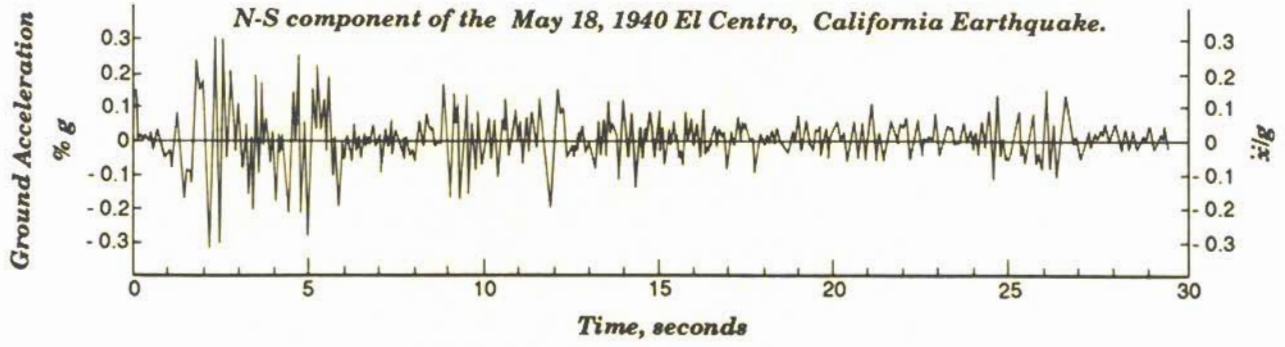
MASONRY WALLS STAND TALL UNDER SEISMIC TESTING

NEW

University of Southern California Study Confirms Strength of Tall Slender Masonry Walls Under Simulated Earthquake Conditions



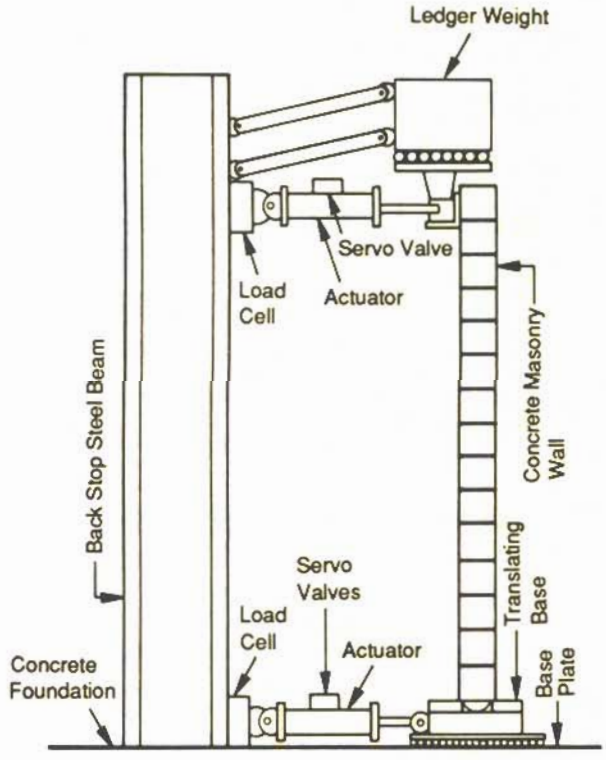
Methods of Testing

An experimental program was designed to test full scale wall panels representing a concrete block masonry building.

This program is an extension of the static airbag test conducted by ACI/SC and SEAOSC between 1980 and 1982. In the University of Southern California test program kinematic seismic motions were applied at the base and top of the walls.

The seismic input motions were selected from actual records to represent earthquake motions for various seismic zones in the United States. In addition, these motions were modified to evaluate the response of the test walls to more intense shaking.

In this University of Southern California study, which utilized the experimental facilities and data analysis services of Agbabian Assoc., four walls, 20 feet high, nearly three stories tall, were built and tested. They had a thickness of 4½ inches and 6 inches. The height to thickness ratio was 53 and 43 respectively, which represents an upper bound on current state of practice.



Test Setup for Dynamic Testing of Walls

Concrete Masonry Wall Test Dynamic Out-of-Plane

Wall #	Wall Thickness		H/T Ratio	Bar Splice	Vert. Reinf.	Grouting	
	Nominal	Actual				Full	Partial
1	6	5⅝	43	No	2-#5	X	
2	4.5	4½	53	No	2-#4	X	
3	6	5⅝	43	No	2-#5		X
4	6	5⅝	43	Yes	2-#5		X

Concrete masonry wall width 39.5 inches

Vertical ledger load 300 lb/ft

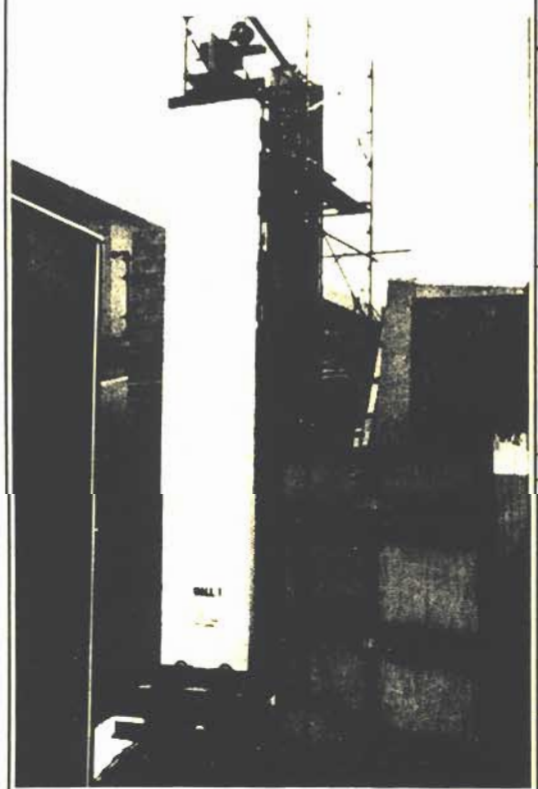
Designated ultimate compressive strength of unit, 2500 psi

Horizontal steel 6–#3 in each wall (approximately 48 inches spacing)

Seismic Input Motions

Earthquake Motion	Base Motion*	Record Duration (sec)	Top Diaphragm Response	Earthquake Record
M1**	0.1	30	Flexible	Hollister-Glorietta Warehouse Morgan Hill, 1984
M2	0.1	30	Stiff	Saratoga-W. Valley College Gym Morgan Hill, 1984
M3	0.2	30	Flexible	El Centro, 1940, S00E
M4	0.2	30	Stiff	Castaic, 1971, N69W
M5	0.4	30	Flexible	El Centro, 1040, S00E
M6	0.4	30	Stiff	Castaic, 1971, N69W
M7	0.4	30	Stiff	El Centro, 1940, S00E
M8	-1.0	15	Stiff	Compacted El Centro, 1940, S00E
M9	-1.0	12.5	Stiff	Compacted El Centro, 1940, S00E
M10	-0.8	30	Flexible	Modified Bonds Corner, 1979

* Peak Acceleration
** M1 = Motion 1



Whitewashed Masonry Wall Specimen in Dynamic Testing Frame

Test Obsevations for Wall Panel #4

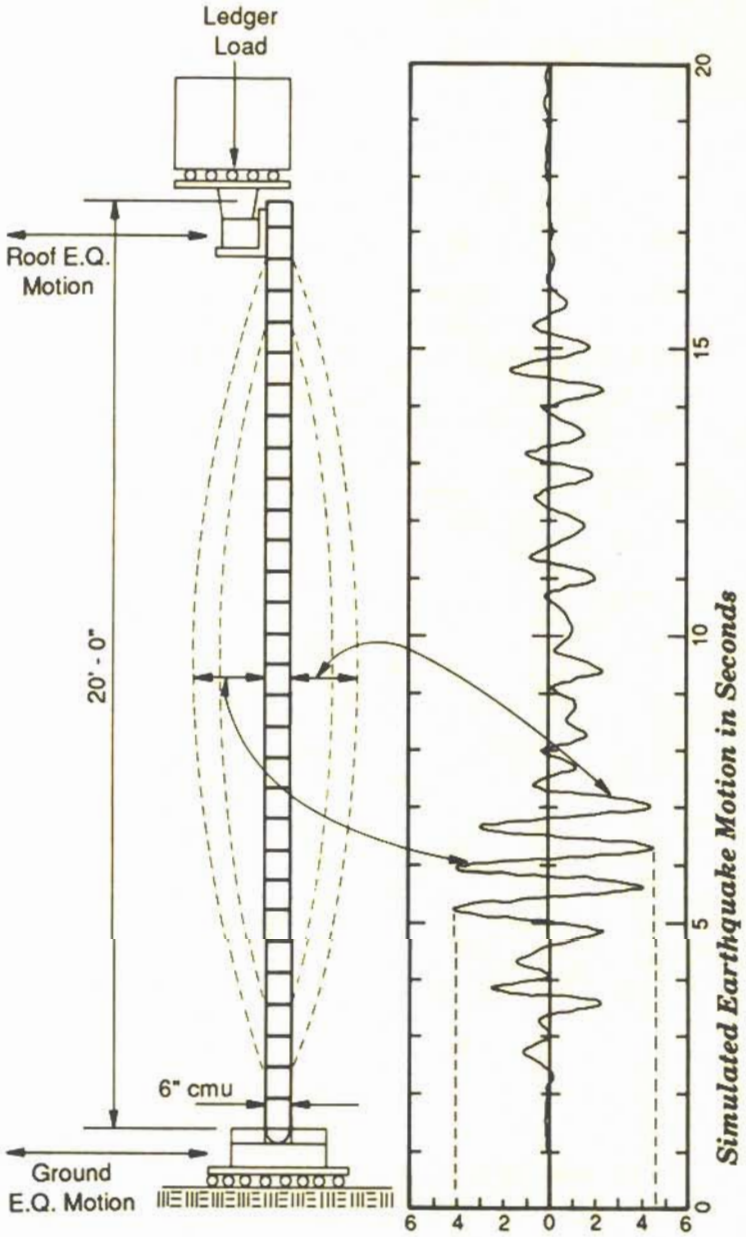
5⅝" Block, 2-#5, Partial Grout, with Lap Splice

Test Sequence	Earthquake Motion at Base	g's$^{\Delta}$	Duration (sec)	Panel Response
1	Hollister (M1)	0.1	30	
2	Saratoga (M2)	0.1	30	Elastic:
3	El Centro (M3)	0.2	30	Hairline
4	Castaic (M4)	0.2	30	Cracks
5	El Centro (M5)	0.4	30	
6	Castaic (M6)	0.4	30	Elastic:
7	El Centro (M7)	0.4	30	Mortar
8	M7	0.4	30	Joint Cracks
9	El Centro (M6)	-1.0	15	
10	M8	-1.0	15	Elastic:
11	M8	-1.0	15	Mortar Crack
12	M8	-1.0	15	Opening
13	M8	-1.0	15	& Closing
14	M8	-1.0	15	
15	M8	-1.0	15	
16	M7	0.4	30	Elastic
17	M8	-1.0	15	
18	M8	-1.0	15	Elastic:
19	M8	-1.0	15	Mortar Crack
20	M8	-1.0	15	Opening
21	M8	-1.0	15	& Closing
22	M8	-1.0	15	
23	M8	-1.0	15	
24	M8	-1.0	15	
25	M8	-1.0	15	
26	Bonds Corner (M10)	-0.8	30	Elastic:
27	M10	-0.8	30	Crack Pattern
28	1.25 x M10	-1.0	30	Recognizable
29	El Centro (M9)	-1.0	12.5	Elastic
30	M9	-1.0	12.5	Elastic: PRD = 4.2"*

* PRD = Midheight peak relative displacement
Δ Values indicate peak base accelerations: peak top accelerations are modified by top actuator

Conclusions of the Dynamic Test Program

Lateral displacement each way of wall specimen for a total of more than 8 inches, plus or minus 4 inches, due to input from simulated earthquake forces.

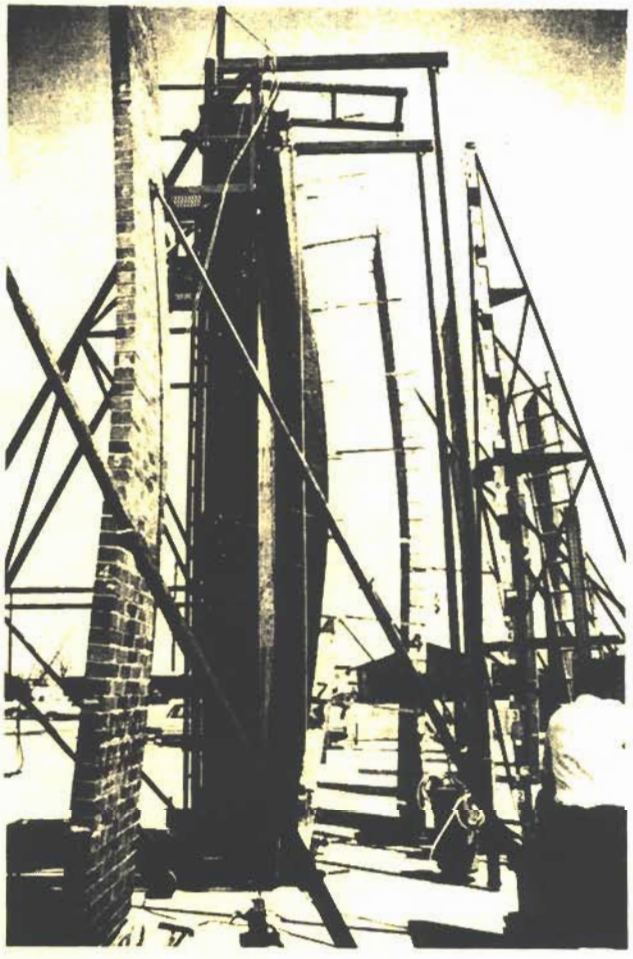


- All walls remained elastic when subjected to earthquake input motions within the range of highest earthquake forces assigned to highly seismic zones such as the Los Angeles and San Francisco.
- Fully grouted walls went into the inelastic range only after being subjected to a series of 15 to 18 severe designed earthquakes.
- The partially grouted walls did not suffer any permanent deformation and remained within the elastic range even after being subjected to 30 earthquake motions.
- The performance of partially grouted walls which had reinforcing bar splices at one-third of the height was identical to the response of those which had no bar splices.

Out-of-Plane Static and Dynamic Earthquake Test Results

The American Concrete Institute, Southern California Chapter, and the Structural Engineers Association of Southern California,* and the University of Southern California static and dynamic test programs concluded that tall slender reinforced masonry walls, constructed with adequate quality control, can safely sustain a large number of moderate and severe earthquakes.

- These walls, as designed under current codes, will be dynamically stable during earthquakes.
- All test walls responded elastically to typical earthquake motions of various seismic zones in the United States.
- Partially grouted walls had less mass and sustained more intense earthquake shaking than the heavier fully grouted walls.
- The response of the test walls with and without reinforcing bar lap splices was identical.
- The slenderness and reduced mass of these walls result in lighter more ductile walls that can sustain severe shaking without the risk of instability or sudden brittle failure.



Test Panel No. 7
6" CMU; h/t = 51.2
f'm = 3185 psi; f_y = 70,000 psi
Reinforced with five #4 bars
Vertical load = 320 plf

Maximum lateral load = 62 psf
Maximum lateral deflection = 17.7"
Lateral load at yield of steel = 46 psf
Lateral deflection at yield of steel = 9.0"

Static Test conducted by ACI/SC and SEAOSC, 1980–82

* Test Report on Slender Walls ACI/SC and SEAOSC Task Committee on Slender Walls, 1980–1982.

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FOR FURTHER INFORMATION,
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