FREE VIBRATION TESTS OF STRUCTURAL WALLS

by

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As part of an experimental and analytical investigation of structural walls for earthquake-resistant buildings, large isolated reinforced concrete specimens have been tested under reversing in-plane lateral loads. The investigation was supported in part by NSF-RANN Grant GI-43880. In the experimental program, free vibration tests were carried out to determine the frequency and damping characteristics of isolated walls. These tests were conducted at selected stages as the number and magnitude of the reversed lateral load cycles applied to the specimen were increased. Details of the test specimens are described in a paper under Topic 5 of this conference. Results of the free vibration tests are described in this paper.

The free vibration test setup is shown in Fig. 1. Tests were performed using two methods. In the first, all specimens were tested using an "initial displacement-sudden release" method. The force used to displace the wall was lower than the calculated cracking load. In the second, smaller amplitude tests were performed using the impact force of a 3.63 kg. hammer to initiate vibrations. Plots of displacement of the top of the wall versus time were used to compute the natural frequency and logarithmic decrement. The damping coefficient was calculated from the logarithmic decrement.

The results of the tests are presented in Table 1. Frequency measured prior to the application of lateral load ranged from 64% to 82% of the frequency calculated based on uncracked section properties. The differences are attributed to the existence of micro-cracks caused by shrinkage and handling.

The measured frequency decreased by an average factor of 2.2 from the initial tests to the tests carried out after application of lateral load cycles near yield. For the same conditions, the average damping coefficient changed from 3.4% to 8.5% of critical.

"Initial displacement-sudden release" tests on specimens that previously had been cycled well beyond yield indicated that the frequency decreased considerably after yielding. However, the damping did not change significantly. Hammer impact tests for the same conditions for Specimen B5 indicated that the damping decreased significantly. In general, smaller amplitude hammer tests gave higher frequencies and lower damping coefficients than "initial displacement-sudden release" tests. This can be attributed to the differences in crack closure resulting from the magnitude of the initial displacement.

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TABLE 1: FREE VIBRATION TEST RESULTS

Specimen	Loading History: Prior No. of Load Cycles	Loading History: Prior $\frac{\Delta_{max}}{\Delta_y}$	Excitation: $\frac{P_i}{P_y}$	Excitation: Initial Amplitude (mm.)	Calculated Frequency (Hertz)	Measured Frequency (Hertz)	Measured Damping % of Critical
F1	0	-	0.05	0.43	45.6	33.8	2.0
	12	0.7	0.05	1.37	-	13.0	9.8
B1	0	-	0.17	0.41	38.9	30.0	2.2
	12	1.0	0.17	2.49	-	11.1	8.5
	24	5.6	0.17	17.29	-	3.9	9.1
B2	0	-	0.07	0.36	40.9	29.4	3.6
	15	1.0	0.07	1.65	-	13.0	10.0
	24	3.7	0.07	8.89	-	3.9	14.5
R1	0	-	0.36	0.66	26.6	21.8	3.4
	6	0.5	0.36	2.41	-	10.5	6.7
B3	0	-	0.17	0.38	38.0	29.7	2.7
	12	1.0	0.17	2.69	-	10.9	9.6
	24	5.8	0.17	15.19	-	4.3	8.1
	36	11.2	H.I.T.	(1)	-	5.2	9.0
R2	0	-	0.17	1.14	27.8	17.8	5.5
	15	1.0	0.17	3.07	-	8.8	6.8
B4(2)	0	-	H.I.T.	(1)	38.7	29.4	2.8
	0	-	0.13	0.46	38.7	29.4	2.4
	0	-	0.20	0.58	38.7	28.8	2.7
B5	0	-	H.I.T.	0.10	41.0	30.6	2.9
	0	-	0.07	0.66	41.0	29.5	4.0
	6	0.4	H.I.T.	0.10	-	20.4	9.2
	6	0.4	0.07	1.57	-	15.2	9.6
	15	1.1	H.I.T.	0.10	-	18.2	11.2
	15	1.1	0.07	2.29	-	12.0	12.0
	24	3.6	H.I.T.	0.10	-	11.8	3.2
	24	3.6	0.05	7.37	-	6.4	14.5
B5R(3)	0	-	H.I.T.	0.13	-	16.0	3.1
	0	-	0.07	1.91	-	13.3	4.0
	6	0.4	H.I.T.	0.13	-	13.2	4.0
	6	0.4	0.07	2.79	-	10.8	5.7
	15	1.1	H.I.T.	0.18	-	11.9	3.6
	15	1.1	0.07	3.84	-	8.3	11.0

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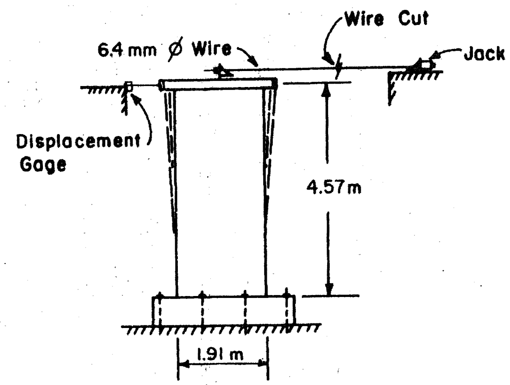

Fig. 1 Free Vibration Test Set-up

WHERE:

Δ_{max} = Maximum deflection of top of wall during prior lateral load cycles.

Δ_y = Deflection of top of wall at which first yielding of main flexural steel was observed, during lateral load tests.

P_i = Load applied at top of wall to initiate vibrations

P_y = Load applied at top of wall corresponding to Δ_y.

H.I.T. = Hammer Impact Test

NOTES:

(1) Initial amplitude not measured.

(2) Specimen B4 tested with monotonic lateral load.

(3) Specimen B5R was a repair of Specimen B5. Yielding in B5R was assumed to occur at the same load, P_y, for B5.