2718

EFFECTS OF DISTANT AND LARGE MAGNITUDE EARTHQUAKES ON THE TALLEST BUILDINGS IN BUENOS AIRES CITY

Juan S CARMONA[1], Cristian SISTERNA[2], Nora SABBIONE[3], Marcelo MAGRINI[4], Raquel PALAU[5], Luisa GARCIA[6] And Roberto PINCIROLI[7]

SUMMARY

The evaluation of the motion amplitude of the highest buildings in Buenos Aires city, the capital of the Argentine Republic, generated by the seismic events whose magnitudes are over 7 and the epicenters of which are located at more than one thousand kilometers, are presented hereby.

Buenos Aires city is located on an extended plane area. Because the seismic activity around this city is low, the motion due to distant and large magnitude seismic events with epicenters in western Argentina or in Chile, are more frequently perceived on the upper levels of tall buildings in Buenos Aires city, some of them generating strong alarm.

In order to estimate the amplitudes of these motions, the fundamental periods of six tall buildings, including the tallest one 160m heigh, have been obtained by microvibrations on the one hand and on the other, the evaluation and anlysis have been made of the response spectra of the accelerogram with maximum horizontal ground acceleration of 0.75 gal, recorded in one broadband seismograph located at La Plata city, near Buenos Aires, during the Mw=7.1(USGS-NEIC) October 15, 1997 Chilean earthquake, whose epicenter was 1300 km from Buenos Aires.

These horizontal components absolute acceleration response spectra analysed show important peaks at periods of 1.3 and 2.7 sec., while the period values of the tall buildings measured are larger than 1 sec and their maximun period reaches 2.7 sec for the tallest. In the upper levels of this tall buildings the absolute acceleration amplitudes of the motion generated by this eartquake reach nearly 10 gals and it lasts more than one minute. This explains why the distant and large magnitude seismic events have been perceived well and also with alarm on the uppermost floors of the tall buildings in Buenos Aires city.

INTRODUCTION

Buenos Aires city, the capital of the Argentine Republic, with a metropolitan population of nearly ten million inhabitants, is sited on the eastern side of an extended plane area formed by deep sedimentary alluvial soil layers, which are the Argentinian “pampas”. The seismic activity of the area is low. However, from the end of the past century when the number and height of the buildings increased, more occupants of the upper floors reported having felt the buildings motion caused by the large magnitude seismic events occurred in the western part of Argentina or in Chile, at distances longer than one thousand km from Buenos Aires. Although these motions have not damaged buildings yet, their amplitudes, frequencies and duration generated unpleasant emotions in their occupants and sometimes also strong alarm.

[1] *Earthquake Engineering Research Institute National University of San Juan Argentine Email:idia@unsj.edu.ar*
[2] *Earthquake Engineering Research Institute National University of San Juan Argentine Email:idia@unsj.edu.ar*
[3] *Department of Seismology National University of La Plata 1900 La Plata Argentine Email: nora@fcaglp.fcaglp.unlp.edu.ar*
[4] *Earthquake Engineering Research Institute National University of San Juan Argentine Email:idia@unsj.edu.ar*
[5] *Earthquake Engineering Research Institute National University of San Juan Argentine Email:idia@unsj.edu.ar*
[6] *Earthquake Engineering Research Institute National University of San Juan Argentine Email:idia@unsj.edu.ar*
[7] *Department of Seismology National University of La Plata 1900 La Plata Argentine Email: nora@fcaglp.fcaglp.unlp.edu.ar*

Since the Buenos Aires city tallest buildings are now over one hundred meters in height and moreover, taking into account that the seismic history of the western part of Argentina and the neighbouring territory of Chile shows that the occurrence of seismic events of a magnitude larger than Ms=8 are several times in a century, it is convenient to estimate the amplitudes of the motion of these buildings when they are shaken by the earthquake waves generated by these distant and large magnitude seismic events.

To this purpose, the fundamental periods of six tall buildings in Buenos Aires city, including the tallest one 160m high, has been obtained by microvibrations. On the other hand, evaluation and analysis have been carried out of the response spectra of the accelerogram with a maximun horizontal acceleration of 0,75 gal, recorded in one broadband seismograph located in La Plata city, near Buenos Aires, during the Mw =7.1(USGS-NEIC) October 15, 1997 Chilean earthquake whose epicenter was 1300 km from there.

SEISMIC GROUND MOTIONS IN BUENOS AIRES CITY AND ITS SEISMICITY

Seismic Ground Motions Felt in Buenos Aires City

Buenos Aires city is the largest and most populated metropolitan area in Argentina. It is located over the right side of the wide La Plata River, near one hundred km before its waters reach the Atlantic Ocean. After more than four hundred years from its foundation by the Spaniard conquerors in the XVI century, there are no memories of any earthquake that has shaken the area strongly producing damage and death. Only on few occasions have some earthquake motions been felt. The most important of them was the quake that occurred one century ago, at the first minutes of June 5, 1888 which shook the city with a IV Mercalli seismic intensity. According to the information about the perception of the ground motion, it was estimated that its epicenter was located on the Delta of the Paraná River, at about 30–40 km from Buenos Aires city, and its focus at normal depth while its magnitude was estimated in 4.4 [Gershanik, 1996].

Also, sometimes swinging earth motions with low amplitudes and relatively long period and duration have been felt at street level and they correspond to distant seismic events with large magnitudes. One of them is the October 27, 1894 Argentinian earthquake whose epicentral area was north-west of San Juan province territory, near the border with Chile, at 1100 km from Buenos Aires city. According to the extension of the damaged area and how far it was clearly felt, its magnitude was estimated as 7.7 [Gershanik, 1996] and therefore, it is the largest magnitude seismic event occurring in the Argentine territory since the Spanish conqueror times. On this opportunity, the newspaper La Nación edited in Buenos Aires reported about how it was perceived in this city ”...The ladies were the ones more impressed by the phenomenon. Many of them, who were walking on the street, suddenly felt sick and began looking for shelter in the entrance of the houses and in the shops ..”.

In addition to this, on several occasions, this swinging ground motion generated by distant seismic events with large magnitudes was clearly felt on the high levels of the tallest buildings in Buenos Aires city. Thus, La Nación, a centennial newspaper then, reported this behaviour during the Ms=7.2 January 15, 1944 Argentine earthquake which destroyed San Juan city and caused more than 8000 deaths. Its epicentral area was near this city, at 1000 km from Buenos Aires. Perhaps, the most unpleasant of these motions occurred during the Ms=7.4 November 23, 1977, San Juan, Argentine earthquake, whose epicenter was 950 km from Buenos Aires, [Carmona et al., 1978] in which many of the dwellers of the upper levels of the twenty- and thirty-storied buildings immediately fled away frightened.

The large magnitude seismic events mentioned before had their epicentral area at the western part of the Argentine territory. Similarly, the larger magnitude seismic events focused on the Chilean territory also were felt well on the upper levels of buildings in Buenos Aires city, such as during the world biggest Mw=9.6 May 22, 1960, south of Chile earthquake and also during the last of them occurred in March 3, 1985 in central Chile with Mw=7.9. To have an idea about the sensitivity of the occupants of tall buildings in Buenos Aires city in relation to distant seismic events, it is appropriate mentioning that the Mw=8.2 June 9, 1994, 650 km deep Bolivia earthquake, whose epicenter was 3000 km from Buenos Aires, was also slightly felt on some of its highest buildings.

Up to date, these motions on the upper floors of tall buildings in Buenos Aires city caused by large magnitude and distant seismic events have generated visible swinging of hanging pictures on walls and of lighting fittings hanging from the room ceilings or have generated the opening of office equipment doors and also the opening of drawers of offices and home furniture not locked; however, no building structural damage has been detected.

Regional Seismic Activity Around Buenos Aires City

Although seismic events at short epicentral distances from Buenos Aires city have been instrumentally recorded, their low magnitude did not generate motions clearly felt by its inhabitants. Thus, according to USGS-NEIC seismological information, during the last seventy years the nearest seismic event instrumentally recorded whose magnitude was 5.5 had 460 km as epicentral distance to Buenos Aires city, while for the Ms=6 event with depth lesser than 70 km, this epicentral distance increased to 560 km and to 950 km for the Ms=7 event.

This instrumentally seismological information obtained during the last seventy nine years about the area surrounding Buenos Aires city shows how low its seismicity is.

VIBRATION PERIODS OF TALL BUILDINGS IN BUENOS AIRES CITY

Tall Buildings in Buenos Aires city

As in every great urban concentration, Buenos Aires city has buildings of different heights, some of which are, at present, higher than 100 m, the tallest one rising to 160 m. The structures of these tall buildings are made of reinforced concrete and their foundations are adapted to the type of soil of the “pampa” plain over which they have been built.

The winds blowing in the area are relatively moderate though, on some occasions, they turn into tornados and, as it was previously described, its seismic activity is low. Due to these circumstances, the level of the horizontal forces with which the structures of the buildings in Buenos Aires city are designed is relatively small in comparison to those of other areas with known seismic activity. Besides, the structures resulting from tall buildings are quite less stiff than those of the buildings in other South American cities located in Andean areas.

In this opportunity, six of the Buenos Aires city tallest buildings were selected for the study of their dynamic characteristics. All of them have a floor plant pattern which is repeated in almost all its height so its geometrical description is simple. Other main characteristics of these buildings are[Carmona, Sisterna and Magrini, 1995]:

1. **Le Parc Tower Building**: Up to date, it is the tallest building in Argentina. It is 160 m high and it is located at the center of a square block. This building consists in: a technical mezzanine level, 43 typical stories, 4 duplex stories, 1 terrace roof with a water tank of 163 m^3, 1 level for elevators machine room, 1 terrace slab for a heliport and 2 basement levels, thus totalling 53 levels from the foundation floor. The slabs and the structure are made of reinforced concrete. The structure consists in interior shear walls and frames in its perimeter.

2. **Libertador 4440 Tower Building**: It is a 140 m high reinforced concrete structure building. Its supporting structure is made up of 2 reinforced concrete cores linked to each other. It is a slender building.

3. **Chacofi Building**: It is a 115 m high reinforced concrete building whose foundation is made of piles.

4. **Catalinas Norte Tower Building**: It is a square floor plant building with 27 stories and it is 108 m high. It is a slender and simple tall building. Its reinforced concrete structure layout is a central core and perimetral columns, with its foundation at 12m beneath the ground level.

5. **Bouchard Tower Building**: It is an office building with a square plant, the sides of which are 30 m long. It has 30 stories and a height of 100 m. It has a reinforced concrete structure with a square central core of 12 m in side and a group of 16 perimetral columns. Its foundation consists in piles of great diameter.

6. **Pirelli Tower Building**: From all the buildings hereby considered, it is the one with distinguishing features. It has a pentagonal floor plant nearly 100 m high. It has 20 stories of offices, 2 stories for general services one at mid height and the other near the top, 1 panoramic level and a heliport on the terrace. Its structure is a reinforced concrete one with a triangular plant core, upon which the two structural stories and a terrace coverage are supported. Each structural storey is made up of a set of 8 prestressed and postensioned cast-in-place concrete cantilever beams fixed in the central core. From each one of them 8 inferior stories are hanging.

Fundamental Horizontal Vibration Periods of Tall Buildings in Buenos Aires City

As the seismic motions are dynamic excitations over the buildings, their responses will be a consequence of their dynamic properties. Among the properties of these buildings, their vibration periods are one of the most important because they are the time units by which each building senses the variation in time of the excitation motion. For a better evaluation of the values of each building periods it is more convenient to make adequate dynamic tests on site.

In this opportunity, to evaluate the fundamental horizontal vibration periods of six of the tallest buildings in Buenos Aires city their horizontal microvibrations on the upper levels induced by environmental excitations have been recorded and analysed. This is a simple, easy and low cost method which is widely used, although it must be born in mind that its results correspond to very low excitation levels and could not be appropriate for higher levels of excitations. Its fundamental principies are the random characteristics of the environmental excitations on the one hand, and the building behaviour as a filter with low damping, on the other, which result in building motions on their upper floors with predominant components whose periods are very close to the building vibration periods. For this purpose, by means of a two channeled portable seismograph whose horizontal pendulum sensors with 2 sec natural periods were installed on one of the upper floors of each tested building, their horizontal microvibrations were transduced to electrical signals and then stored in digital mode at 200 samples per second. The measurements were extended during few minutes and repeated at different instants. Then, the clearest parts of the records thus obtained were selected and the numerical analysis corresponding to Fourier Transform were applied to them. Through this methodology, the largest horizontal vibration period value obtained on the buildings tested was 2.7 sec on the Le Parc Tower which is the tallest in Buenos Aires city.

In Table 1, the fundamental horizontal vibration periods obtained by the record and analysis of their environmental microvibrations are detailed, while in Figure 1 the values of these periods are presented as a function of the building height. The ratio resulting between the period and the corresponding building height is limited by the values 0.014 and 0.024 sec/m. These values are larger than those obtained in buildings of similar height with reinforced concrete structures built in seismic areas, where the horizontal strength requirements lead to structures with a higher stiffness.[Carmona and Herrera, 1969][Carmona, Sisterna and Magrini.,1995].

Table 1: Tall Buildings in Buenos Aires City
Fundamental Horizontal Vibration Periods Obtained from Environmental Microvibrations

BUILDING	HEIGHT (m)	PERIODS (sec.)	
		Direction 1	Direction 2
1 - LE PARC	160	2.7	2.3
2 – LIBERTADOR 4440	140	2.6	2.5
3 – CHACOFI	115	2	2
4 – CATALINAS NORTE	108	2.4	2.3
5 – BOUCHARD	100	1.8	1.8
6 – PIRELLI	100	2.4	2.2

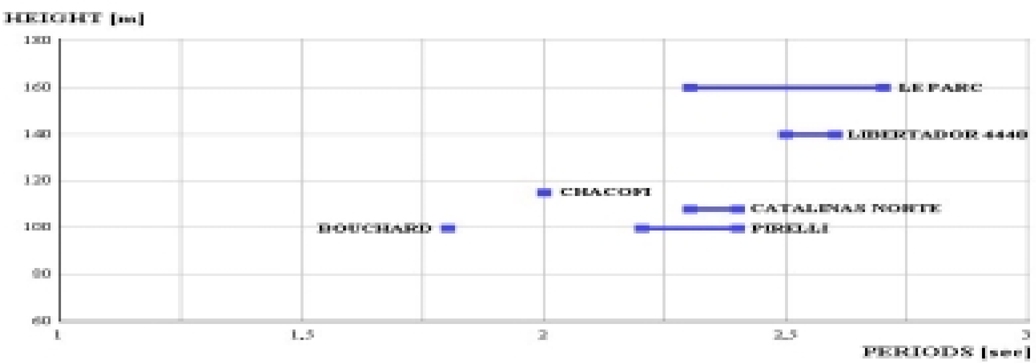

Figure 1- Tall Buildings in Buenos Aires City
Fundamental Horizontal Vibration Periods and Building Height

THE OCT. 15, 1997 CHILEAN EARTHQUAKE AND THE TALL BUILDINGS IN BUENOS AIRES

The October 15, 1997 Chilean Earthquake

In October 14, 1997, a few minutes after 22 hs local time, 1h Oct 15 UTC, the occupants of the upper levels of the tallest buildings in Buenos Aires city again perceived the unpleasant motion previously described though with a lower intensity than in previous occasions. In this case, the cause was the Mw = 7.1 (USGS-NEIC) seismic event which had taken place in central Chile. Pueblo Nuevo and Punitaqui with seven casualities were the most damaged towns. La Serena and Coquimbo cities were also slightly damaged. According to the USGS–NEIC seismological information, its origin time was 1h 03m 33.4s. UTC, while its epicentral coordinates were South Lat 30.93 and West Long 71.22 and 58km its focal depth, which gives an epicentral distance of approximately 1300km from Buenos Aires city.

As in previous occasions, this last event caused no damage to city buildings in Buenos Aires, only alarm among the inhabitants of the higher floors of tall buildings. Other cities in Argentina were also shaken by this 1997 Chilean earthquake, different alarm levels being generated among their inhabitants. However, it caused no damage or casualties. In the Argentine provincial capital nearest to the epicentral area, i.e. San Juan city, located 250 km from the epicenter, the ground motion caused alarm due both to its duration, almost a minute, and to its waves with a period near to one second. It neither caused damage nor casualties, its intensity being estimated as V in Mercalli Modified Scale. One simple Wilmot Seismoscope with 0.7 sec period and 10% of damping installed in this city recorded this earthquake ground motion with an acceleration spectral value of 0.03g.

The October 15, 1997 Earthquake Acceleration Record in La Plata City

Although since 1920 Seismological Stations have been in operation in Buenos Aires city and also in La Plata city, separated 50 km one from the other, due to its low seismicity, neither in Buenos Aires city area nor in other surrounding cities were there any strong motion accelerographs installed. The prior large magnitude and distant earthquakes which were felt in the tallest buildings in Buenos Aires city saturated the recording capabilities of the seismological instruments installed in the area and so no information could be obtained about the amplitudes, frequencies and durations of the ground motions generated in Buenos Aires city by those important seismic events. However, in this occasion, a broadband seismograph had already been installed in the Seismological Station of the National University of La Plata which is located in the N-E quadrant of La Plata city. It was working with the proper sensitivity for these ground motion intensities, which allowed recording the evolution on time of the acceleration in the three components of the motion. The tranducers were placed 5 m. below the ground level. The soil of this area is an alluvial coast type plain consisting of quaternary loess with a thickness of approximately 500 m.[Russo et al., 1979] As the transducers are placed on this noisy soil and, also, as it is near La Plata city center, a relatively high level microvibration cultural ground noise is detected in this Station [Pinciroli, Sabbione and Rosa, 1997]]. Hence, the instrument sensitivity was not its greatest but, on this occasion, it was the suitable one in order to record the whole movement due to this Mw = 7.1 Oct 15, 1997 Chilean seismic event, with an epicentral area at 1300 km far from the instrument site location.

At the time of this Chilean earthquake occurrence, the record digital value sequence was 10 samples per second, corresponding to an interval of 0.1 sec between the samples. This interval is relatively large if accelerograms of epicentral areas aimed at the dynamic analysis of buildings are required. However, this interval is appropriate to analyse the responses of vibration systems with periods greater than 1 sec. as the buildings studied in this analysis have. Figure 2 shows the 360 sec most important part of the three components of this acceleration record obtained in the Seismological Station of the National University of La Plata with the described instrument. The strongest part of the ground motion lasted approximately 100 sec in the N-S component, which is the most intense, and their maximum acceleration values measured in gal =cm/sec^2 are:

$$A_{max}\,(N\text{-}S) = 0{,}75\,\text{gal};\quad A_{max}(E\text{-}W) = 0{,}53\,\text{gal};\quad A_{max}(V) = 0{,}27\,\text{gal}.$$

These maxima horizontal accelerations are aproximately only one thousand the maximun accelerations in epicentral areas of earthquakes whose magnitudes are similar to this Chilean seismic event. On the other hand, these low acceleration values explain why this motion has not been felt at the ground level in Buenos Aires city.

The Absolute Acceleration Response Spectra Curves of La Plata Record

Figure 3 shows the absolute acceleration response spectra curves for 2% of damping and periods ranging between 0.7 and 5 sec, which correspond to each one of the three components of the acceleration record obtained

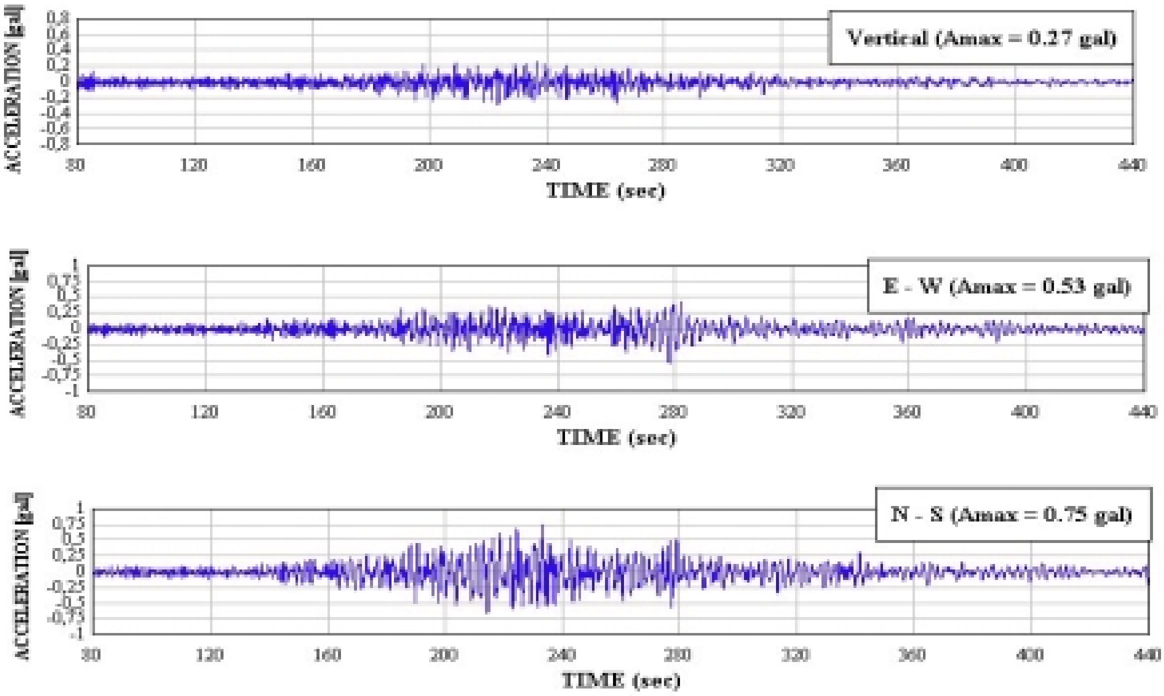

Figure 2 – Ground Motion Acceleration recorded in La Plata city during Oct 15, 1997 Chilean earhquake.

in La Plata Seismological Station during the Mw=7.1 Oct 15, 1997 Chilean seismic event at 1300 km epicentral distance from it.

The curves corresponding to the horizontal components show peaks at near 1.2 sec and 2.7 sec, whose values are 6 and 8 times larger than its maximum acceleration component and a minimum of 3 times for periods between them, showing how relevant the amplification of the motion is as a consequence of the duration of the strongest part of the ground motion shown in Figure 2.

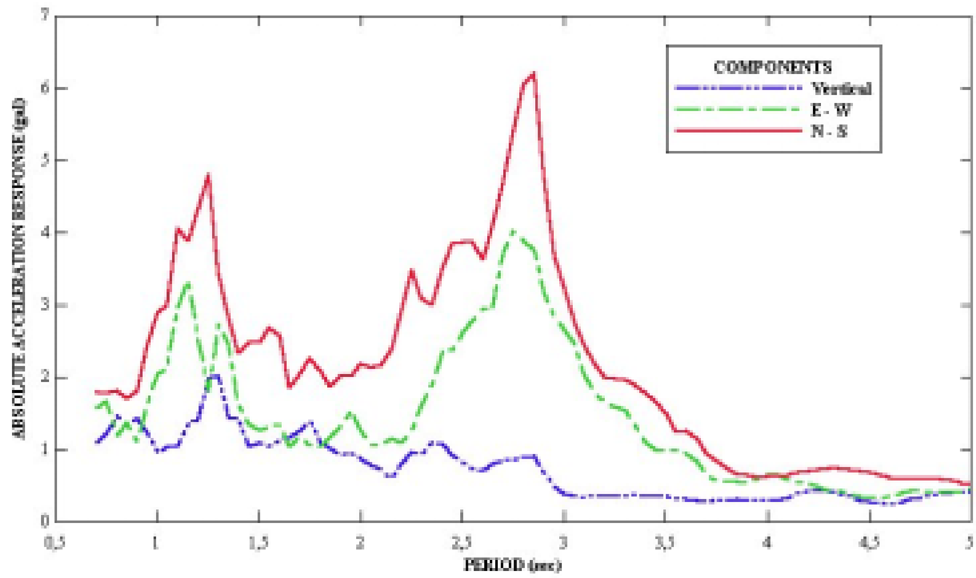

Figure 3 – Damping 2% Absolute Acceleration Response curves of Figure 2 La Plata record

The Motion on the Upper Levels of the Tallest Buildings in Buenos Aires City

In order to evaluate the motion amplitudes on the upper levels of the tallest buildings in Buenos Aires city during the Oct 15, 1997 Chilean earthquake, some assumptions will be made, which are:

The acceleration record shown in Figure 2, obtained in La Plata city, would be similar in frequency and amplitude distributions to the acceleration time history occurred during this earthquake in each one of the foundation level of the tall buildings sites of Buenos Aires city here studied. This is an appropriate assumption because both cities, Buenos Aires and La Plata, are located over plain lands whose soil layers several hundred meters deep are similar and corresponding to the Argentinian “pampas” [Russo et al., 1979]. In addition, there is 50 km distance between these cities, which is smaller than the 1300km distance from La Plata city to the epicentral area of this seismic event and so the difference on the attenuation of seismic waves amplitude was small.

1. As the building motions were relatively small, the tall buildings dynamic properties during this earthquake were similar to that when their environmental microvibrations were recorded. As a consequence, their fundamental vibration period values are those detailed in Table 1 and included in Figure 1.

2. The modal damping values of the first vibration modes of each of the buildings were near 2%. This value, and even a minor one down to 1.5%, were obtained from the analysis of the environmental microvibrations recorded in the tall buildings here studied and also in other studies.[Carmona and Herrera, 1969].

With these assumptions in mind, in order to evaluate the amplitudes of absolute acceleration motions generated by this Chilean earthquake on the upper levels of the tallest buildings in Buenos Aires city, the absolute acceleration response values of the curves shown in Figure 3 can be employed, but with the amplification which corresponds to the upper levels of the fundamental mode shapes of each building. These values are not lesser than 1.4 for the buildings with nearly uniform masses distribution in height. Hence, from the peak values of Figure 3 the maximum acceleration amplitudes of the absolute motions on the upper levels of the buildings in Buenos aires during the Mw=7.1 Oct 15, 1997 Chilean seismic event reach approximately 7 and 9.5 gals for those buildings with fundamental vibration periods near 1.2 and 2.7 sec and a minimum of nearly 2 gals for periods between them. These acceleration values are something like 9 and 11 times larger than its maximum ground acceleration component value and show how large the influence exerted by the building structural dynamic behaviour on the amplification of this type of earthquake ground motion could be over the resulting motion on the upper levels of the tallest buildings in Buenos Aires city.

The Distant and Large Magnitude Earthquakes and the Tall Buildings in Buenos Aires.

The Oct. 15, 1997 Chilean seismic event had a magnitude Mw=7.1 and its epicenter was located nearly 1300 km from Buenos Aires city. This value of magnitude is lesser than those corresponding to other seismic events with their epicenters also in Chilean territory but that were felt with more intensity in tall buildings in Buenos Aires city and also slightly on their city area ground levels. On the other hand, other seismic events with similar or a bit larger magnitudes to this Oct. 15, 1997 event, but with their epicenters at the western part of Argentine whose distances to Buenos Aires city are nearly 1000 km, have also been felt with more intensity in the tall buildings of this city than it was in Oct 15, 1997.

As consequence on the fact that the period of the peaks shown in the absolute acceleration response curves, Figure 3, of the accelegram recorded in La Plata city, Figure 2, are inside the range of the period values of the tall buildings in Buenos Aires city detailed in Table 1, the largest amplitudes on these buildings are generated by the seismic waves whose periods are around 1.2 and 2.7 sec. Around the 1.2 sec period value the peak appears in each acceleration component curve, horizontal or vertical, but around 2.7 sec the peak is only in the horizontal component curves and larger in the north-south direction. It means that the waves with period about 2.7 sec, to which the largest absolute acceleration response value correspond, are horizontally polarized in the tranverse direction in which the seismic waves generated by this Oct 15, 1997 Chilean seismic event are propagating. From this brief analysis, it is concluded that the larger amplitude motions in the taller buildings in Buenos Aires city caused by distant and large magnitude seismic events are generated by their body waves and surfaces Lg waves. A measure of the power of the Lg waves contained in an accelerogram is the evaluation of the magnitude mb(Lg) by means of the definition given by Nuttli for Eastern North America.[Nuttli, 1973]:

$$mb(Lg) = \log.A(D) + mb(D) + mb(0) \tag{1}$$

where: A(D) is amplitud waves recorded on the site at epicentral distance D, the second term represents the influence of the attenuation due to distance D on the Lg wave amplitudes and mb(0) is the reference constant value. Similarly to local and body wave magnitudes, this Lg magnitude also presents the saturation of its value in relation to the increase of the seismic event size, a peculiarity which begins approximately on Mw=6.4-6.6 and is fully developed approximately on Mw=7.1-7.3. Therefore

a-If the magnitude saturation is presented in the evaluation of mb(Lg) from the instrumental records obtained in Buenos Aires or in La Plata cities, other seismic events at equal epicentral distance D to the Oct 15, 1997 but with larger magnitude than the Mw=7.1 which corresponds to this Chilean earthquake, will increase its log.A(D) only in a value approximately larger than 0.2-0.3 and then the A(D) value for larger Chilean magnitude events would be twice this one.

b-In the same way, if a larger magnitude seismic event is located at lesser epicentral distance to Buenos Aires city than the 1300km of Oct. 15, 1997 earthquake and the saturation of the mb(Lg) magnitude occurred, then the log.A(D) could be increased in the same amount as the second term would decrease. If the attenuation value for Lg waves in Central North America is used[Nuttli, 1973], the decreased on the second term value would be 0.2 and hence the total increase as a consequence of both effects, that is the saturation on magnitude and the lesser epicentral distance, would be 0.5 the value for log.A(D), and so A(D) would be increased to nearly three times the maximum ground aceleration of La Plata record during Oct 15, 1997 Chilean seismic event.

Another important fact, perhaps the most unpleasand for the upper floor occupants of tall buildings in Buenos Aires city when a distant and larger than Mw=8 magnitude seismic event occurs, is the relatively long duration of the acceleration time history envelope as a consequence of the important duration in time rupture in the source and the scattering of the seismic waves.

CONCLUSIONS

Regard to the motion amplitude on the upper levels of the tallest buildings in Buenos aires city as consequence of distant and large magnitude seismic event, the absolute acceleration response curves, Figure 3, of the accelerogram, Figure 2, obtained in La Plata city, separated 50 km from Buenos Aires and with similar soil layer profile, during the Mw=7.1 Oct 15, 1997 Chilean earthquake have shown that:

1- The absolute acceleration peaks are around 1.2 and 2.7 sec. and these values are inside the range of the vibration period values of the tall buildings in Buenos Aires city detailed in Table 1. Hence, in tall buildings whose periods are larger than 1 sec the acceleration amplitude of the motion on their upper levels are until 10 times the maximum ground acceleration and their duration reach to a few minutes.

2- For others larger Chilean magnitude events, these motion amplitudes on the upper levels would increase twice and this increase would be three times for others also more larger seismic events with lesser epicentral distance and located in the western part of Argentine. Therefore the occupants of the upper levels of the tallest buildings in Buenos Aires city would perceive an absolute acceleration as large as 30 gals during few minutes in these largest magnitude earthquakes, generating strong alarm on them and also getting panicky.

REFERENCES

Carmona, J.S. and Herrera J. (1969), “Periods of Buildings of Mendoza City (Argentina)”, *Proceedings IV World Conference on Earthquake Engineering*, Santiago, Chile.

Carmona, J. S. et. al.(1978), “El Sismo de Caucete, San Juan, Argentina, del 23 de noviembre de 1977 y la Seguridad que Proveen las Normas Sismorresistentes”, *Proceedings Seminario Internacional de Preparación para Atención de Catástrofes* - Viña del Mar, Chile.

Carmona, J. S., Sisterna, C. A. and Magrini, M.C.,(1995) “Periodos de Vibración Medidos en Edificios Torre de la Ciudad de Buenos Aires con Altura Mayor de 100 m.”, *Proceedings XXVII Jornadas Sudamericanas de Ingeniería Estructural*, Tucumán, Argentina, Vol. 6, pp561-571.

Gershanik, S.(1996), *Sismología*, Universidad Nacional de La Plata, pp789-790.

Nuttli, O.W.(1973) “Seismic wave attenuation and magnitude relations for eastern North America”, *J. Geophys. Res.*,78, pp876-885.

Pinciroli, R., Sabbione, N. and Rosa, M.L.,(1997) “Aspectos del Ruido Sísmico en la Estación LPA”, *Proceedings 19ª Reunión Científica de Geofísica y Geodesia*, San Juan, Argentina, pp237-241.

Russo, A, et al.,(1979) “Llanura Chaco Pampeana”, *Proceedings Segundo Simposio de Geología Regional Argentina*, Academia Nacional de Ciencias, Córdoba, Argentina, Vol. I, pp139-183.