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BUILDING MONITORING EARTHQUAKE RESPONSE NETWORK IN LIMA

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Abstract: Under the Peru - Japan SATREPS Project a building monitoring network has been implemented in Lima city, under the support of JST and JICA. The network considering a set of 5 sensors installed on different levels of three building: One is framed concrete structure, the second is a masonry and concrete wall building and the third is a hospital with concrete framed structure. The buildings are located in two kinds of soil of Lima (two in medium soil, and one in rigid soil). Since the installation of the sensors, seven moderate quakes has been register. This paper presents the monitoring response of one building and the dynamic characteristics measure from the stronger event registered for the buildings. Good agreement with simulation previously performed was found, and the results give us the confidence for the developed of parameters for the stiffness degradation under small and moderate quakes for concrete framed structures.

1. INTRODUCTION

Under the Peru - Japan SATREPS Project, with the support of JST and JICA, a building monitoring network has been implemented in Lima city since 2011.

A total of 15 sensors are to be installed on different levels of three buildings: One is a framed concrete structure, the second is a masonry and concrete wall building and the third is a hospital with concrete framed structure. One of the recorded moderate quake is shown and the response of a building analyzed and compared with previous studies.

1.1 Sensors Network Setting

Accelerations sensors are connected through internal network and IP addresses to access to Internet

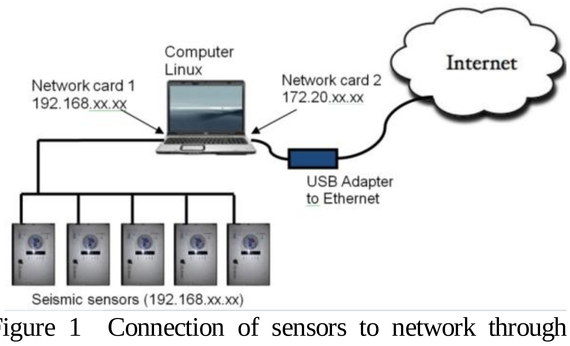


Figure 1 Connection of sensors to network through IP address and internet

After preliminar testing period in a local network (Figure 2), a set of 5 sensors has already been set in 2 buildings at UNI campus.

Figure 2 Network setting test and final placement of sensor at basement level in UNI Central Building

At each building, the 5 sensors set are aligned to a vertical line, and if possible near to gravity center. At the basement level, sensors has been fixed in a hole box in floor, and then at ceiling (slab) for each upper level.

1.2 Selected Buildings

The criteria for the selection of the buildings to be measured was the consideration of likely used structural system in Peru and also the different combination of materials.

A set of 5 sensors will be installed in each of three buildings, which was selected as representative of typical structures and material:

- Central Building of UNI is 3F+ BF Level and 16m high, irregular configuration in plan, with masonry and concrete walls and concrete frame structure built more than 80 years ago, used mainly for administrative offices

- G2 Block at Civil Faculty of UNI, is for classrooms, a 3F framed RC building with irregular configuration of stiffness due to its distribution of masonry walls (hall at 1F, corridors and classroom at upper floors).
- Block A of Edgardo Rebagliati Martins National Hospital is a 14F+BF building, more than 50 years old, RC framed building, classified as essential type for its importance of use.

Figure 3 Central Building and G2 bldg block (North view) at Civil Engineering Faculty at UNI

2. PRELIMINAR STUDIES OF SELECTED BUILDINGS FOR MONITORING

2.1 Central Administrative Building of UNI

As shown in figure 4, plan of Central Building of UNI is irregular its longer dimension L=117m and B=23m wide for the main body. Sensors has been set to the South-East part of the building about 0.25L from gravity center

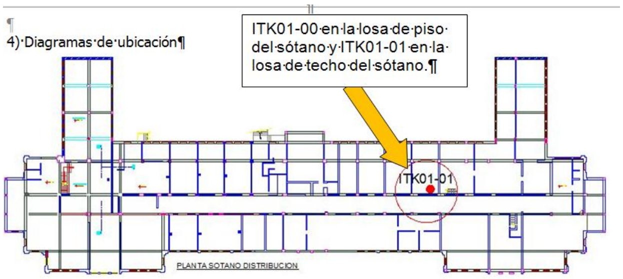


Figure 4 Plan of Central Building in UNI and location of sensors

Some previous calculation and measurement has been conducted as reference for assess dynamic monitoring results. Microtremor measurements has been conducted in 3 points (soil: center zone and at 3F: NO and SE wing of building) and showed fundamental periods (from Fourier Amplitude Spectra) of Tx=0.23s and Ty=0.28s for the building where X is longitudinal axis, and for soil Ts= 0.41s.

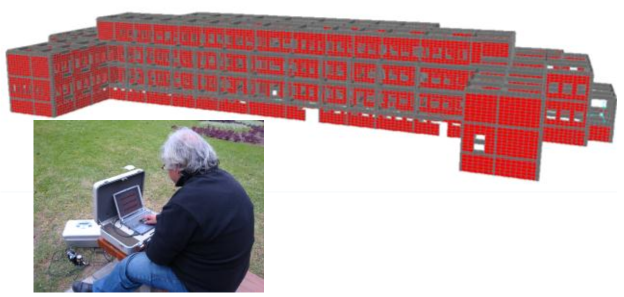


Figure 5 Preliminary measurement and analysis: microtremor and modeling

2.2 Central block of G2 building at Civil Engineering Faculty of UNI

Central Block G2 Bldg of Civil Engineering Faculty (FIC) is a 58 year old, reinforced concrete framed, 3-stories (10m high) structure with one underground floor. Half of its typical plan continue down to a basement floor. First floor is the main entrance hall, and upper levels are for classroom and corridors. So, in plan shown regular configuration (28m x 12m approximately), but some masonry thick walls (250mm) not aligned, in upper levels, changes its stiffness at each story (soft floor).

Figure 6 Location of Central Block G2 in FIC and South side view of building

Previous studies and evaluation has shown some reference values for natural period of building: From microtremor measurement (2007) Tx (longitudinal direction): 0.195s, and Ty (short direction): 1.62s

Preliminary analysis confirms a weak first level with greater relative displacements. Observing damage and failure at columns before than beams. From theoretical elastic analysis, it was obtained periods of 0.31s for first mode, which model is shown in figure 7

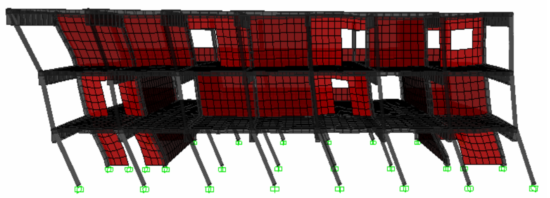
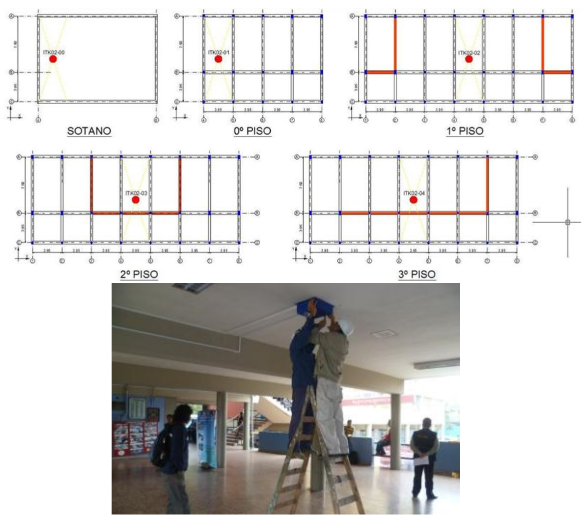


Figure 7 Modeling G2 building and deformed configuration

Setting of sensors was located at center of gravity in plan, aligned in a vertical line, and is shown in figure 8

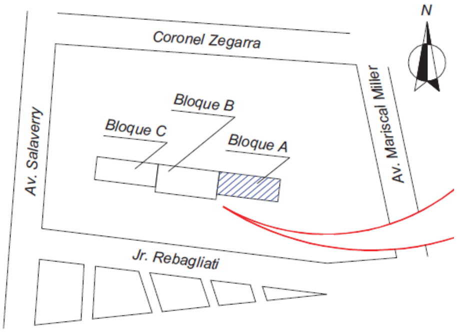


Figures 8 Central Block in G2 FIC and setting of sensors to the ceiling (below)

2.3 Edgardo. Rebagliati Martins Hospital - Building A (East block)

This 14F, reinforced concrete building, 55year old, beard 2 main earthquakes (1966 and 1974), but main structure have not been damaged. “A-Block” was focused for this study and is the right block show in Figure 9. Dimensions in plan are 15.9m x 73m, and 45.6m high from ground level with 14F

Figure 9 E Rebagliati Hospital and studied block



As reference also for this building exist two previous studies: evaluation 1997 and more detailed, non linear analysis conducted for a thesis research. For intermediate level earthquake, predicted damage are expected in beams in both directions of analysis, endangering inmediatly occupancy or interrupting normal performing of functions as hospital

3. DATA ADQUISITION FROM RECENT EVENTS AND RESULTS

Since the installation of the sensors, seven moderate quakes has been registered in the network. In table 1 is shown a official List of Earthquake registered by IGP National Network in November and December 2012. Lightened row of table 1, was registered as 2.6 max response at upper level in the network notice, as shown in Figure 10.

Table 1 List of Earthquake registered, Nov&Dec 2012 Lima studied block

	Date	Time	Magnitude	Intensidad - localidades
1	03/11/2012	20:52:12	4.7 ML	III-IV Yauyos; III Lima
2	13/11/2012	00:48:58	4.0 ML	II Lima
3	15/11/2012	19:21:55	4.8 ML	III San Vicente de Cañete, Chincha Alta; II-III Lunahuana; II Lima, Ica
4	27/11/2012	04:19:59	4.4 ML	III Barranca; III II Huacho; II Lima
5	22/12/2012	01:43:39	4.2 ML	II Chila, Lima
6	28/12/2012	20:57:40	4.3 ML	II-III Huaral, Lima
7	31/12/2012	03:46:17	4.7 ML	III-IV Huacho III Lima


Event data of PRU01
TrigTime : [PRU01]12/12/31_03:46:46_MAX2.6

itk00 : 1.6
itk01 : 1.9
itk02 : 2.1
itk03 : 2.1
itk04 : 2.6

Sensor-pabellon mailing list
Sensor-pabellon@cismid-uni.org
http://cismid-uni.org/mailman/listinfo/sensor-pabellon_c

Figure 10 Notice of registered event at ITK network for UNI building

Additional data of this event to process: Depth 53Km, Latitude -11.42ºS; Longitude -77.92º

Data for G2-FIC building has been processed. Figures 11 and 12 show signal at basement and 4F. It is possible to read that acceleration on the top of the building reach a value of 20 gal, almost 3.3 times the basement acceleration.

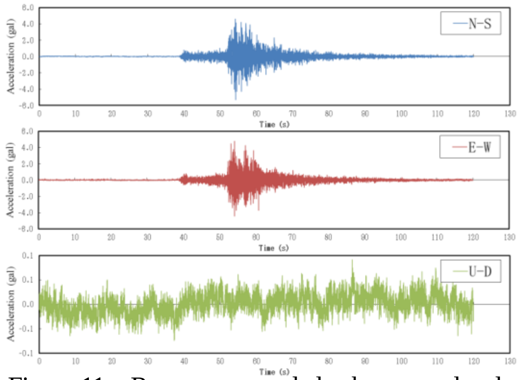


Figure 11 Response recorded at basement level

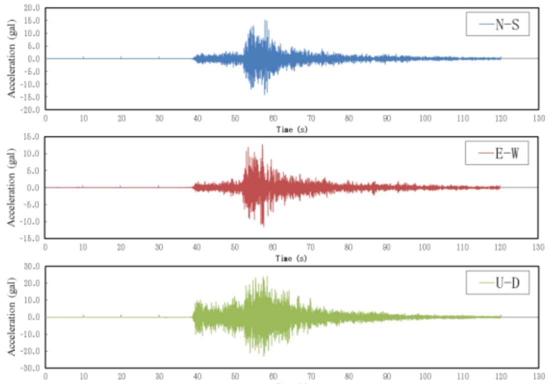


Figure 12 Response recorded at 4F level

Response of each level has been processed. Figure 13 shows predominant modal distribution and a large displacement evidence very flexible N-S direction compared with E-W.

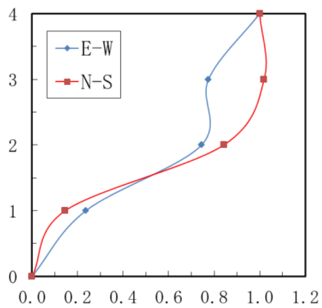


Figure 13 Predominant modal distribution

Table 2 shows predominant period for each direction of analysis. Values of periods for mode 2 in this table agree with previous measurements (see item 2.2)

Table 2 Predominant periods (s) for each direction

mode	EW	NS
1	0.22	0.23
2	0.19	0.16
3	0.15	0.12

Figures 14 and 15 shows spectra (acceleration and velocity) for basement level measurements

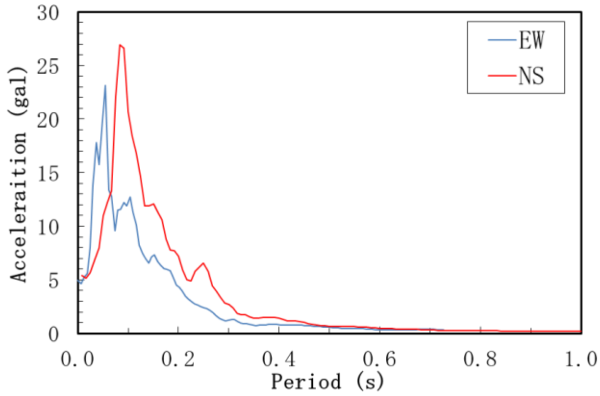


Figure 14 Acceleration spectra (h=0.05). signal from basement

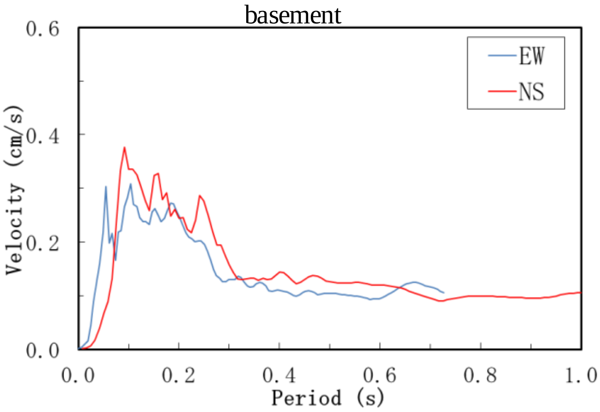


Figure 15 Velocity spectra (h=0.05). signal from basement

Both figures presents peaks values at the predominant periods and components of acceleration reach a maximum spectral component for a range between 22 to 27 gals for each direction of the building. Also the velocity indicates a peak value between 0.3 s. to 0.38 s. for this building.

4. CONCLUSIONS

First building monitoring network has been installed and is working at the present time in Lima Peru, as an output of the Project for Enhancement of Earthquake and Tsunami Disaster Mitigation Technology in Peru (JICA/JST), under the cooperation scheme of SATREPS.

Three sets of five sensors have been installed in Lima city. Two on buildings at UNI campus and other set at Edgardo Rebagliatti Hospital. The instalation process has been presented and the sensors are now on line.

Monitoring response of one of selected buildings and the dynamic characteristics measure from the events has been presented. Good agreement with simulation previously performed was found, and the results give us the confidence for the developed of parameters for the stiffness degradation under small and moderate quakes for concrete framed structures.

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