DYNAMIC RESPONSE OF A CHILEAN BASE ISOLATED CONFINED MASONRY BUILDING

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Abstract

This paper describes the tests program carried out in a 4 storied, base isolated, confined masonry building, located in Santiago, Chile. In situ test were performed to determine the basic vibration characteristics, and to ascertain the validity of design values and the reliability of the isolated system. Since the structure was finished several earthquake records have been obtained.

A similar, not isolated building, was also constructed, aimed to compare the seismic behavior between them.

The results of these experiments and observations verify the theoretical values and show the favorable effect of base isolation on the seismic response of buildings.

Introduction

Base isolation is an effective technique for low-rise buildings to safely resist very strong earthquake motions, and to protect their content.

The construction of two similar confined masonry buildings have just been finished in Santiago. One of them is resting on eight high damping rubber bearing, while the other has conventional foundation. A strong motion array of four accelerographs has been installed in both buildings, with the purpose of comparing their seismic behavior and the reliability of the isolation system, Sarrazin et al. (1992, 1993).

In this paper the vibration characteristics, obtained through microvibration studies, the results of static and free vibration tests on the isolated one and strong motion records of several small earthquake events are presented.

Outline of buildings

The buildings weight 163 ton, are four storied high, structured with reinforced concrete shear walls in the first floor, and with confined masonry shear walls in the upper floors. Figure 1 shows the plan and elevations of the buildings. All floors have a 10 cm thick reinforced concrete slab. The roof has a wooden structure.

The isolated building is mounted on 8 high damping rubber bearings, which rest on independent foot foundations, interconnected with reinforced concrete beams, figure 2. The isolators are bolted both to the building and to the foundation.

Outline of isolators

The isolators are comprised of 34 layers of rubber 6.7 mm thick and 33 steel shims of 2 mm with a total height of 32.6 cm and 31.5 cm in diameter. These dimensions were selected in order to obtain a fundamental period of the building of about 2 sec, to resist vertical loads of 35 ton and to accept a lateral displacement of 20 cm. The isolators were produced in a rubber factory in Santiago. Each isolator was subjected to vertical and horizontal testing. Figure 3 presents the horizontal stiffness as a function of shear strain, for different axial loads.

Field testing

Several microtremor measurements were performed on the finished structures. In figure 4 power spectral density of ambient vibration of both buildings are presented. A predominant frequency of 7.7 and 8.8 hz are observed for the nonisolated building and 6.2 and 6.8 for the isolated one.

An static load-deformation experiment was performed on the isolated building. In this test the structure was pulled from the middle of the longitudinal side of the 1st story slab, to cause a horizontal deformation on the bearings. A wall of the conventional building was used as reaction support. The load-deformation curve corresponding to some of the tests is shown in figure 5. Maximum deformation correspond to a shear strain of 21%. The behavior was non linear. Several loading sequences were applied to reach different displacements as observed in that figure; the loading paths were similar for all tests.

Free vibration pull-back test were also performed. For the se tests a breakable steel bar was introduced in the main rod of the static load device. Free vibrations were generated as a result of breaking the steel bar. To measure the motions of the structure, two seismometers were located on the first floor and one on the top floor. Additionally a LVDT and accelerometers were placed on the first floor. Different diameters for the breakable steel bar were used and displacement up to 4.5 cm were produced.

Acceleration and displacement records are shown in figures 6 and 7. These plots show the strong effect of the equivalent first two modes of the isolated structure and the strong effect that damping has on the response. The equivalent fundamental period of the building and its damping were calculated from the observed motion as a function of the different levels of deformation. Results are presented in Table 1.

Later, four accelerographs have been installed on the buildings. One on the rooftop on the conventional and another on the isolated building, one on the first floor of the isolated building and one at the foundation level. Peak to peak acceleration for three records are presented in Table 2.

Conclusions

A series of experimental test and strong motion observations were performed on two similar structures, one conventional and the other isolated. The dynamic characteristics of the systems under different loading condition and verification of the isolation system itself, were obtained. Additionally, records for actual small earthquakes were obtained and the maximum acceleration at the roof of both buildings were registered by means of digital accelerometers. The results show that the isolation system was effective in reducing the accelerations. is most the events this reduction is more effective when the earthquake is larger. For the largest earthquake recorded, the reduction was 3.4.

Acknowledgements

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References

Sarrazin, M. and Moroni, M.O., 1992 "Design of a base isolated confined masonry building", Proc. X WCEE, p. 2505-2508.

Sarrazin, M., Moroni, M.O. and Boroschek, R., 1993 "Experiments on a Base Isolated Confined Masonry Building", ATC 17-1.

Table 1. Dependence of dynamic characteristics on strain level

TEST	MAX. DISP. (mm) (SHEAR STRAIN)	PERIOD (sec)	DAMPING %
ambient vibration		0.19	
pull-back	14. (6.1)	0.93	11.14
id.	29,9 (13.1)	1.13	17.5
id.	30.4 (13.3)	1.17	17.4
id.	37. (16.2)	1.2	30.4
id.	44.5 (19.5)	1.24	18.6

Table 2. Peak to peak accelerations (g)

EVENT	ISOLATED				NON ISOLATED
		FOUND	1°	4°	4°
10/10/94	EW NS	0.0103 0.0127	0.0181 0.0147	0.0273 0.0190	0.0898 0.0420
18/10/94	EW NS	0.0083 0.0044	0.0141 0.0083	0.0200 0.0122	0.0127 0.0166
22/10/94	EW NS	0.0049 0.0039	0.0079 0.0088	0.0098 0.0181	0.0205 0.0298
28/10/94	EW NS	0.0190 0.0117	0.0327 0.0166	0.0371 0.0215	0.0557 0.0728

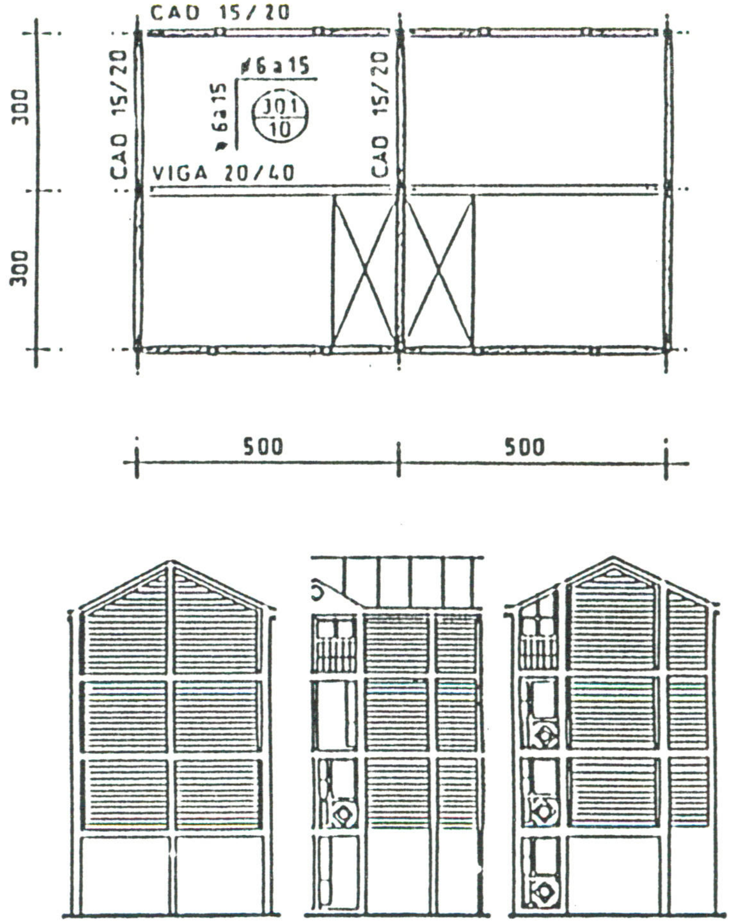

Fig. 1 Plan view over 3rd. floor and elevations.

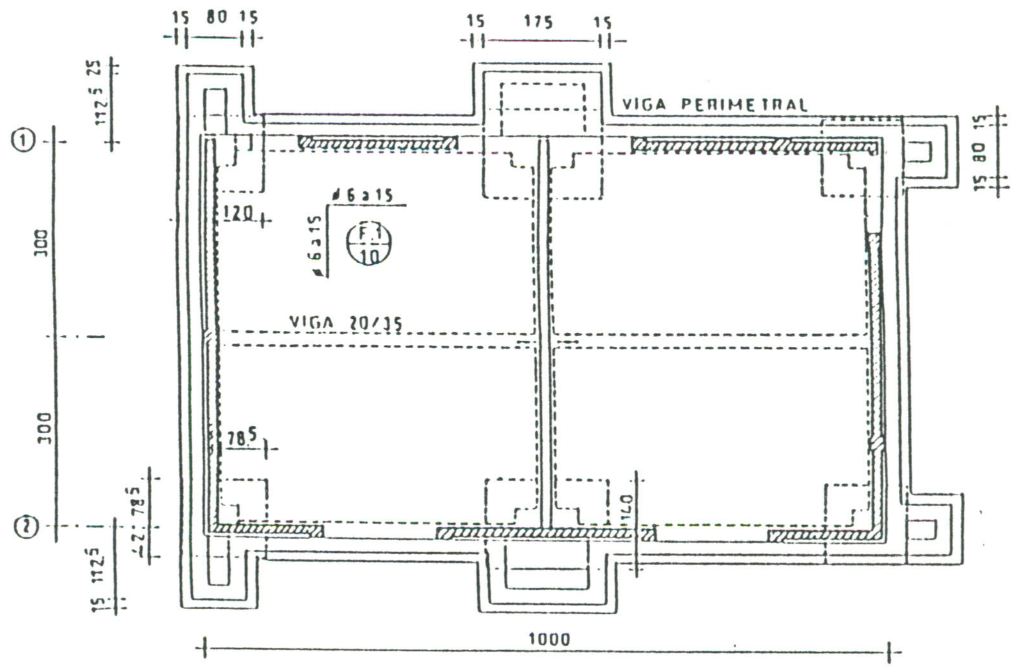

Fig. 2 Foundation

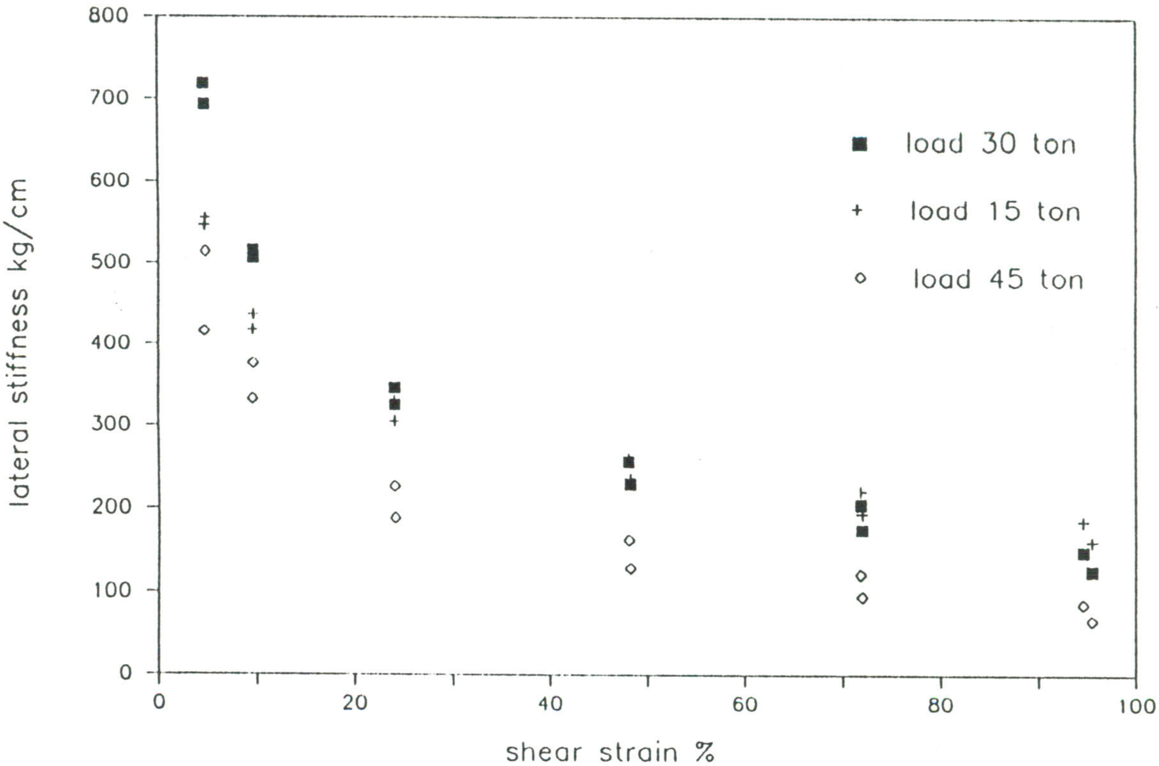

Fig. 3 Horizontal stiffness vs shear strain for different vertical loads. (From test done at Berkeley).

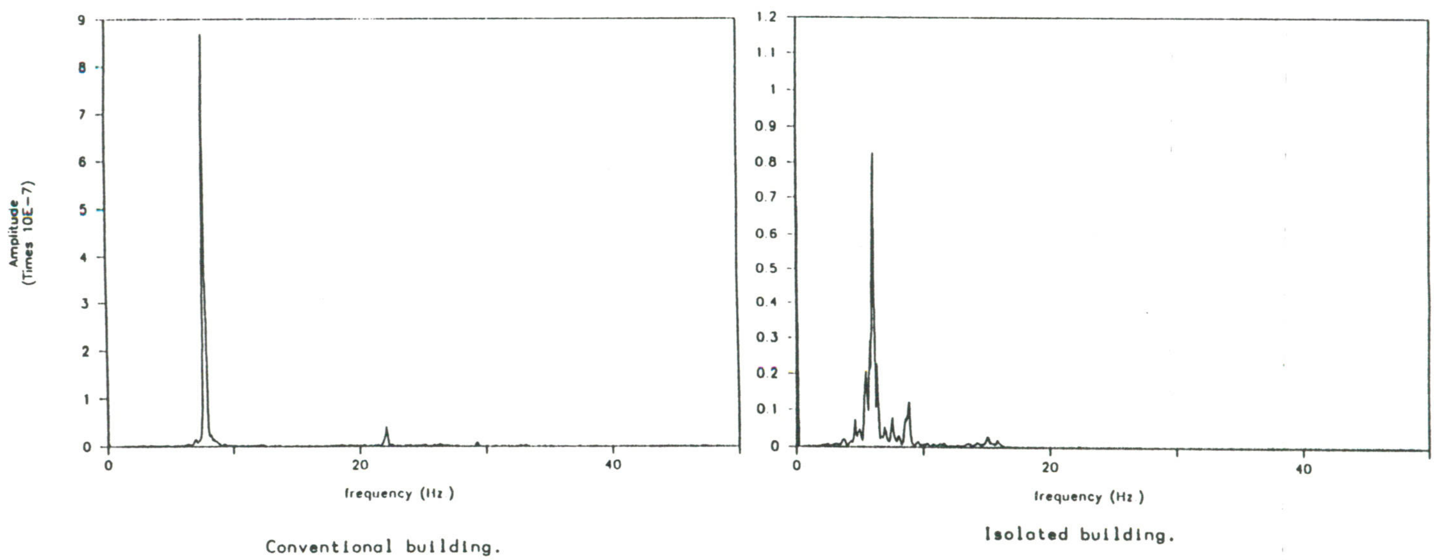

Fig. 4 Power spectral density of ambient vibration.

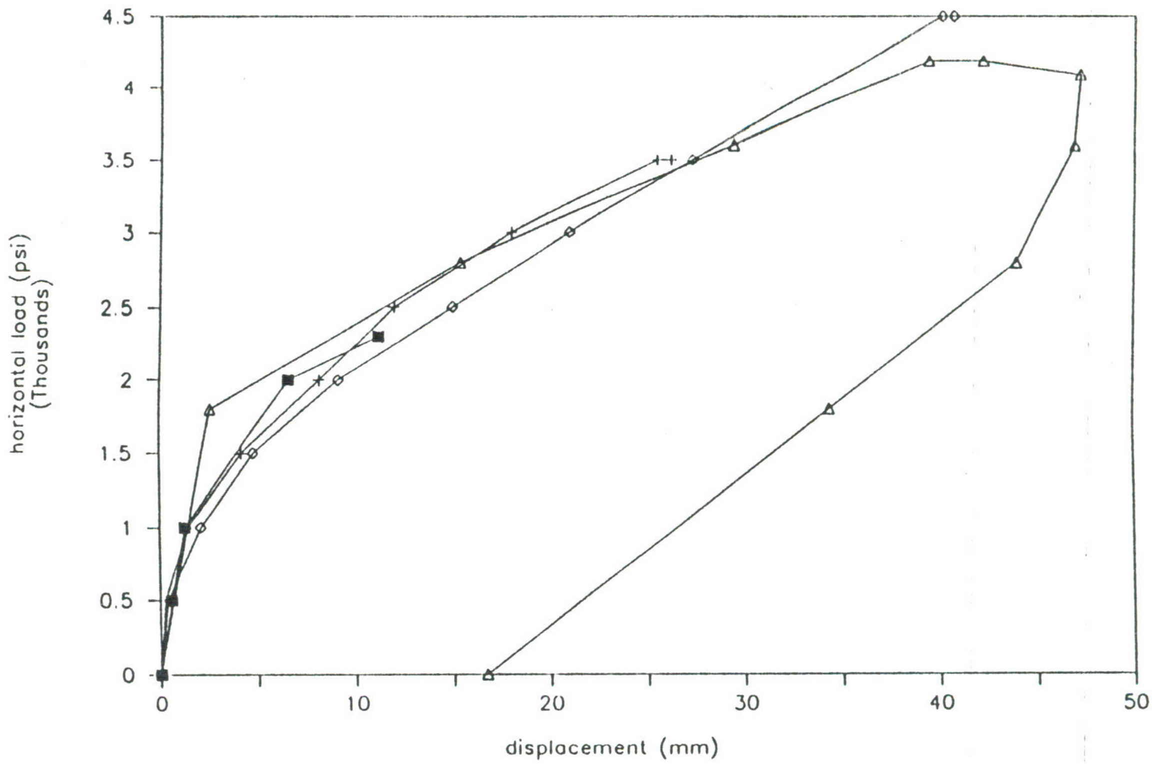

Fig. 5 Static horizontal test of isolated building

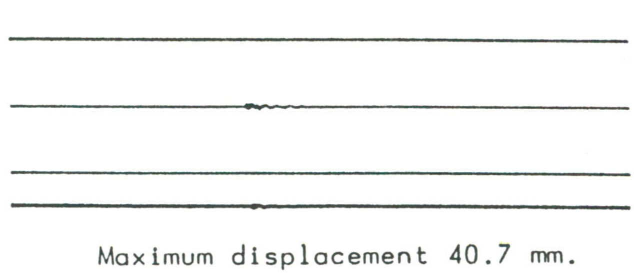

Fig. 6 Accelerometers records obtained from pull back test.

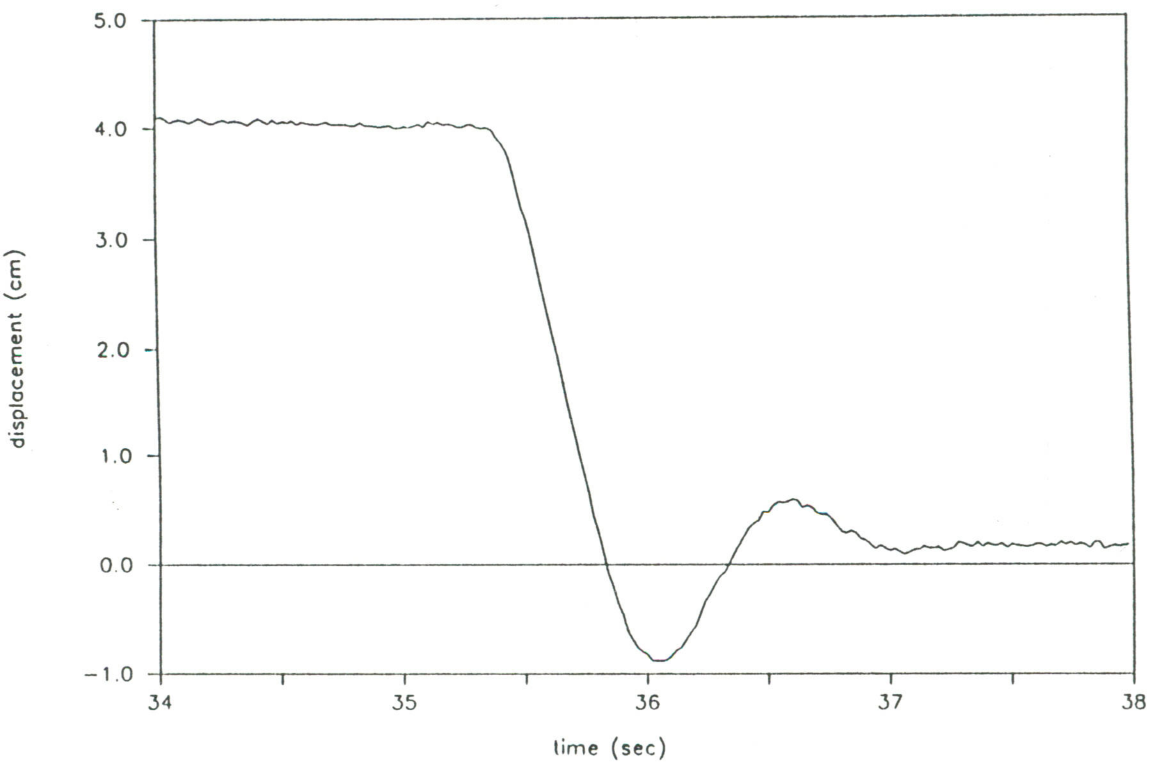

Fig. 7 Displacement records obtained from pull back test.