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EXPERIMENTS ON A BASE ISOLATED CONFINED MASONRY BUILDING

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Abstract

This paper describes the verification tests program carried out to a 4 storied, base isolated, confined masonry building, located in Santiago, Chile. The test were designed to determine the basic vibration characteristics, and to ascertain the validity of design values and the reliability of the isolated system.

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

The experiments consisted on:
- measurements of environmental vibrations,
- static loading test,
- pull back test of the isolated building, and
- monitoring of seismic vibrations in both buildings.

The result of these experiments and observation 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 contento

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

In this paper, the vibration characteristics, obtained through microvibration studies, of these twin buildings, and the results of static and free vibration tests on the isolated one are presented.

Out1ine of bui1dings

The buildings weighting 163 ton, are four story 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 e1evations 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 (see figure 2). The isolators are bolted firmly both to the building and to the foundation.

Out1ine 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 lateral displacement of 20 cm. They were produced in a rubber factory in Santiago. Each isolator was subjected to vertical and horizontal testing, static and dynamic. In figure 3 the variation of lateral stiffness with shear strain is presented with different vertical loads.

Experimental Investigation

A number of research activities have been planned to study the behavior of the isolated building and to compare it with its conventional twin. The properties of the isolators depend on the level of deformation, therefore, it is necessary to conduct different tests in order to determine their dynamic characteristics. They include measurement of environmental vibrations, static load test, pull-back test and monitoring of seismic activity.

Several microtremor measurement were performed. In figure 4 power spectral density of ambient vibration of both buildings are presented. Predominant frequency of 7.7 and 22.1 hz are observed for the nonisolated building and 6.0 and 8.8 for the isolated one. These results show that even for very low amplitude the isolation system has a relatively strong effect on the dynamic characteristic of the system.

In the static load experiment the isolated building was pulled from the middle of the longitudinal side of the 1st story slab, so the upper structure was moved horizontally to cause the horizontal deformation in the bearings. A wall of the conventional building was used as reaction support. For measurement of horizontal displacement, a LVDT was used. For measurement of horizontal load, the pressure in the hydraulic jack was used. Maximum deformation given was 4.8 cm as is shown in the load vs deformation curve of figure 5, which represents 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.

In the free vibration pull-back experiment 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 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.

Figure 6 shows the velocity record obtained from the seismometers in the first and top floor. The records show two distinct behaviors. The initial part shows a strong influence of an equivalent second mode, characterized by relatively higher frequencies and out of phase motions of the first and fourth floor. The later part of the record shows an equivalent predominant first mode with longer period, in phase, and with equal amplitude.

Acceleration and displacement records, figure 7 and 8, also show the strong effect of first two modes of the isolated structure and the strong effect that damping has on the response. From time series and frequency analysis of these observed waves the fundamental period of the building and its damping were calculated, for different shear strain of the isolators and are presented in Table 1.

Later, four accelerographs have been installed on the buildings. One on the rooftop of the conventional and another on the isolated building, one on the first floor of the isolated building and one at the ground to record free field conditions. Until this moment no records have been obtained at the site.

Conc1usions.

A series of experimental tests 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.

Acknow1edqements

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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.

Table 1 Dependence of dynamic characteristics en strain leve1

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

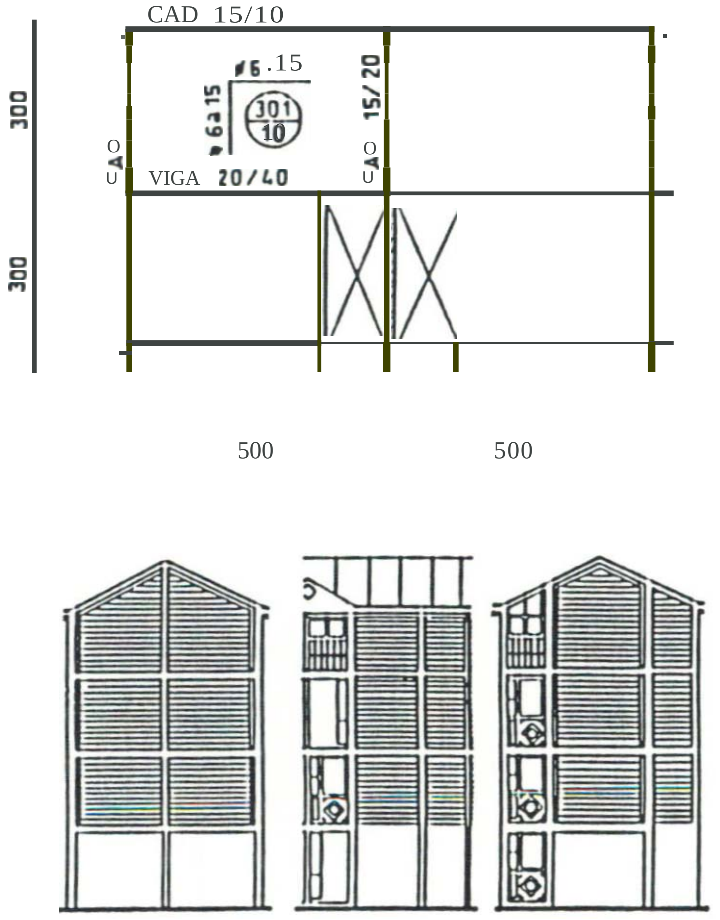


Fig 1. Plan view ayer 3rd. floor and elevotions.

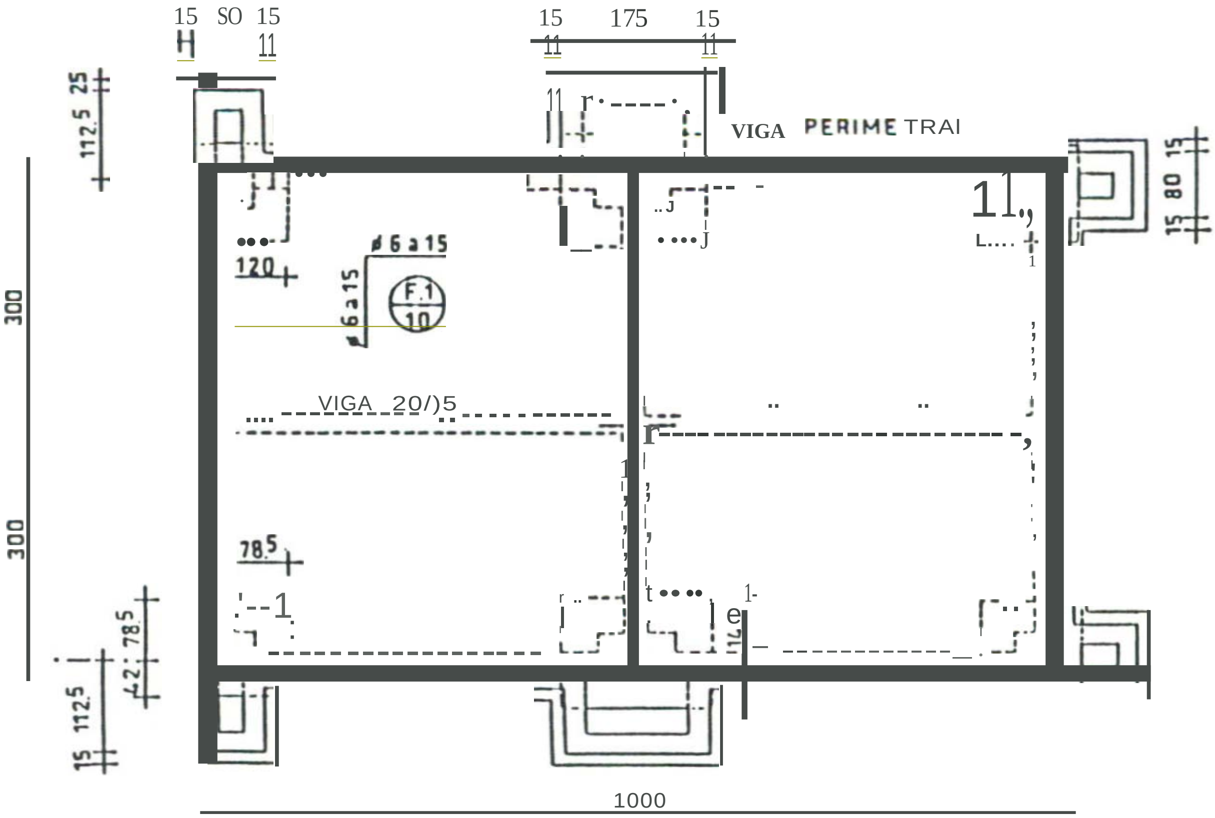


Fig. 2. Foundotion.

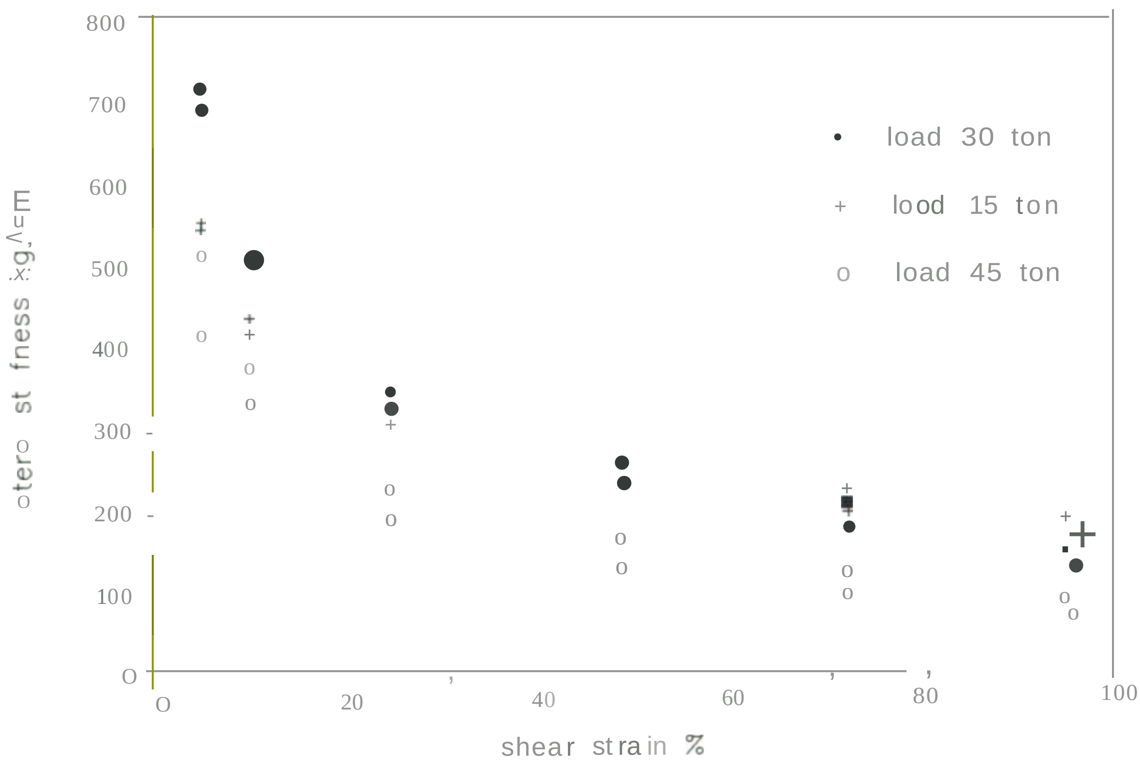
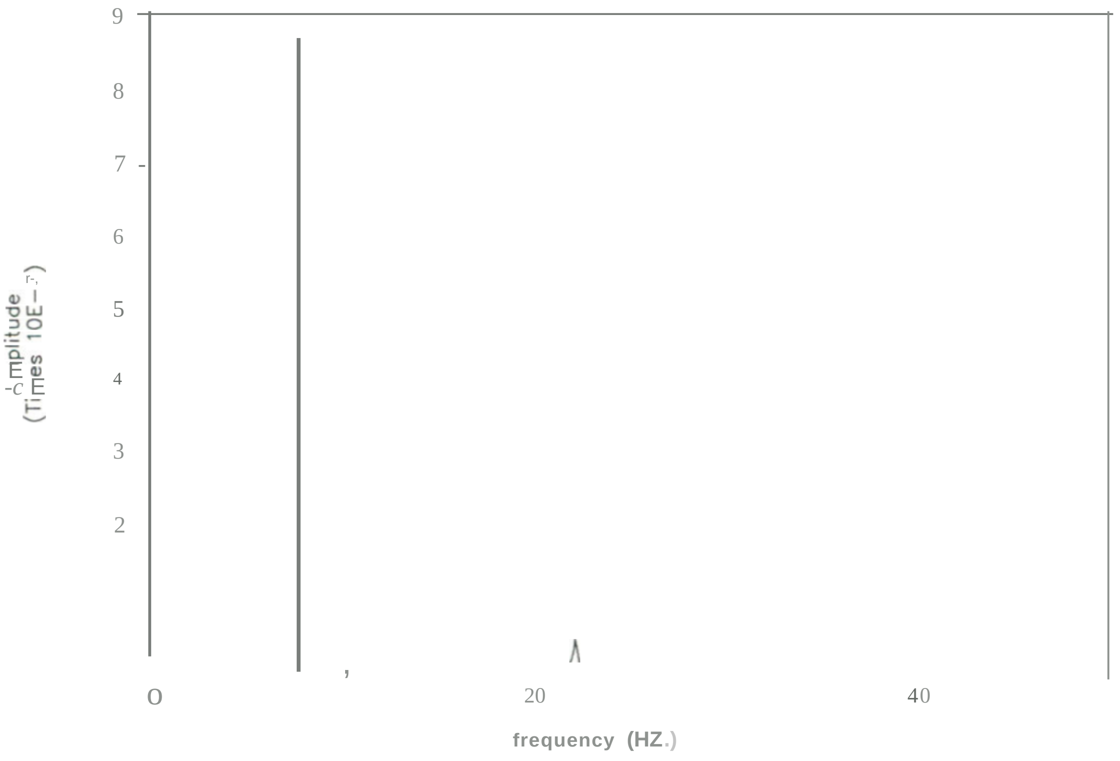
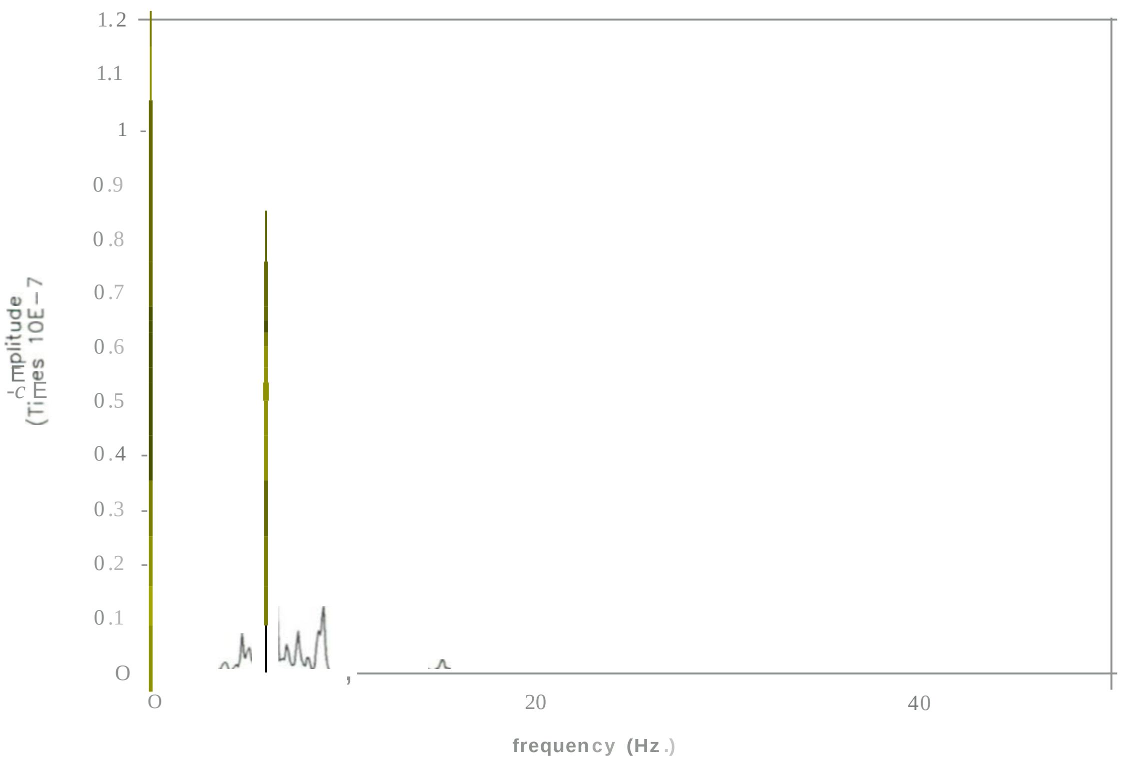


Fig. 3. Horizontal stiffness vs shear strain for different vertical laads. (Fram tests done at Berkeley).



Conventionol building.



Isoloted building.

Fig.4. Power spectrol density of ombient vibrotion.

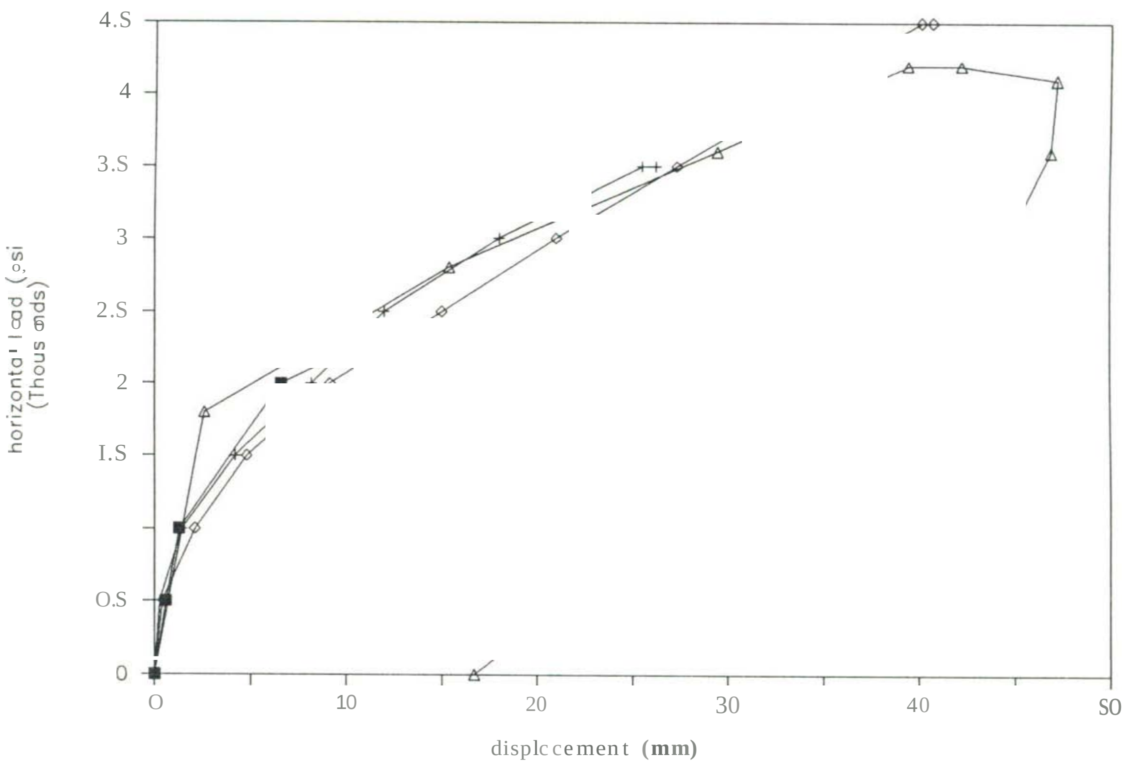


Fig. 5. Static horizontal test of isoloted building.

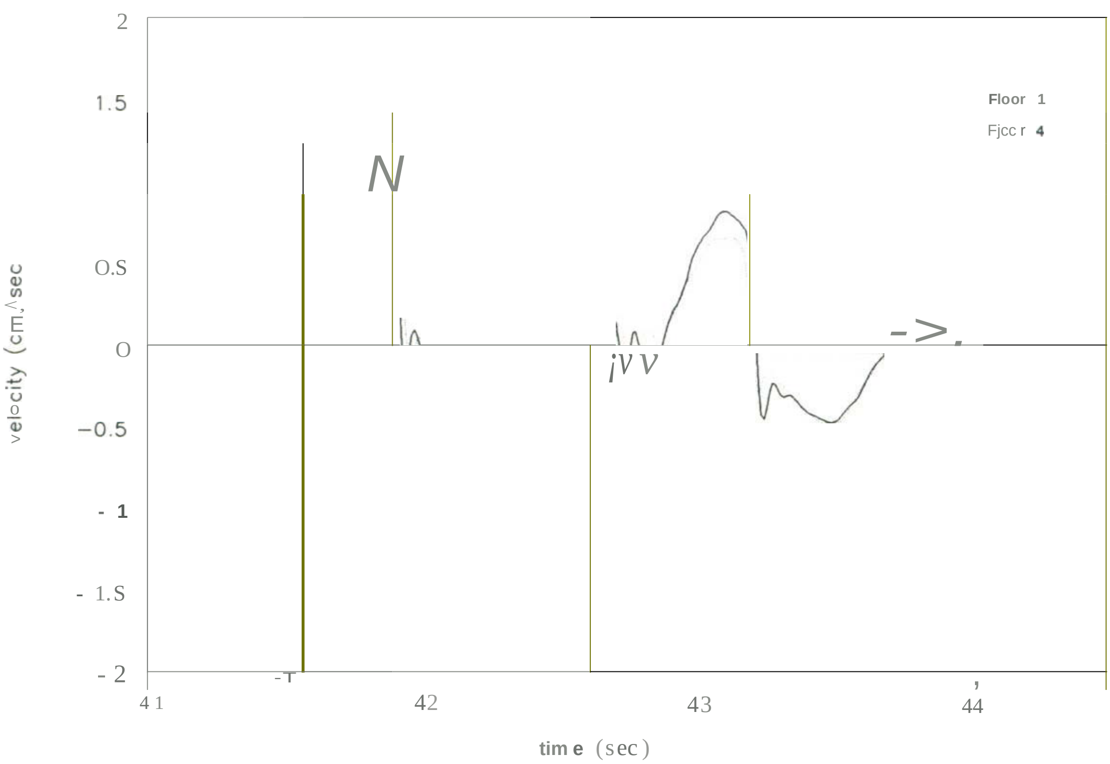
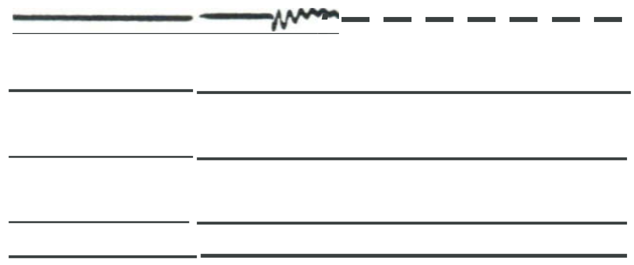
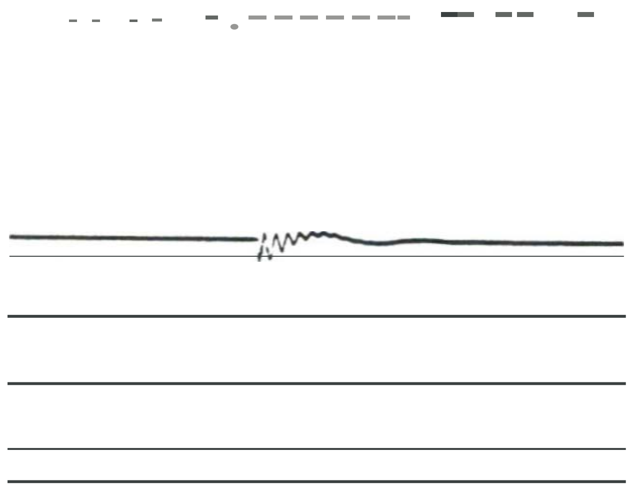


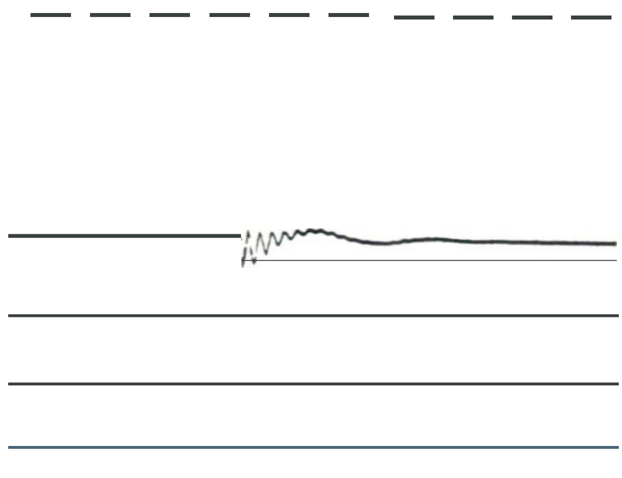
Fig. 6. Seismometers records obtoined from pull bock test.



Moximum displocement 11.2 mm.



Moximum displocement 26.2 mm.



Maximum displacement 40.7 mm.

Fig. 7. Accelerometers records obtoined from pull bock test.