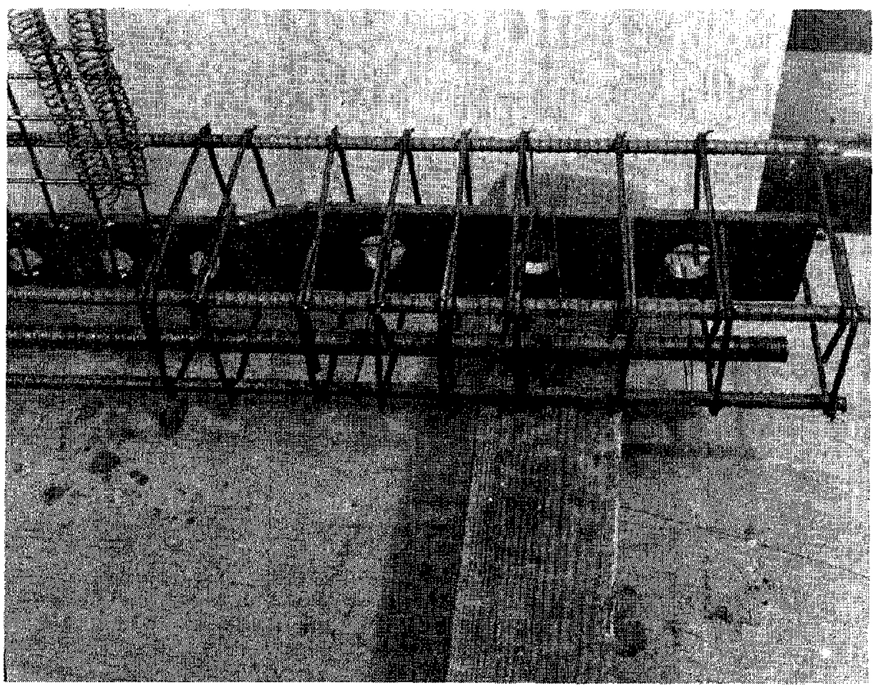
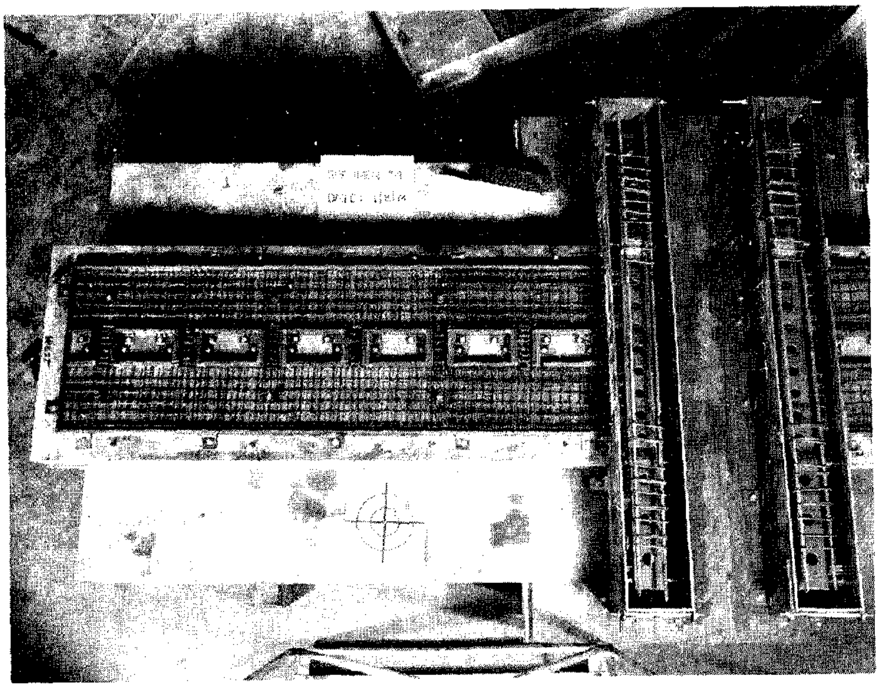


Figure A.22 (continued.) Steel Cages



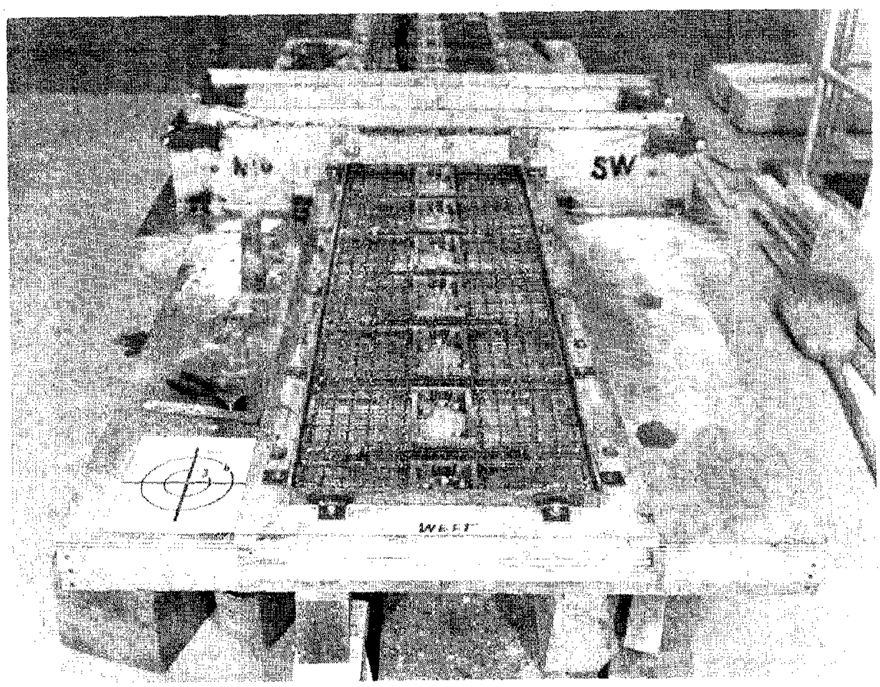
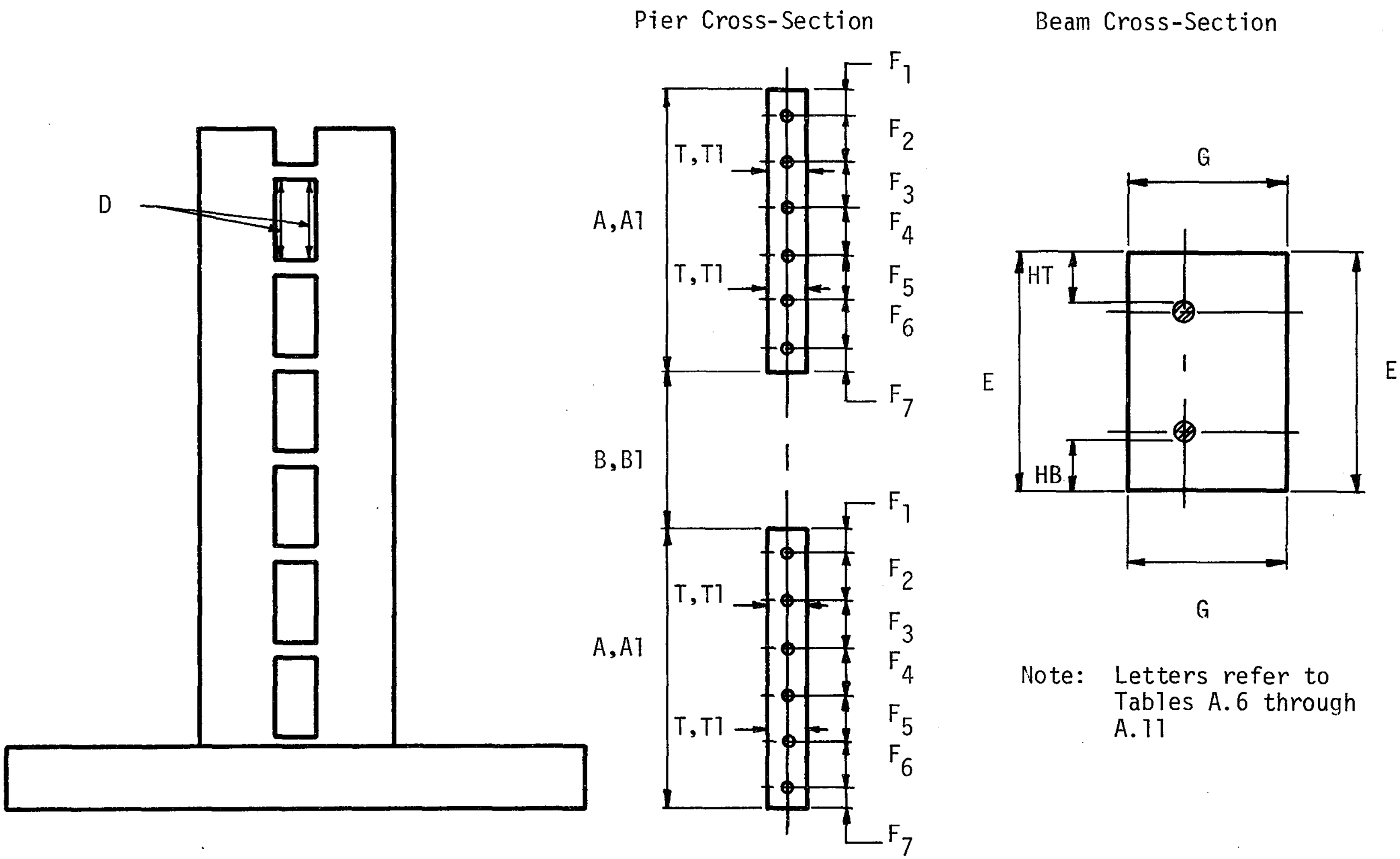


Figure A.23 Formwork for Casting



Note: Letters refer to Tables A.6 through A.11

Figure A.24 Identification of Measured Dimensions of Test Structure

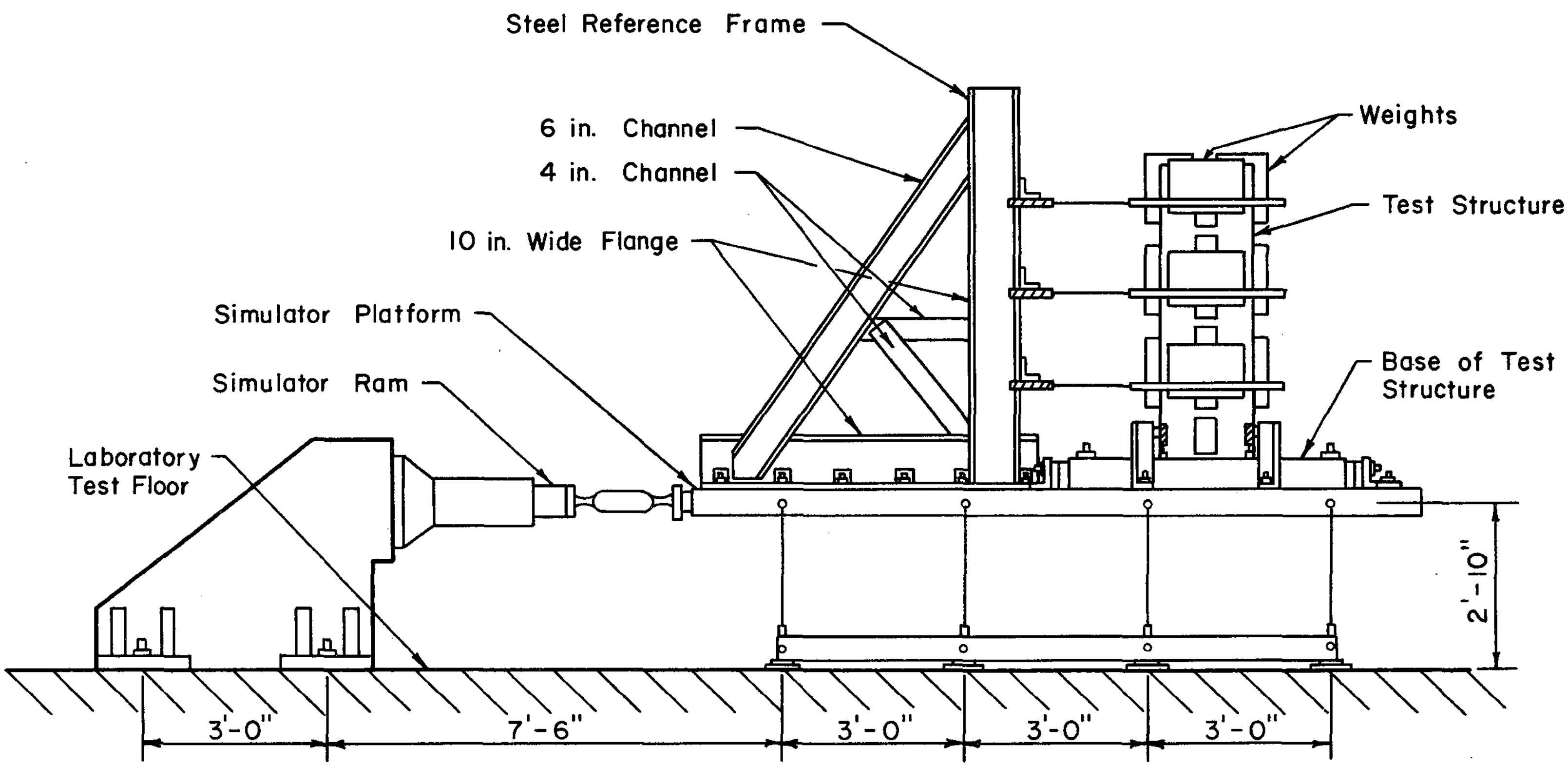


Figure A.25 Overall Configuration of Dynamic Test Setup

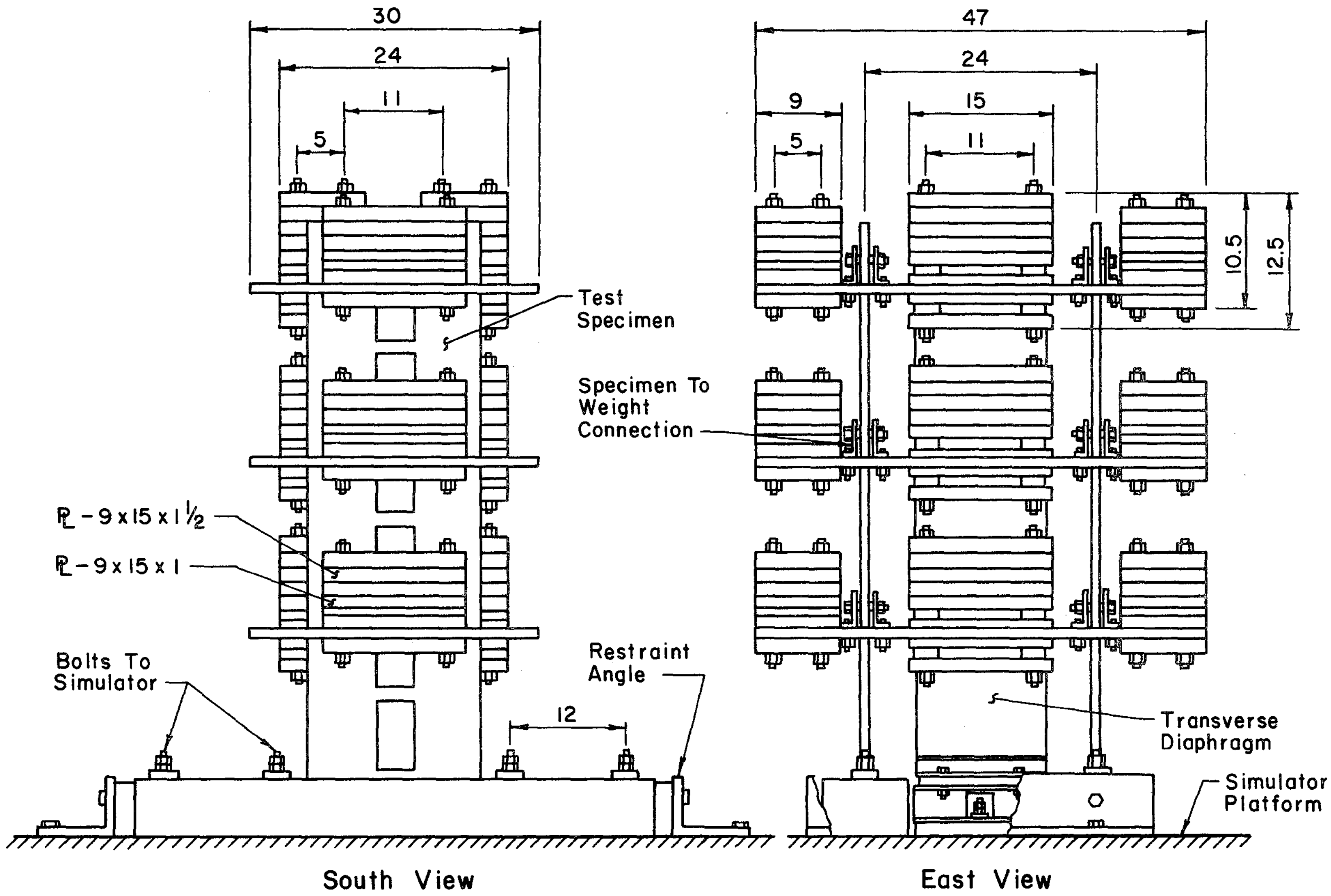


Figure A.26 Test Structure Including Steel Weights

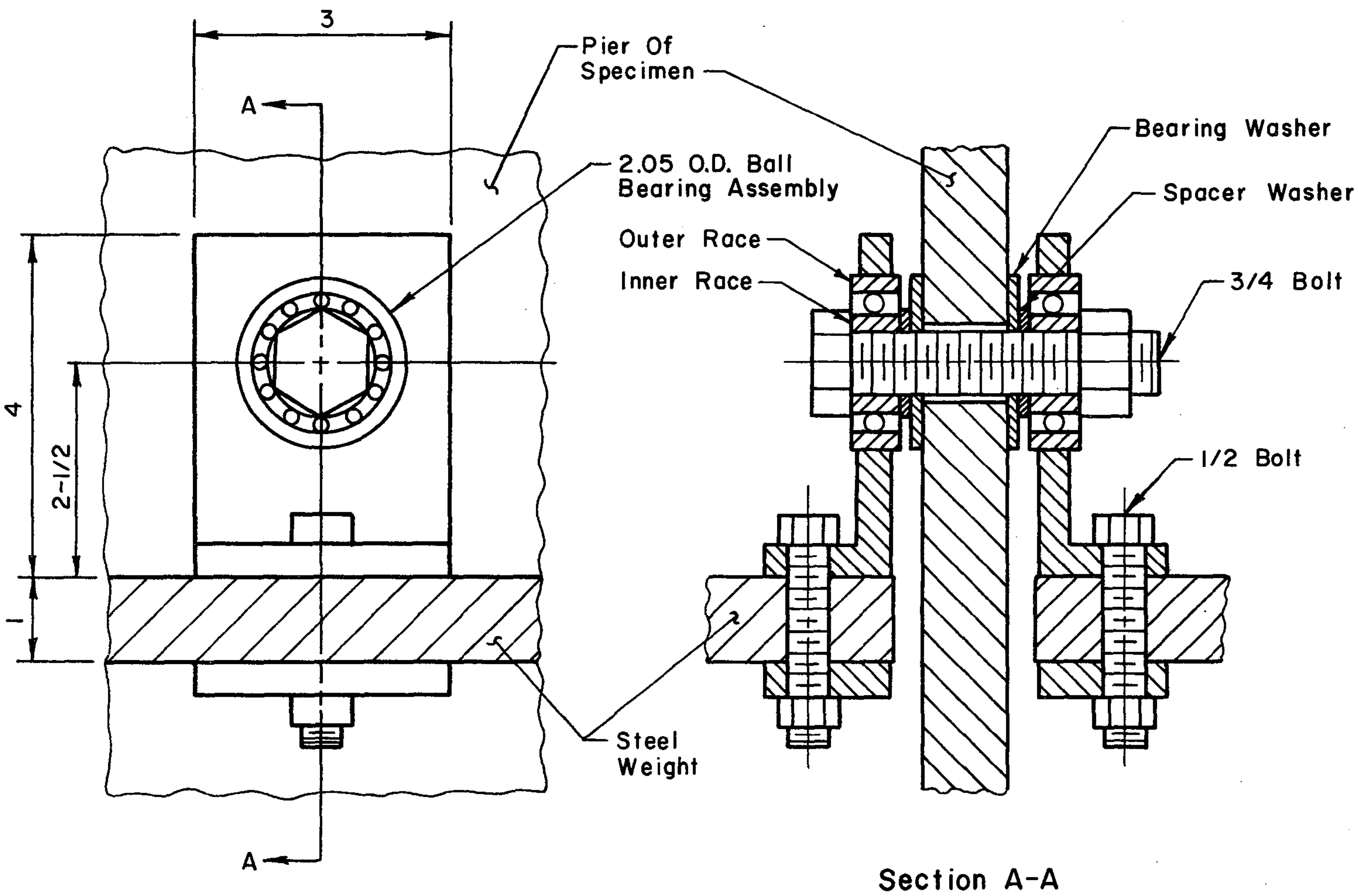


Figure A.27 Detail of Connection Between Steel Weight and Wall

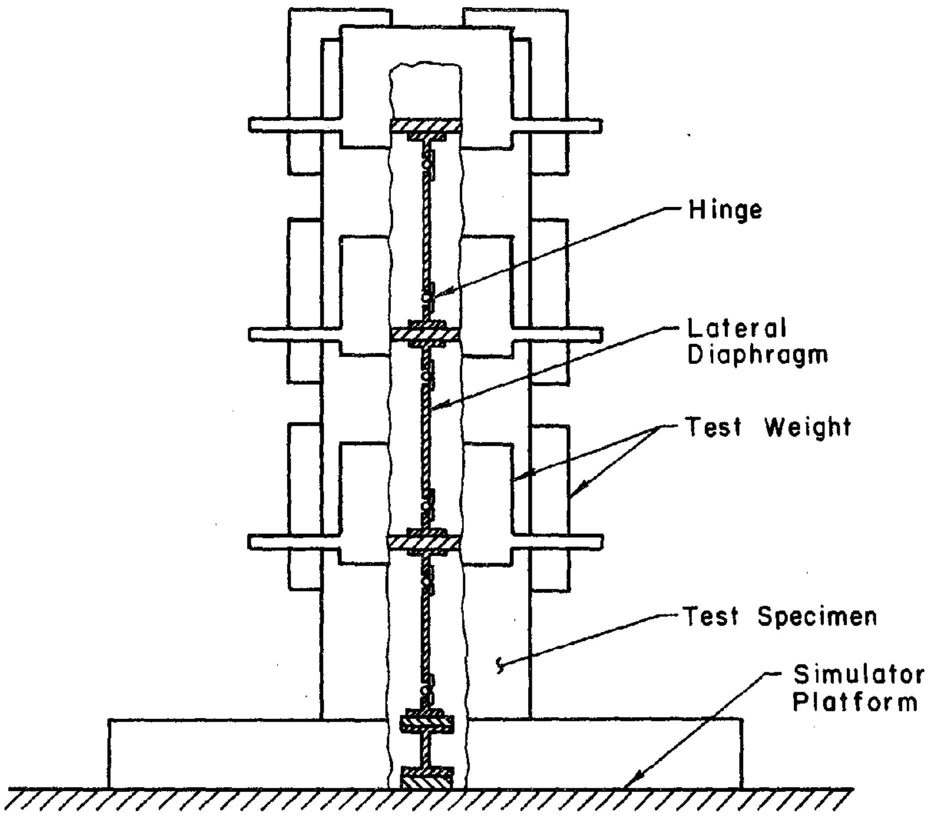


Figure A.28 Lateral Diaphragms

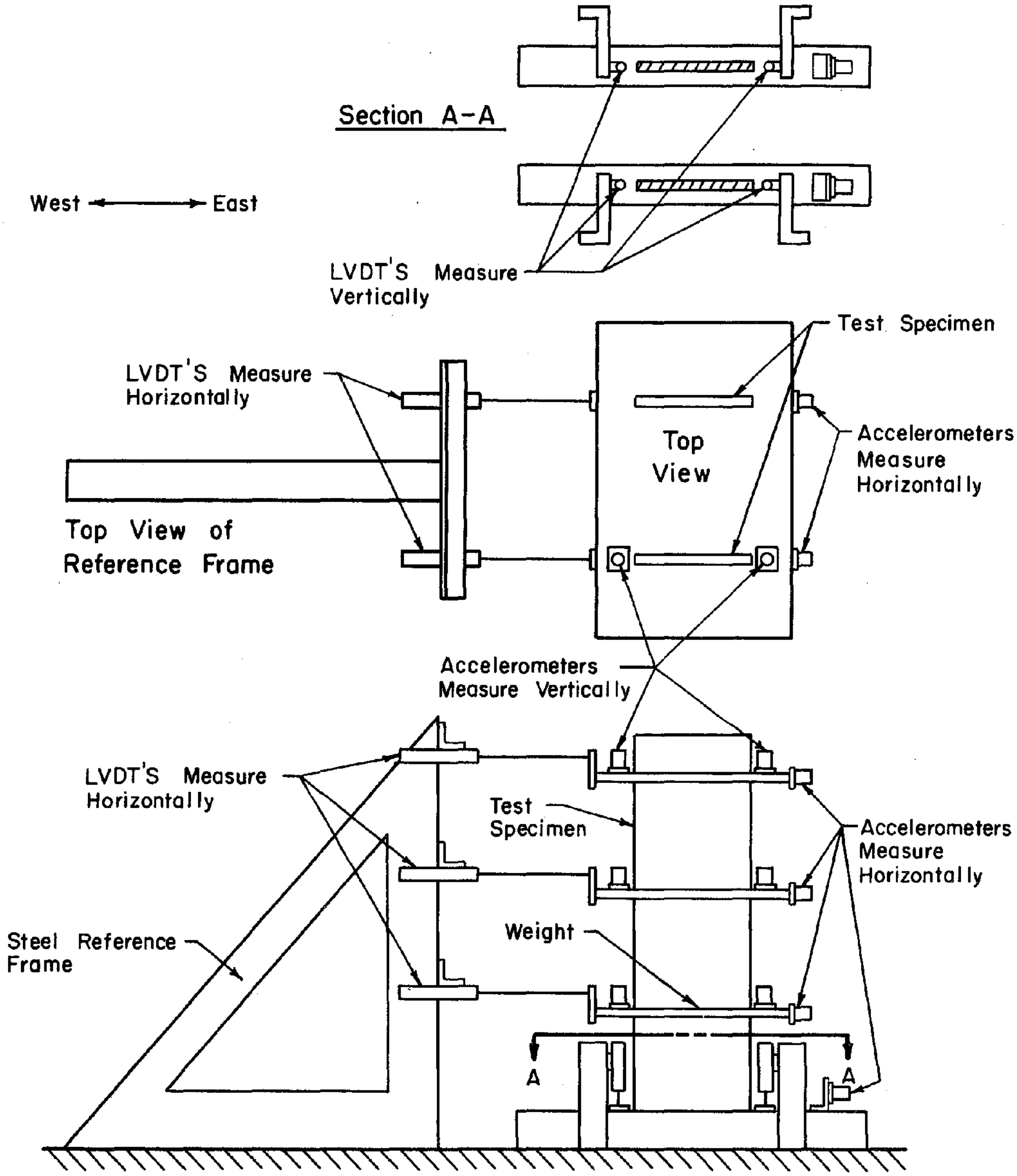
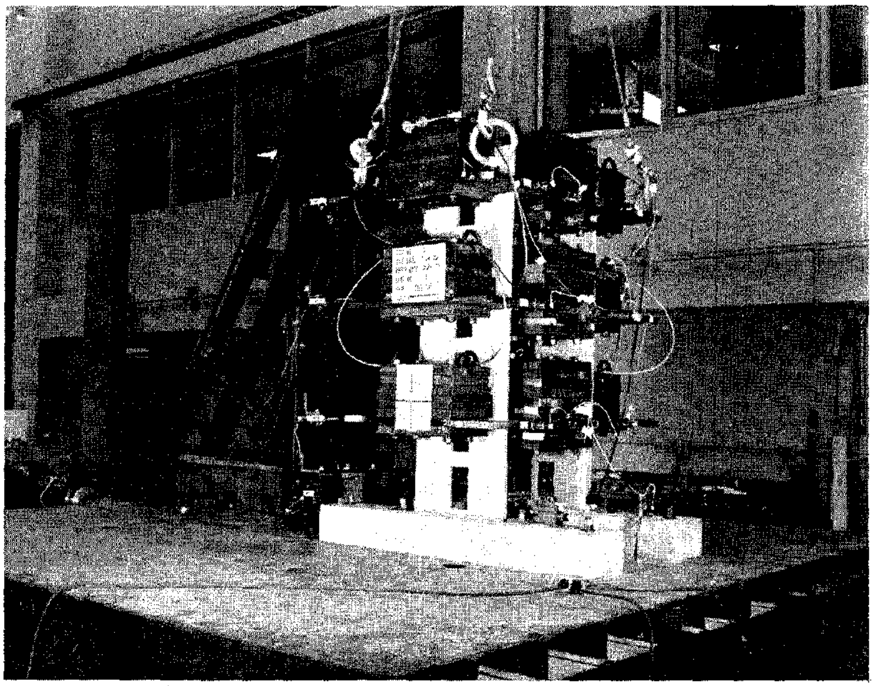


Figure A.29 Dynamic Test Instrumentation



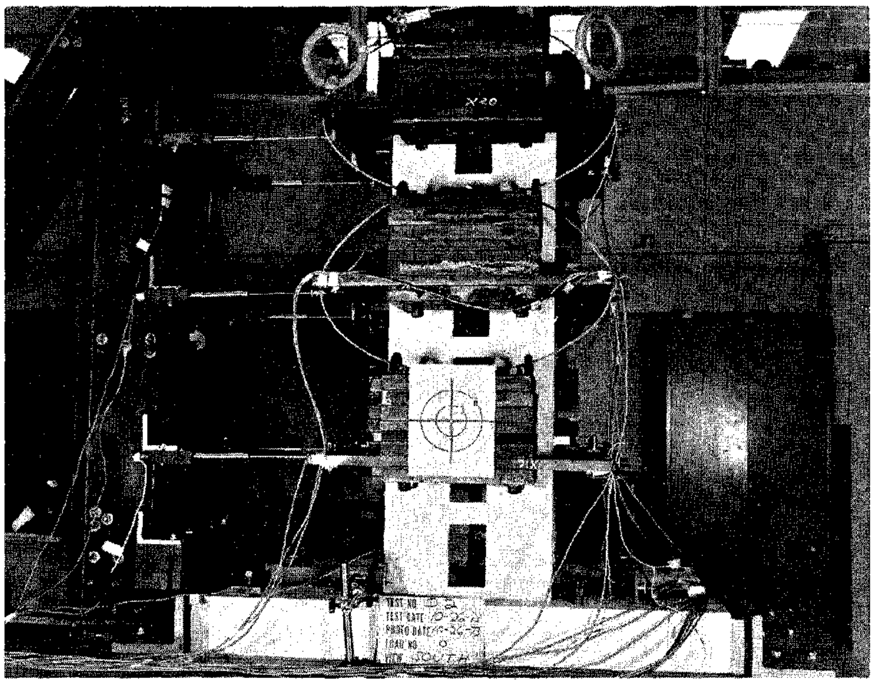
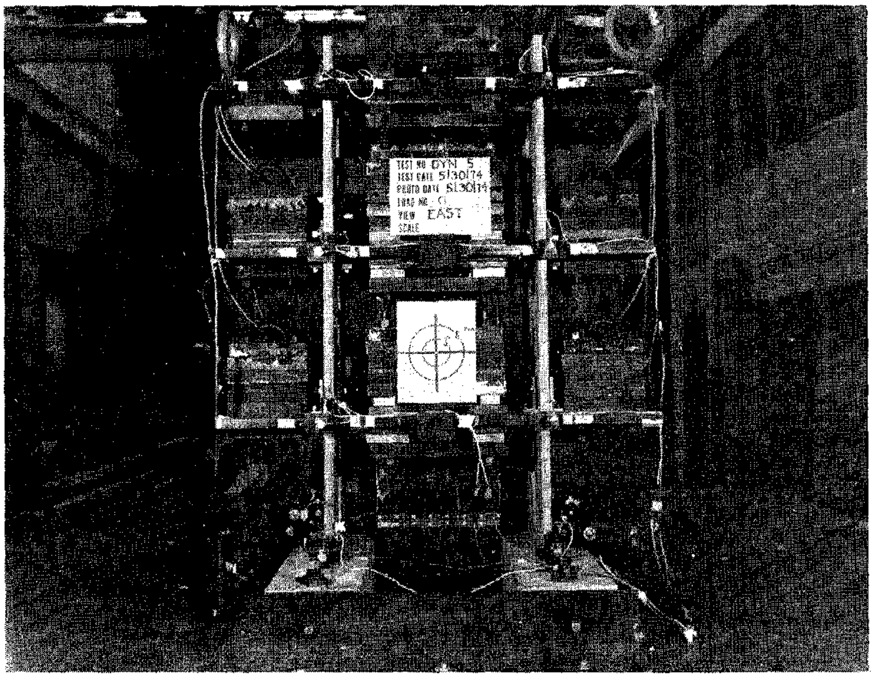


Figure A.30 Dynamic Test Setup



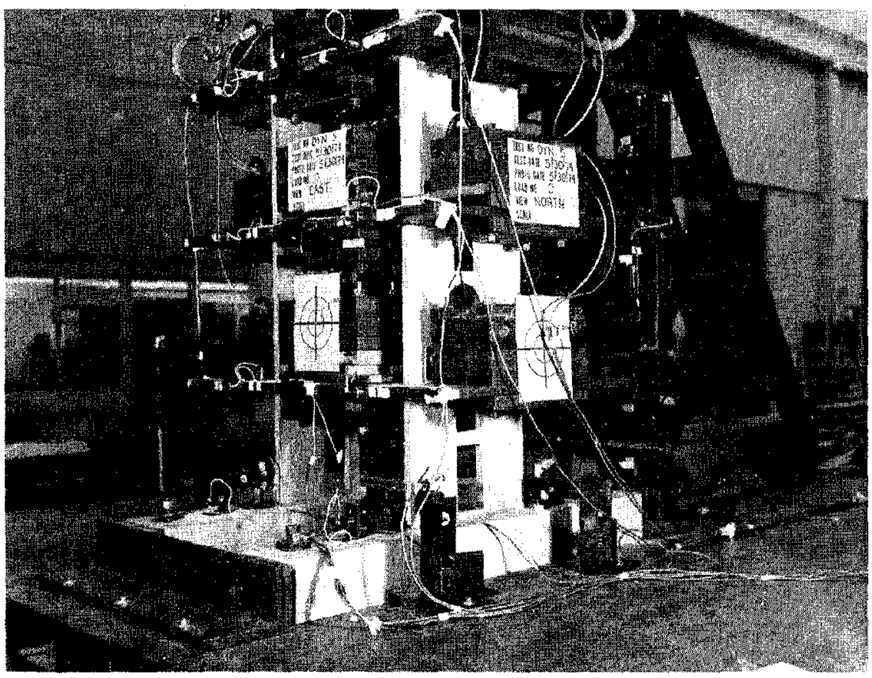
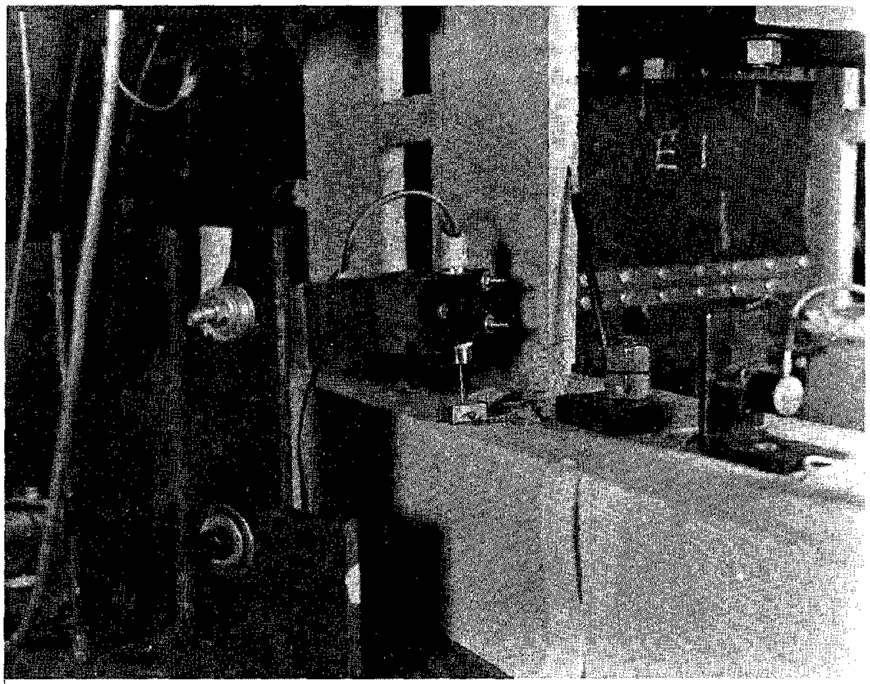


Figure A.30 (contd.) Dynamic Test Setup



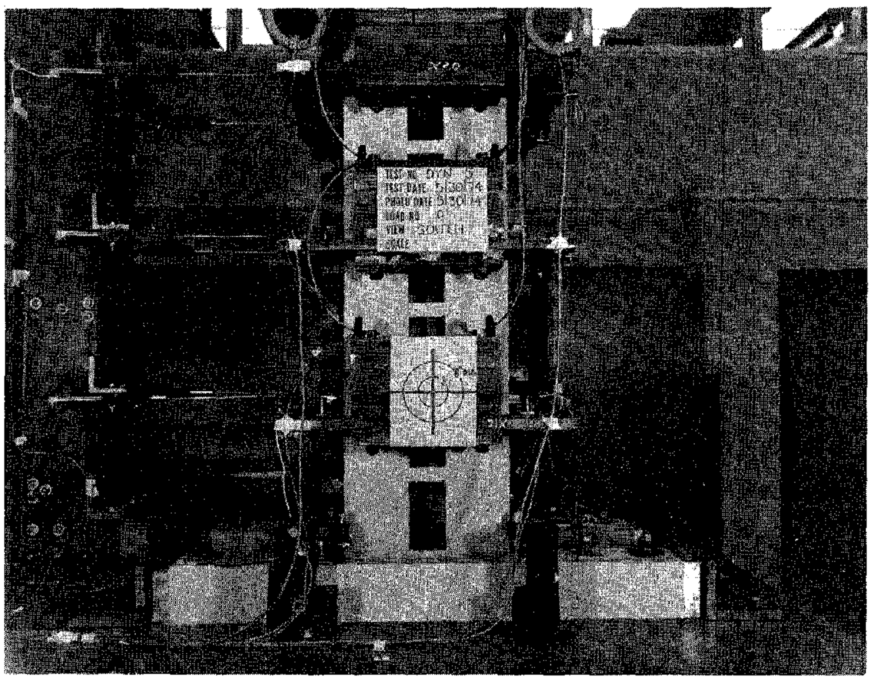


Figure A.30 (contd.) Dynamic Test Setup

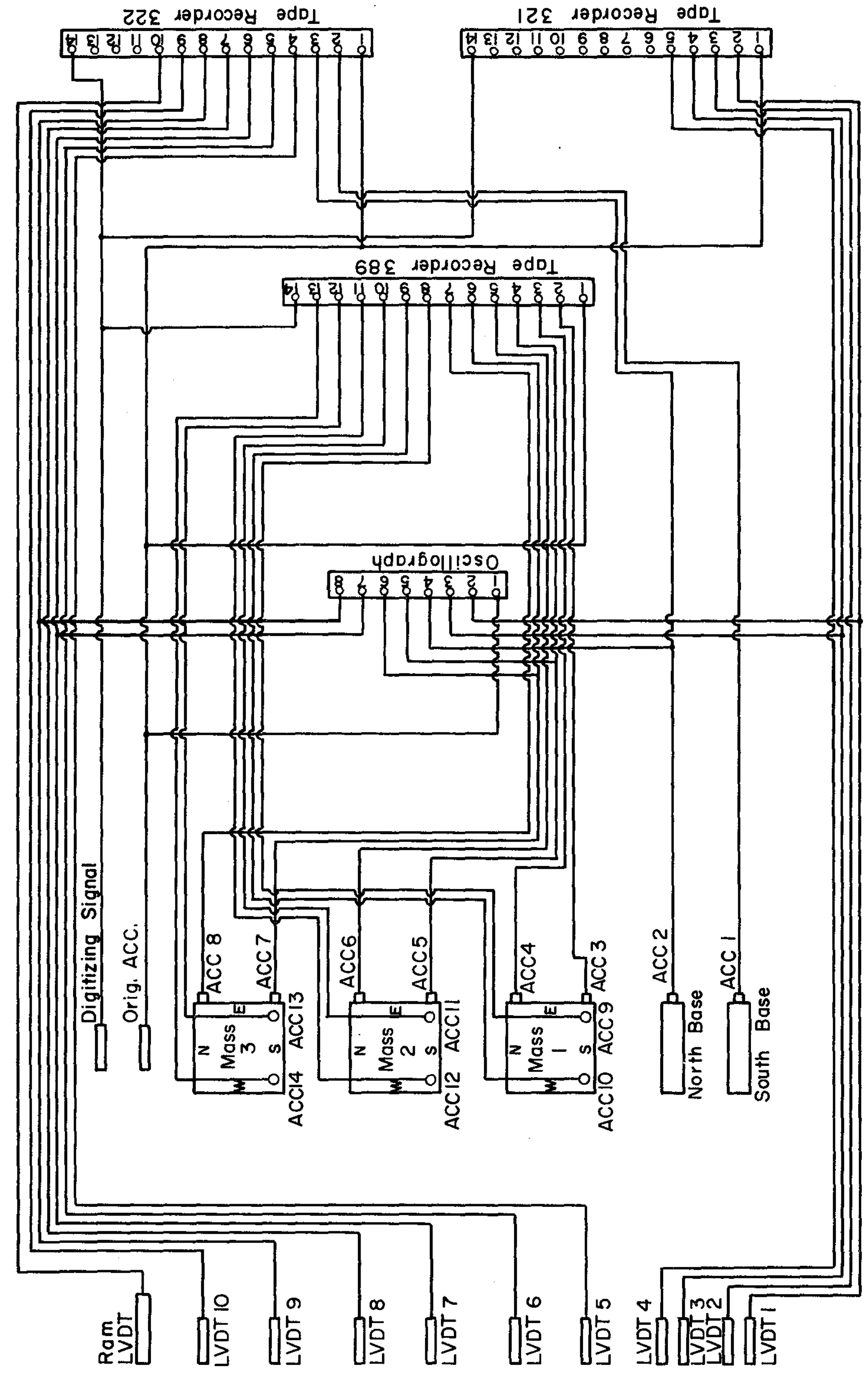


Figure A.31 Data Recording Scheme for Dynamic Tests

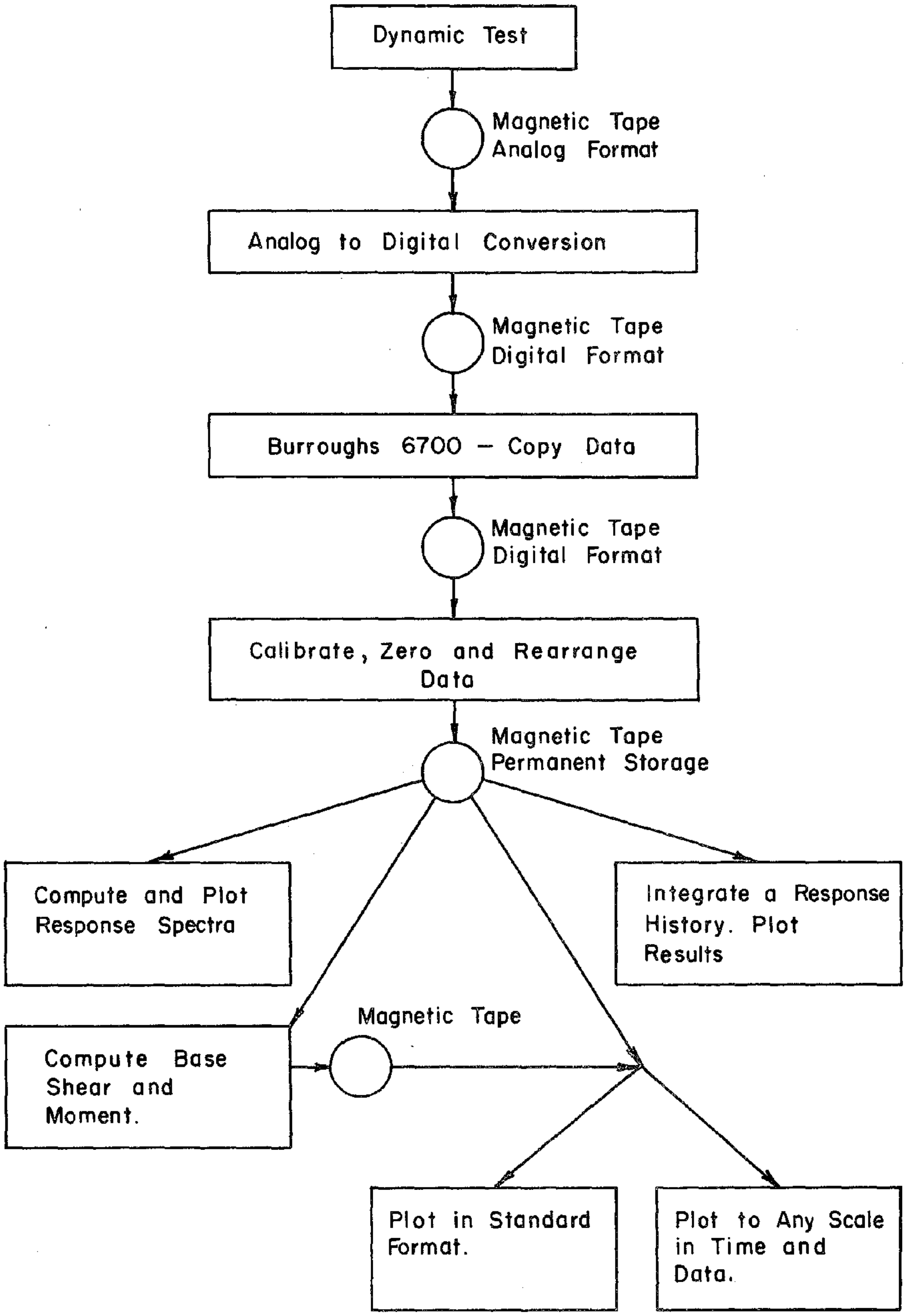


Figure A.32 Outline of Dynamic Test Data Reduction

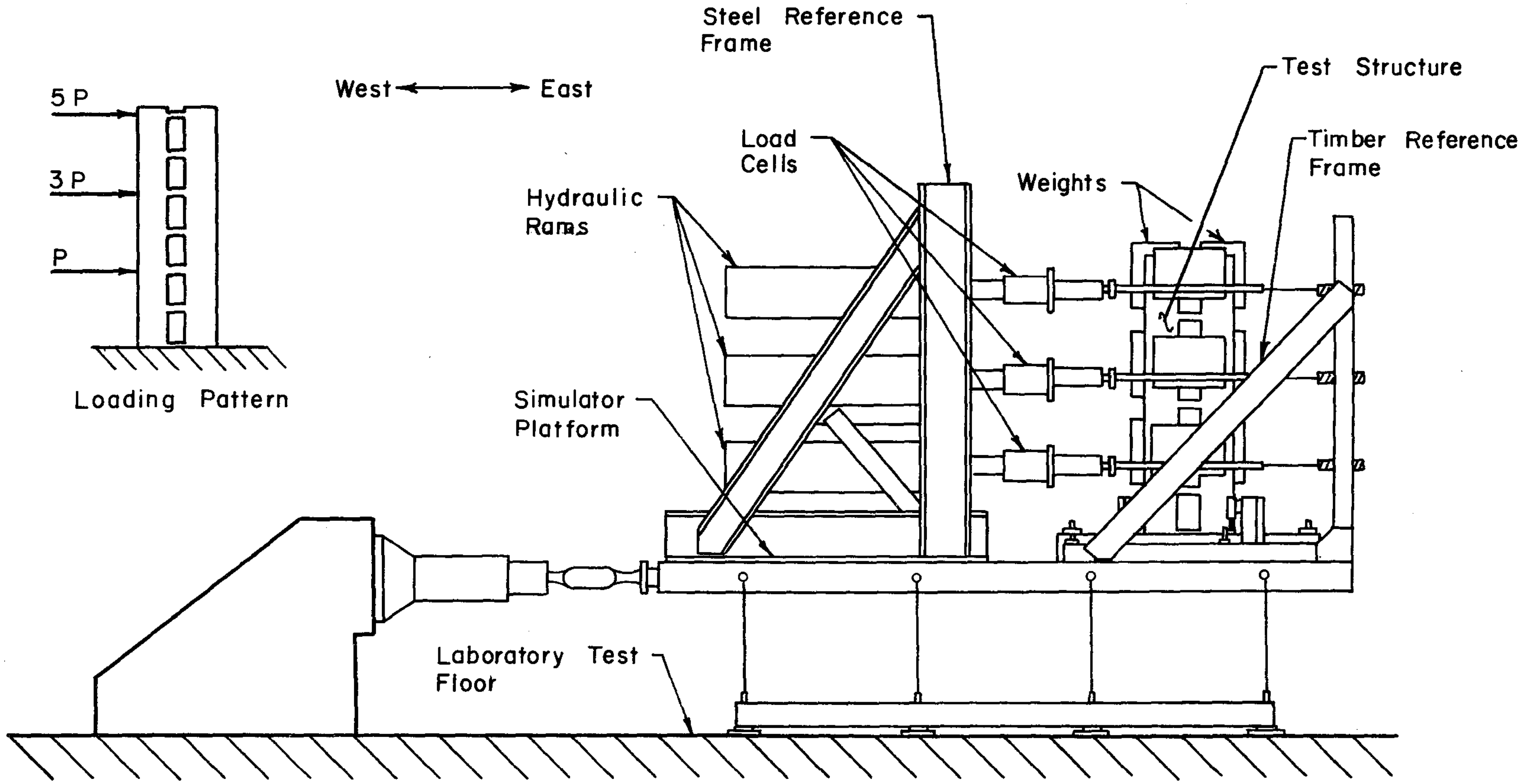


Figure A.33 Overall Configuration of Static Test Setup

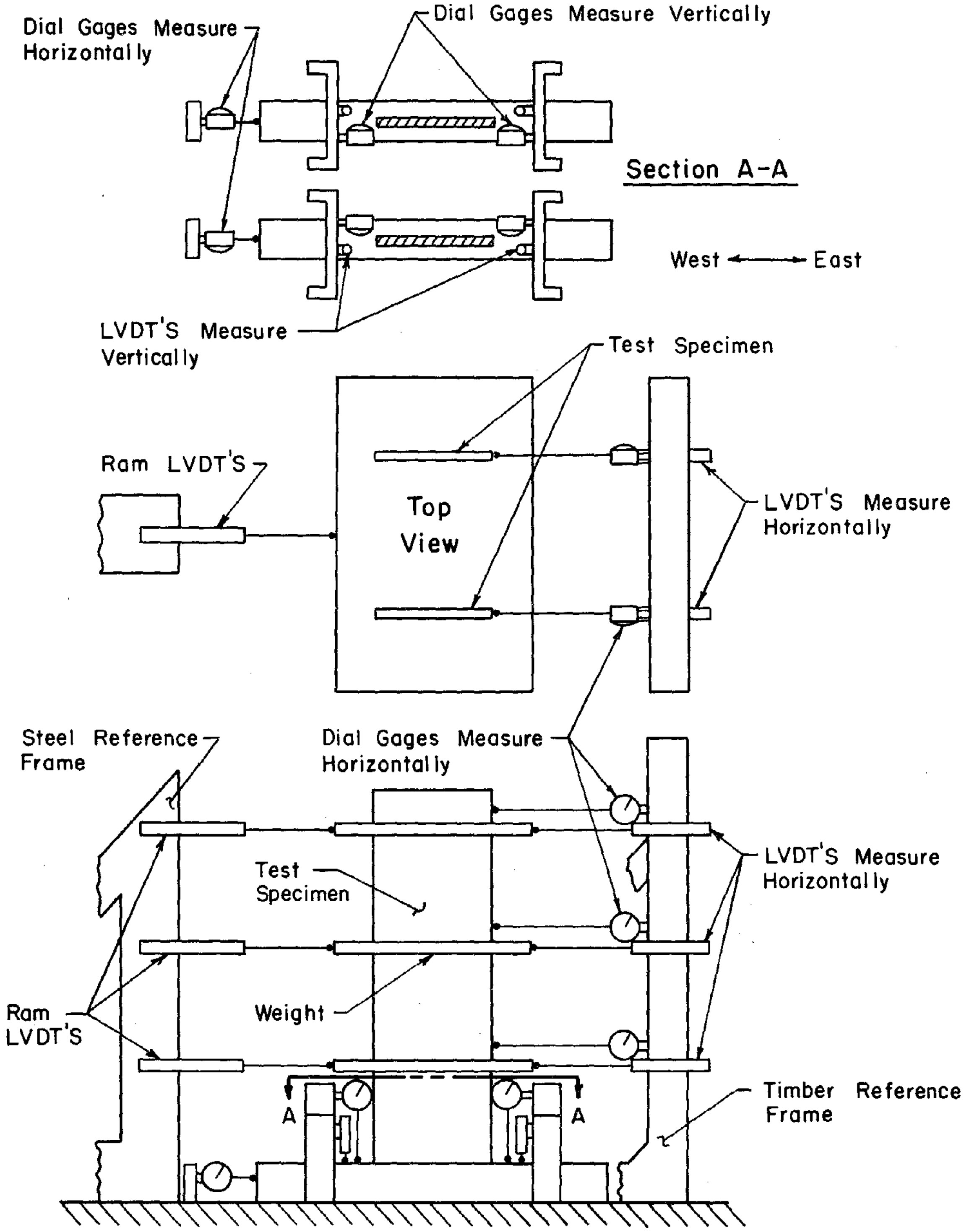
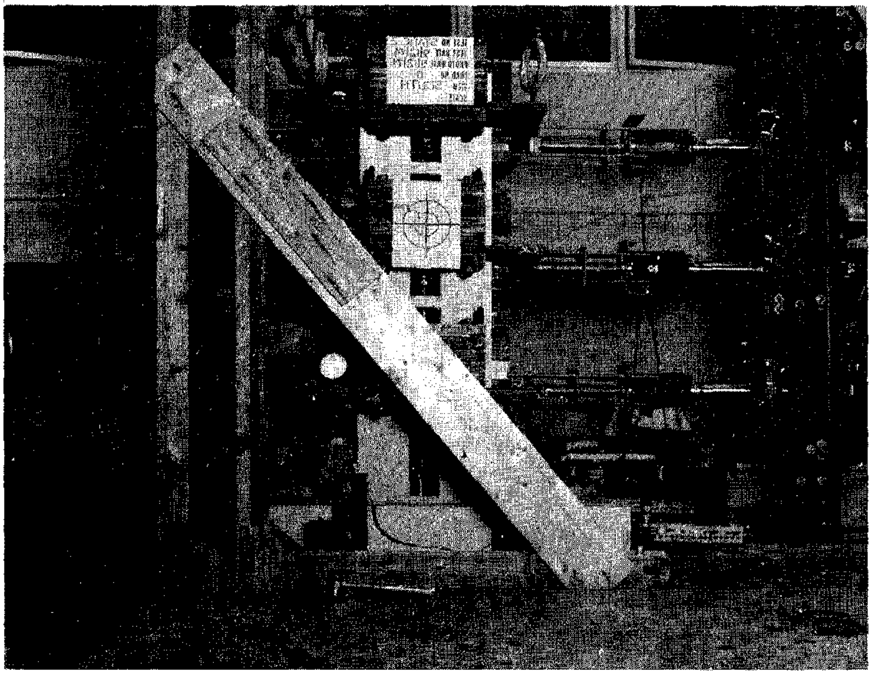


Figure A.34 Static Test Instrumentation



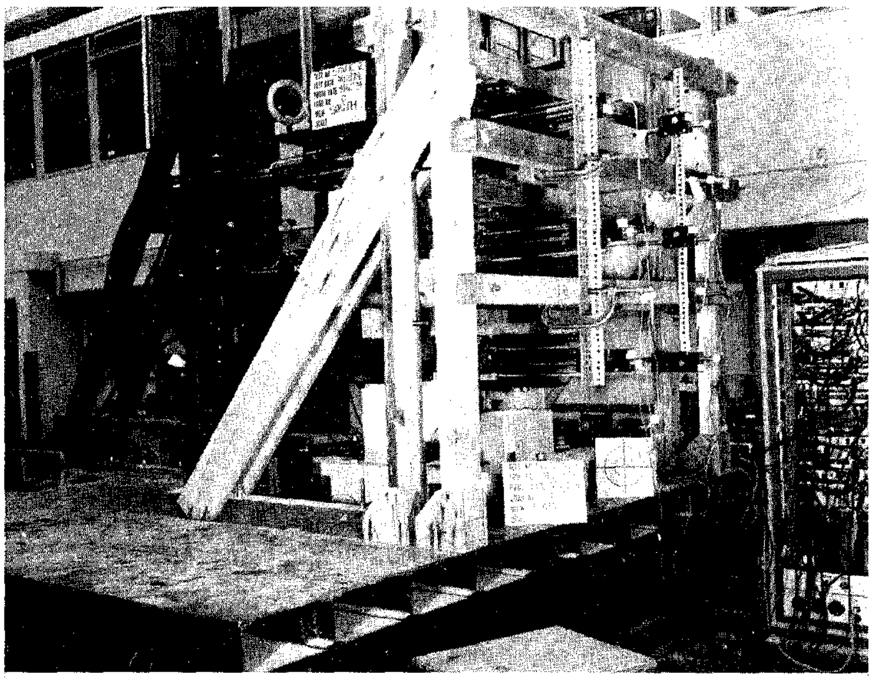


Figure A.35 Static Test Setup

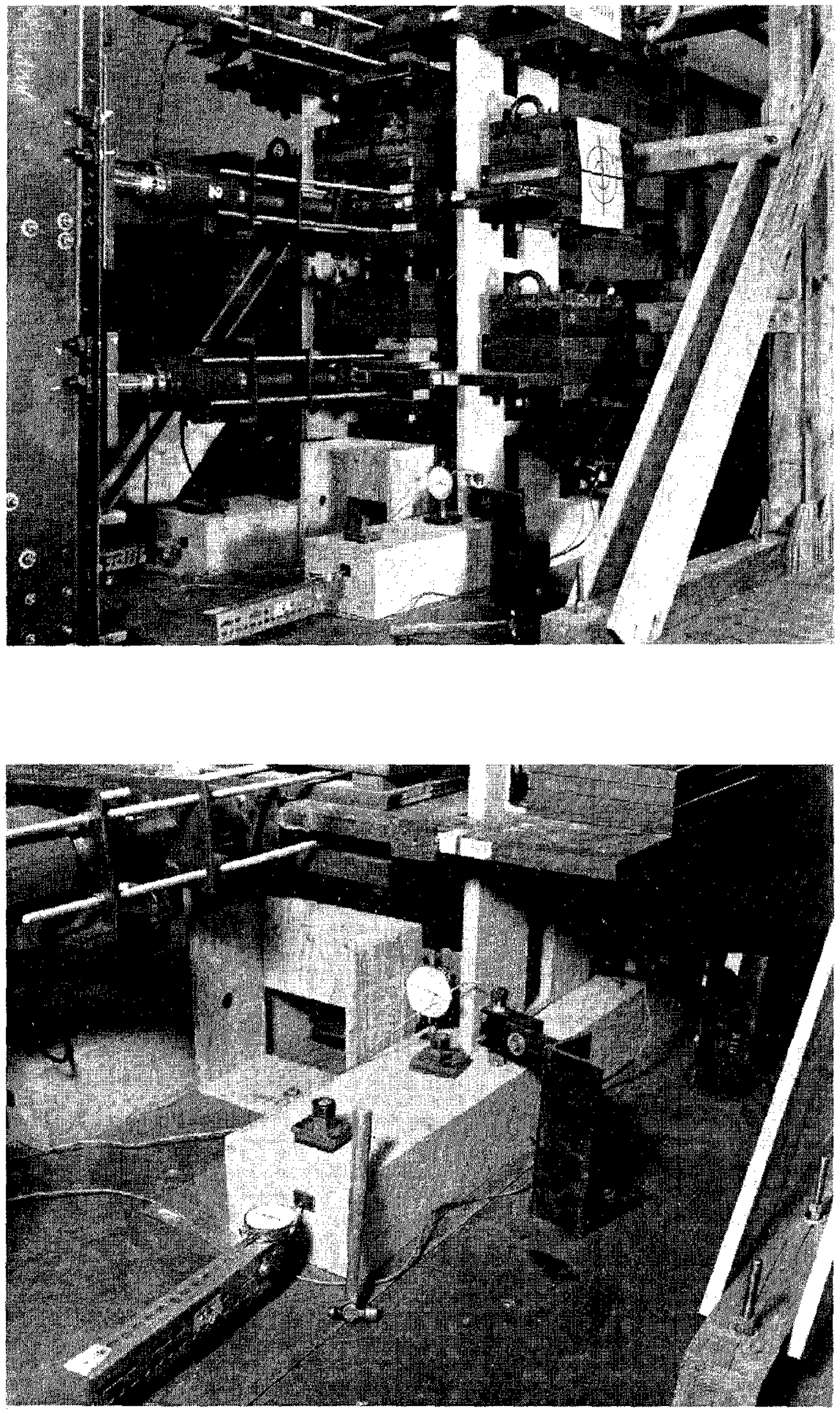
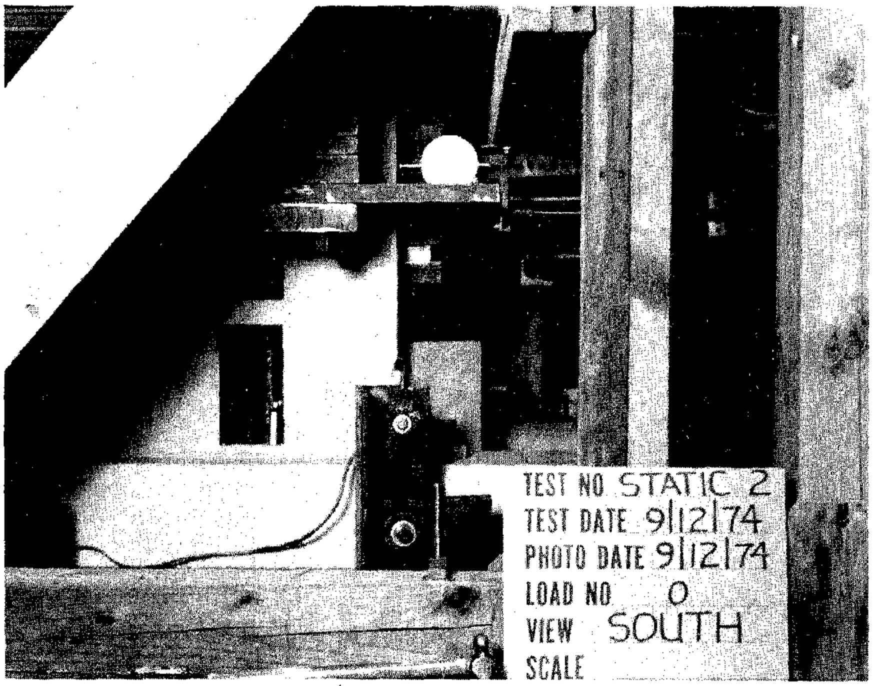


Figure A.35 (contd.) Static Test Setup



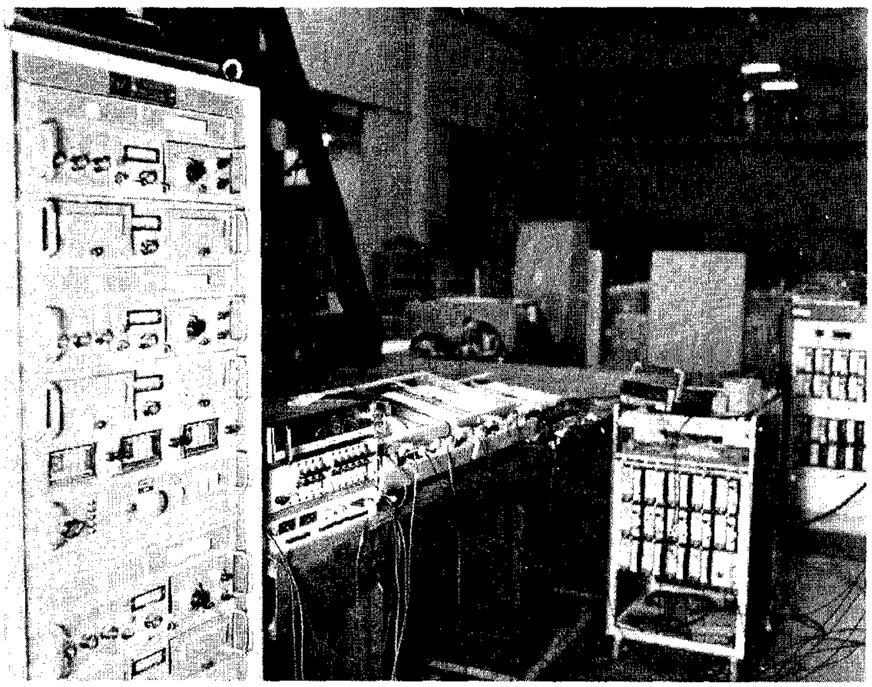


Figure A.35 (contd.) Static Test Setup

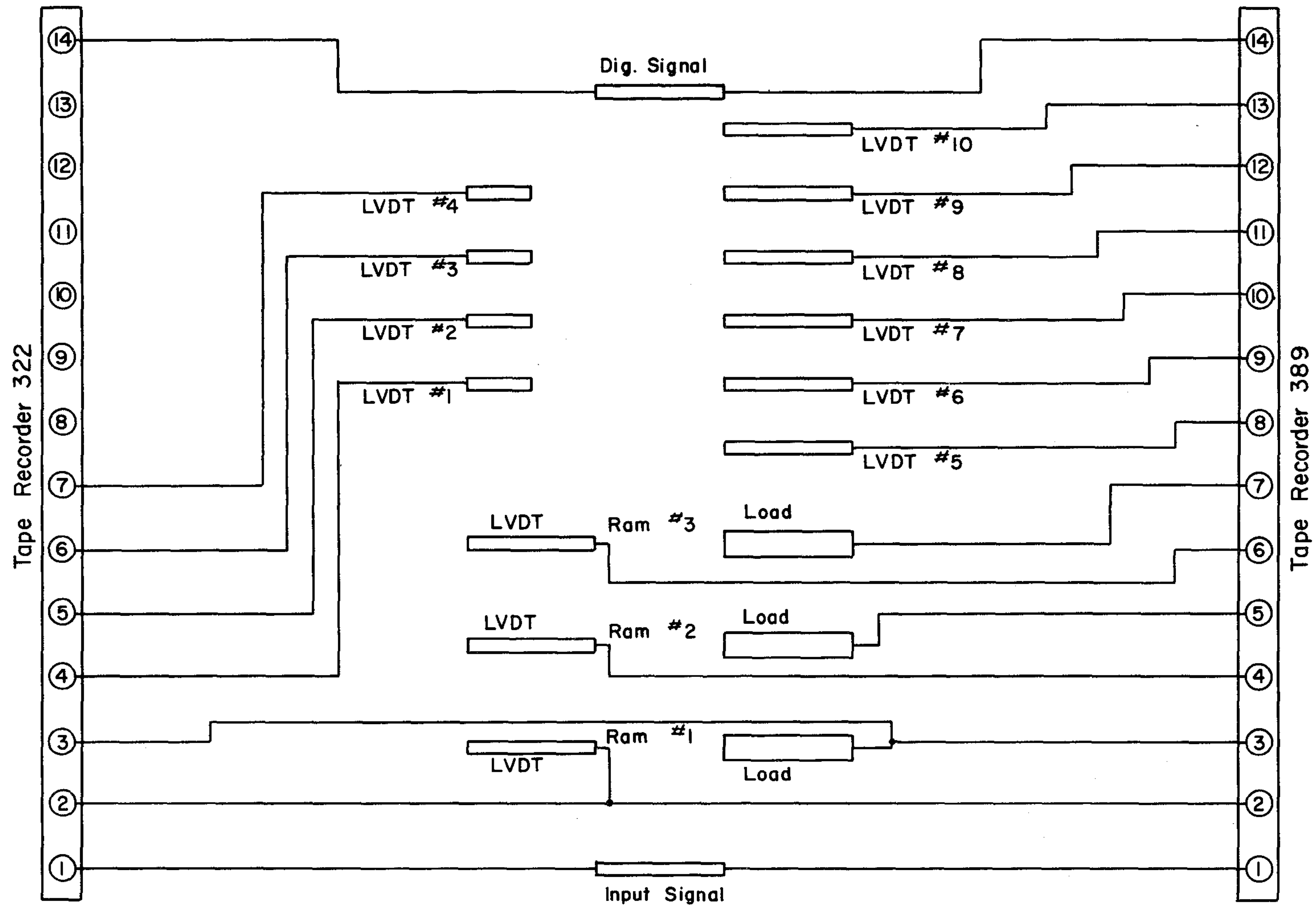


Figure A.36 Data Recording Scheme for Static Test

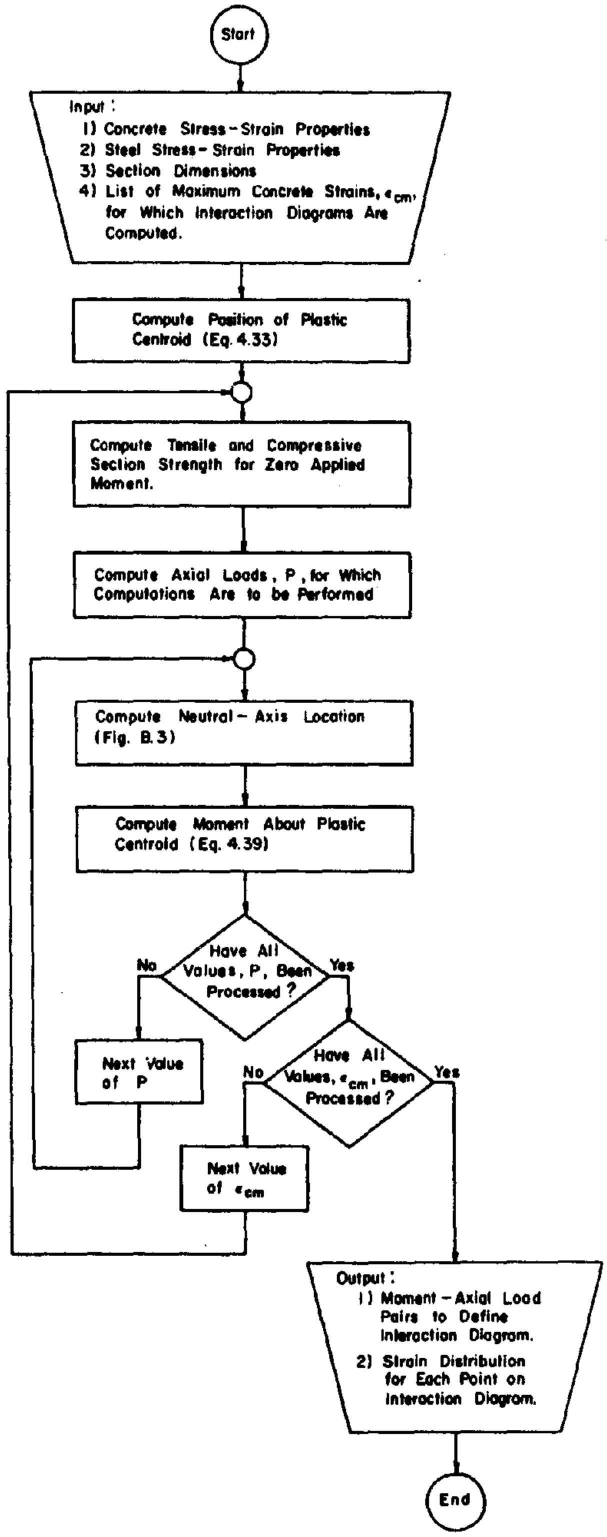


Figure B.1 Flowchart for Computer Program to Compute Moment-Axial Load Interaction Relation

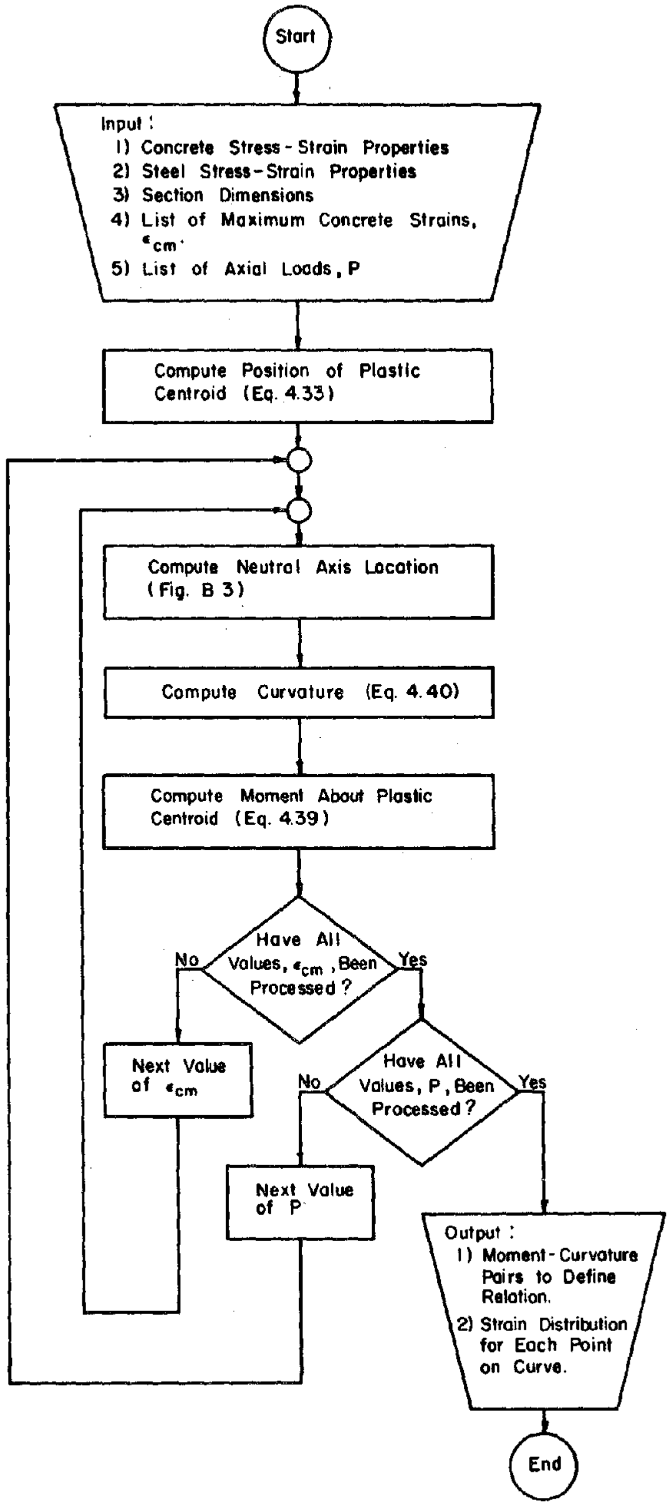


Figure B.2 Flowchart for Computer Program to Compute Moment-Curvature Relation

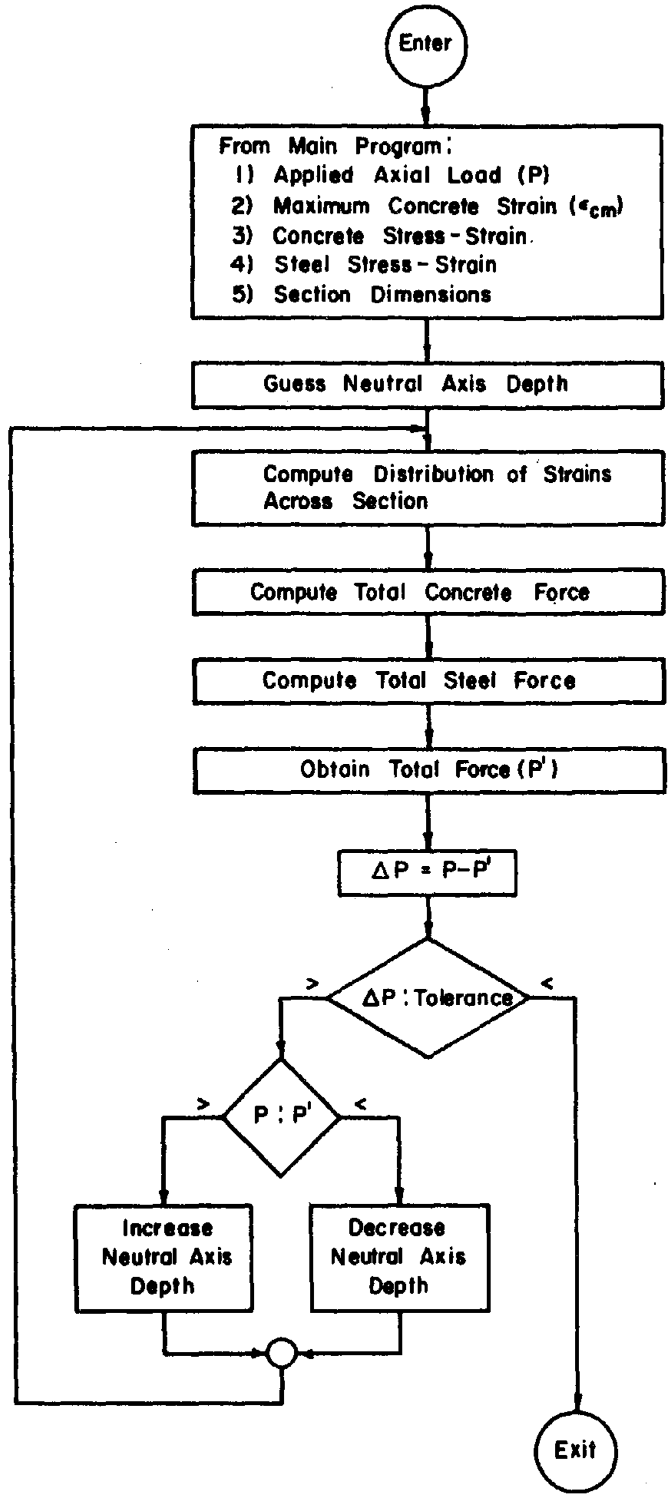


Figure B.3 Flowchart for Calculation Routine to Compute Neutral Axis Location

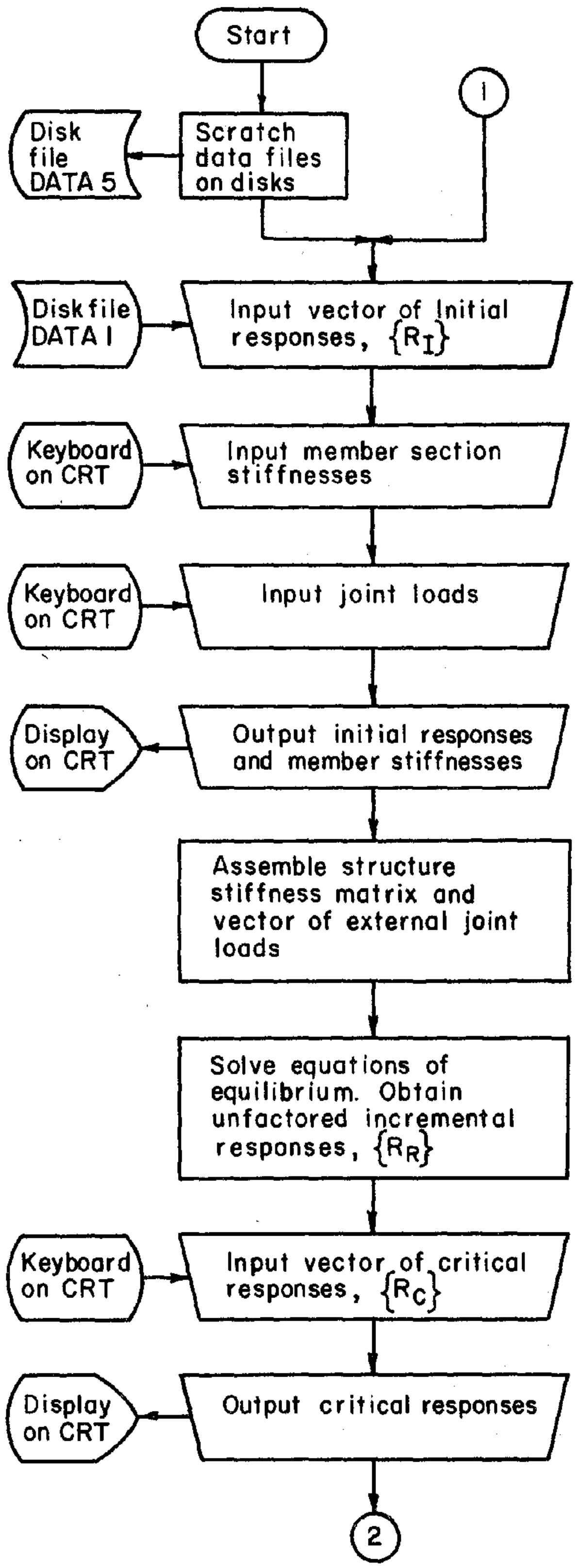


Figure C.1 Flowchart for Computer Program to Perform Calculations for Study of Static Hysteresis

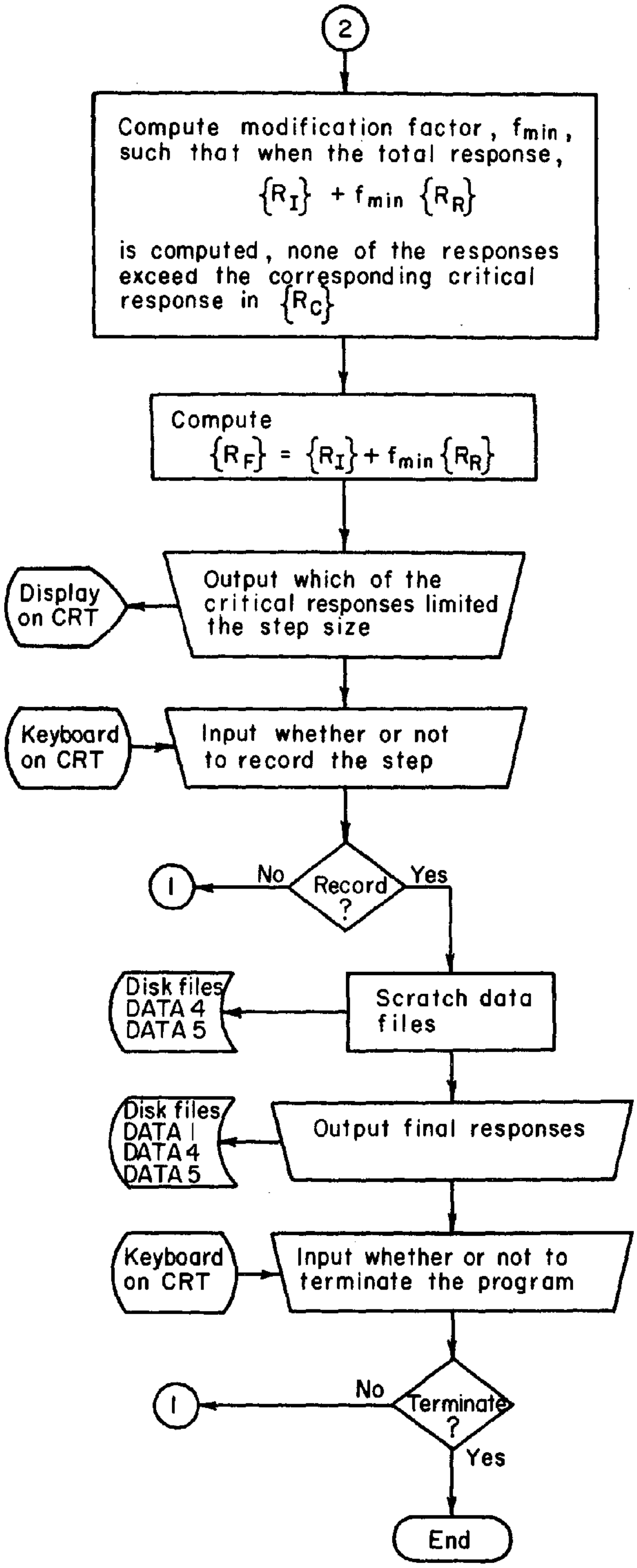


Figure C.1 (contd.) Flowchart for Computer Program to Perform Calculations for Study of Static Hysteresis

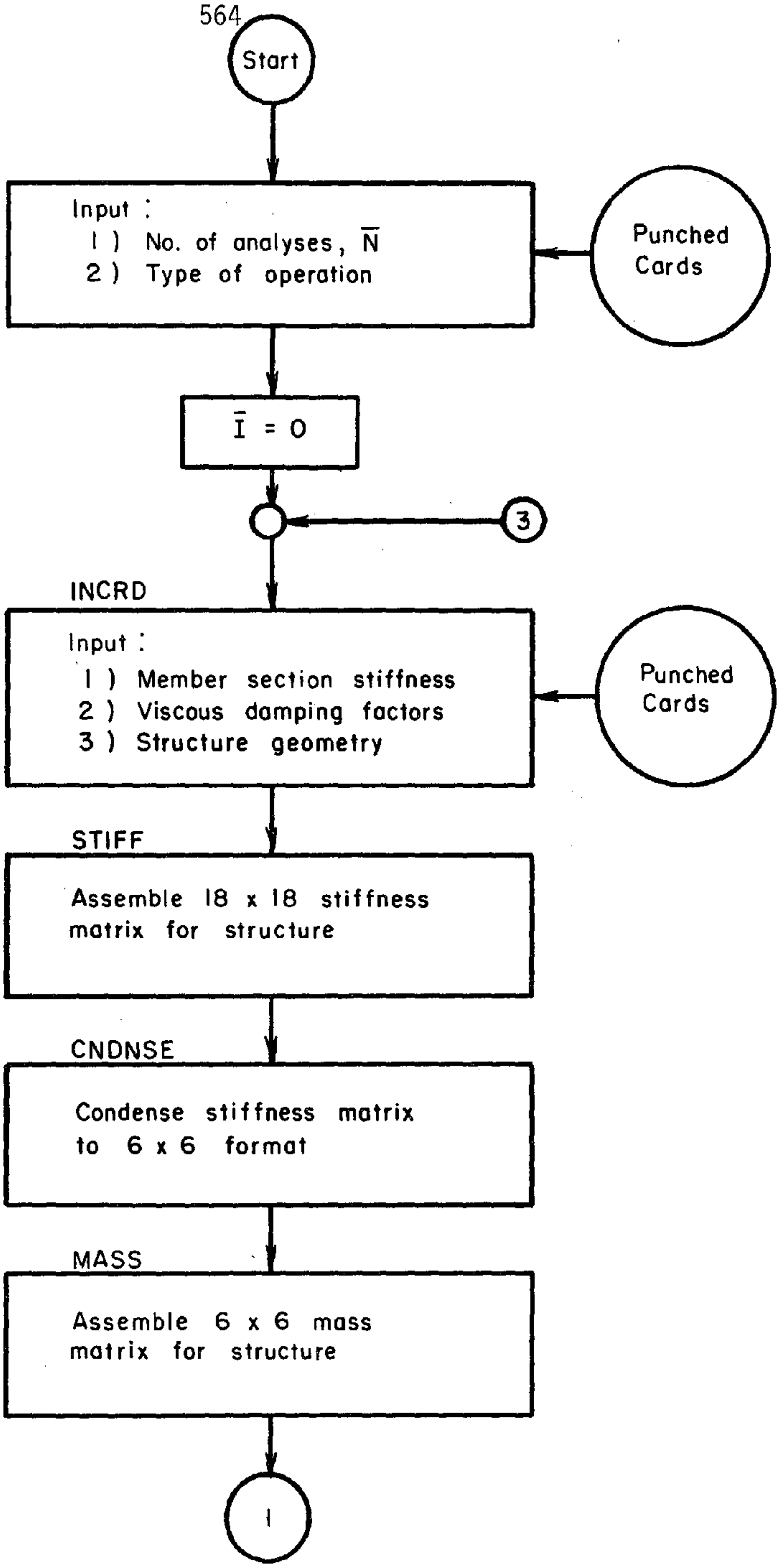


Figure D.1 Flowchart for Computer Program for Dynamic Analysis

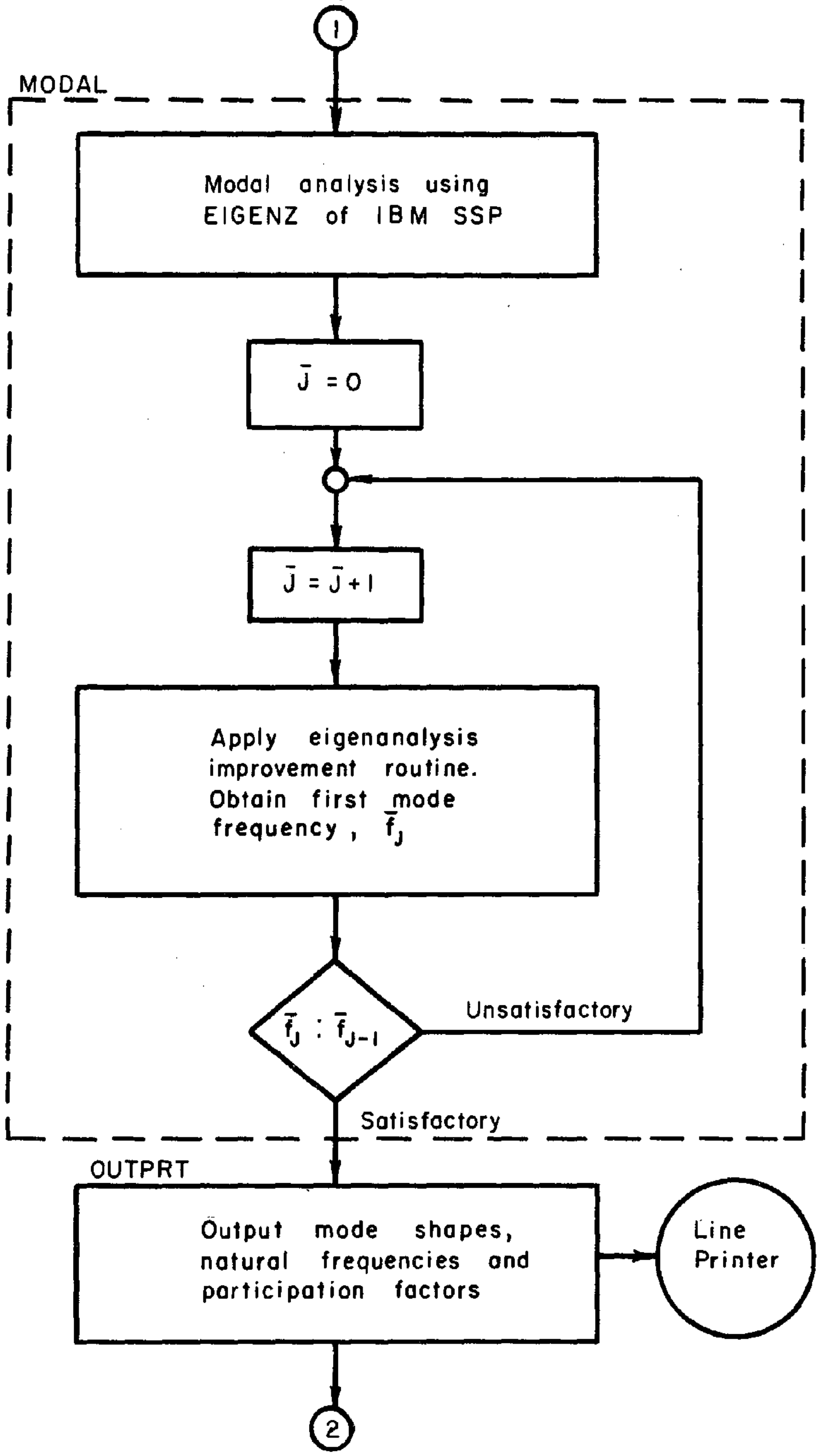


Figure D.1 (contd.) Flowchart for Computer Program for Dynamic Analysis

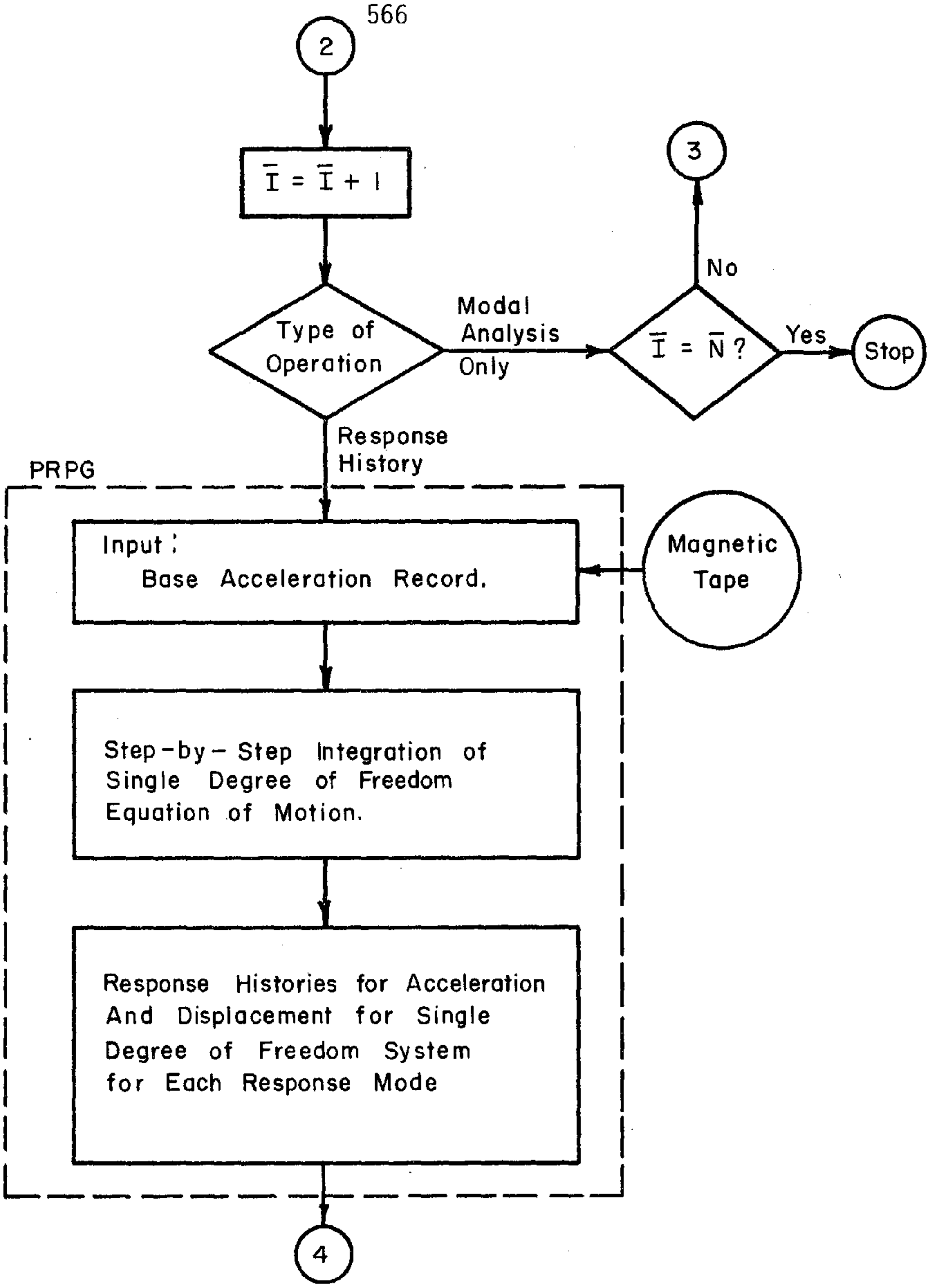


Figure D.1 (contd.) Flowchart for Computer Program for Dynamic Analysis

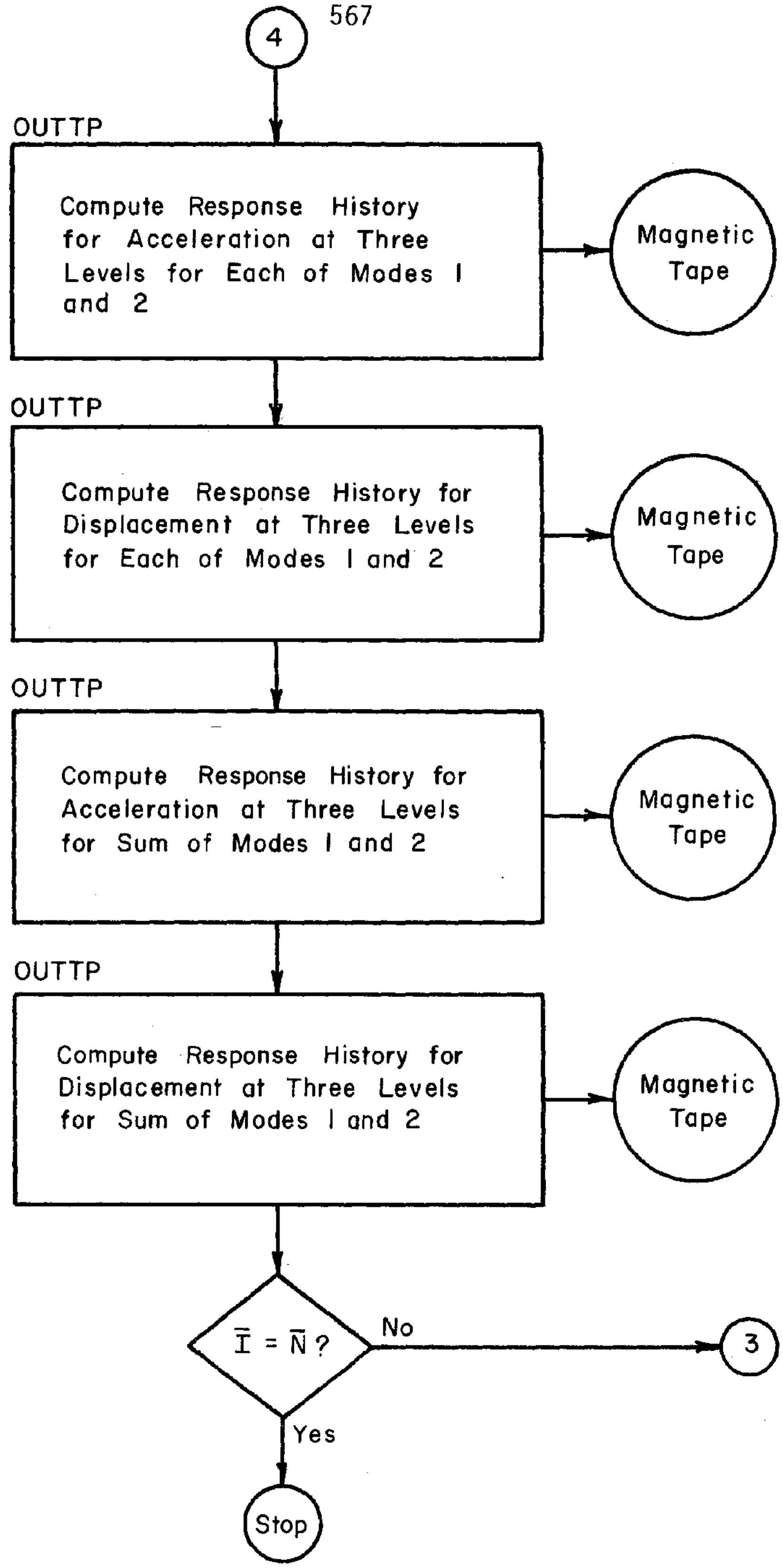


Figure D.1 (contd.) Flowchart for Computer Program for Dynamic Analysis

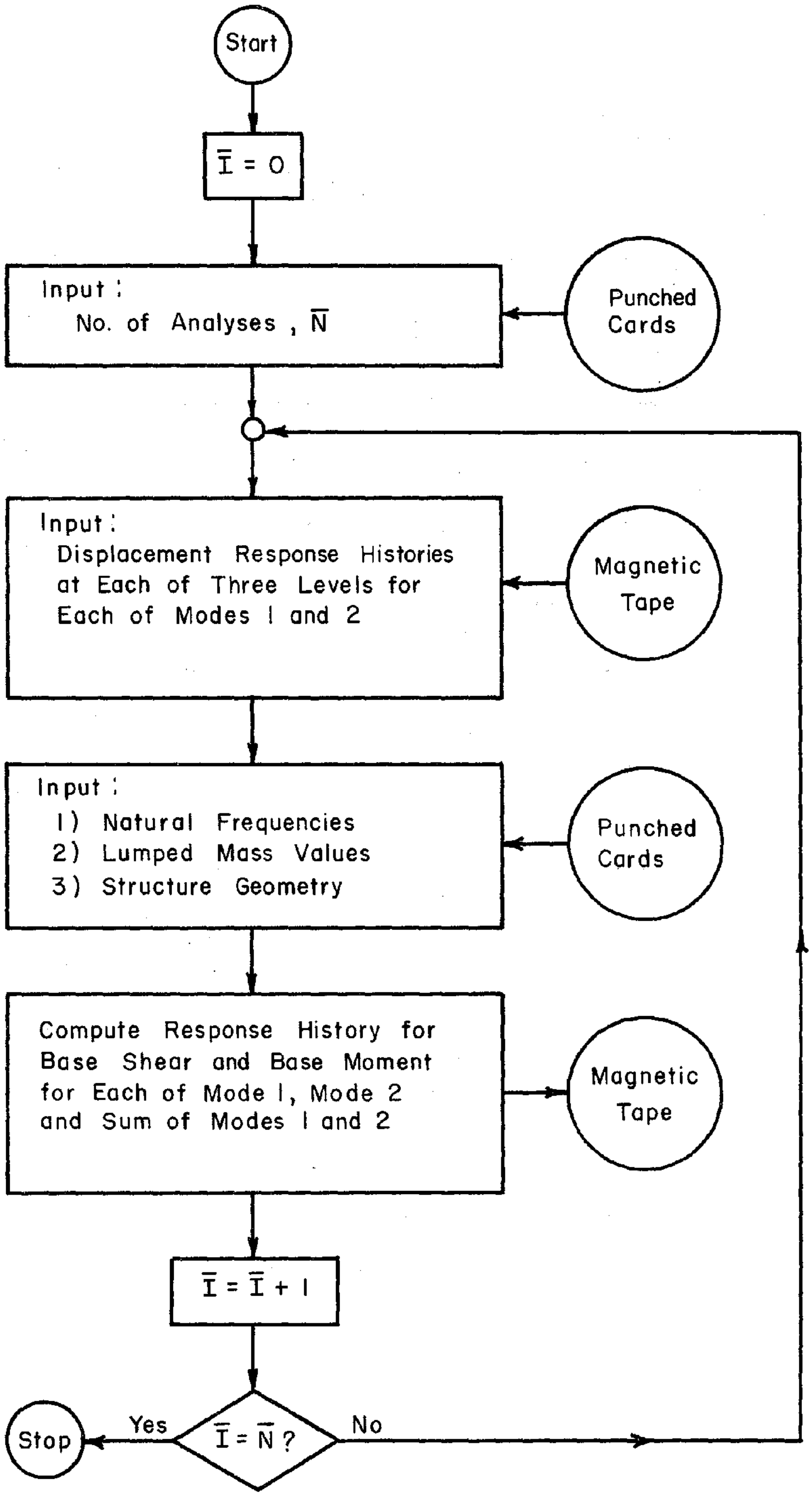


Figure D.2 Flowchart of Computer Program to Compute Base Shears and Base Moments for Dynamic Analysis

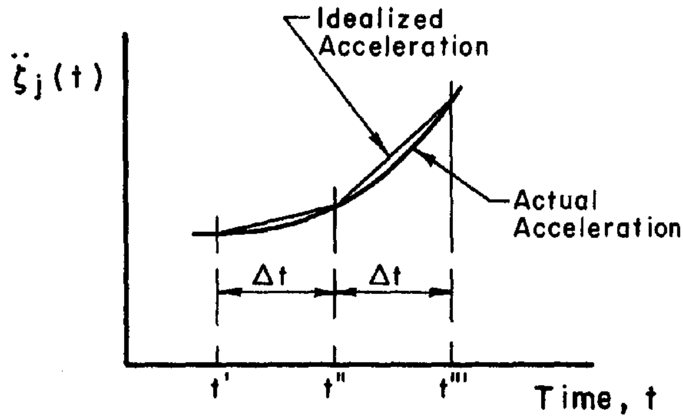


Figure F.1 Acceleration Idealization for Numerical Integration