SEISMIC VULNERABILITY OF TELMEX TELEPHONIC CENTRALS

Antonio Gutiérrez*, Jesús Iglesias**, Ambrosio López*, Bernardo Gómez**, Rocío Robledo*, José Juan Guerrero**, Jorge Aguilar**, Mario Ramírez** and Francisco Rivero**

ABSTRACT

This paper describes a screening methodology for the study of the seismic vulnerability of TELMEX telephonic centrals. This methodology is being used to define retrofitting priorities and to develop plans for the optimal use of the economic resources destined to increase the security of the centrals.

Introduction

The Mexico City telephone service, founded in 1932 by Telefonos de Mexico (TELMEX), evolved in time into a centralized national telephonic network highly vulnerable to earthquakes. As a consequence, the severe damage suffered by Victoria and San Juan centrals left the country without communications with the rest of the world during the 1985 earthquake.

In response to the 1985 earthquake, TELMEX decided to decentralize the long distance service into two new traffic centers in Mexico City and several more all over the country. At the same time, all the damaged telephonic centrals and those most important located in high seismicity zones were retrofitted. As a result of this process, the two real-estate TELMEX subsidiaries: Compañía de Teléfonos y Bienes Raíces (CTBR) and Alquiladora de Casas (ALDECA), have retrofitted 111 telephonic centrals up to date.

Once the emergency response to the 1985 earthquake was finished, TELMEX decided to develop a more broad retrofitting strategy, with the purpose of reducing the seismic vulnerability of the more than 8,000 buildings owned by the company in Mexico. This strategy and the obtained results are presented in this work.

Methodology

Figure 1 summarizes the methodology adopted to reduce the seismic vulnerability of TELMEX infrastructure.

The methodology begins with the structures classification, considering the importance of

*Compañía de Teléfonos y Bienes Raíces, S.A. de C.V., Av. Universidad 1311, 4º Piso, México 03000, D.F.
**Cande Ingenieros S.A., Clemente Orozco 18, Col. Ciudad de los Deportes, México 03710, D.F.

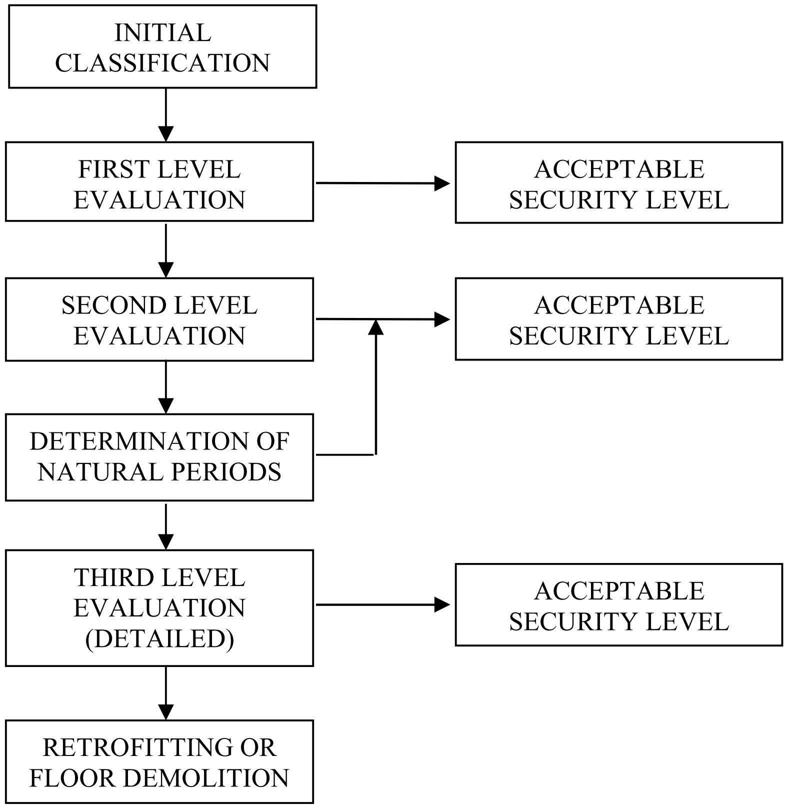

Figure 1. Methodology for the reduction of the seismic vulnerability of telephonic centrals.

the telephone service provided and the seismic risk associated to them. Following the order defined by this classification, up to two levels of simplified evaluation of the seismic capacity of the buildings are used to distinguish those which need a detailed analysis that could finally lead to a retrofitting project or to the demolition of upper floors.

Figure 1 describes a screening process in which the buildings pass through several levels of evaluation of their seismic capacity, each one with increasing precision and cost, to identify the more vulnerable, thus optimizing the economic resources available. In some cases, the determination of the natural periods of soil and structure allows to increase the second level precision. This methodology was developed based on the experience obtained by the Mexico City authorities after 1985 in their effort to reduce the seismic vulnerability of Mexico City (Noreña, Castañeda and Iglesias, 1989).

Initial Classification

Importance of the Telephone Service

The importance of the local service provided by each central and its long distance capacity was first considered. The centrals were classified from 1 to 5, in order of decreasing importance, considering the geographic coverage, the number of telephone lines controlled and the social importance of customers such as hospitals, banks and other strategic institutions. In addition, all the centrals that are part of the long distance network were classified with the higher level of importance.

Seismic Risk

Only the seismic risk associated to the geographical location was considered in this work. For this purpose, a seismic risk map of Mexico was elaborated, based on different available studies (CFE, 1993; Esteva and Ordaz, 1988 and Figueroa, 1963). This map considers four zones, from A to D, in order of increasing risk.

Classification Criteria

Arbitrary values were assigned to each level of importance and to each risk zone to obtain a hierarchical classification of the telephonic centrals. The product of these values allows the classification of the centrals by defining 20 different categories (Table 1). The values associated with the risk zones vary from 8 to 64 according to the seismic coefficients proposed by the studies considered. The values proposed for the importance of the service were arbitrarily chosen such that the maximum importance level in a seismic risk zone leads to a classification value greater than the two lower values of the next more risky zone. In this way, a central in zone C, with an importance level of 1, has a classification value of 2048, greater than other in zone D but with an importance level of only 4 and a value of 1920.

Table 1. Classification values for the telephonic centrals.

		Seismic risk zones			
		D	C	B	A
Importance level		64	32	16	8
1	64	4096	2048	1024	512
2	52	3328	1664	832	416
3	42	2688	1344	672	336
4	30	1920	960	480	240
5	22	1408	704	352	176

First Level Evaluation

This evaluation level is based on a visual inspection of the buildings with the purpose of assigning a value to each of the following indexes:

I. Structural configuration in plan.
II. Structural configuration in elevation.
III. Foundation problems.

IV. Location.
V. Maintenance.

A value of 2, 1 or 0 is assigned to each index, in decreasing order of importance of the observed problems. The sum of the five values defines the security level "S", which allows a decision for the need of a second level evaluation. The criteria described are presented with more detail in Iglesias, 1989.

Second Level Evaluation

This evaluation level requires a more detailed inspection than the first one, with emphasis in the detection of previous damage, the basic geometry of the buildings and the cross sectional areas of the vertical structural elements. With all this information, it is possible to calculate the base shear coefficient corresponding to the failure of the structure "K" and to compare this value with the design coefficient for the seismic zone in which it is located "KS", proposed by the seismic risk studies available (Trigos, 1988; Esteva and Ordaz, 1988; CFE, 1993; Iglesias et al, 1995). When the security level, defined as the ratio K/KS, is less than unity, it is necessary to proceed with the third level evaluation.

Determination of Natural Periods

The knowledge of the dynamic characteristics of the foundation soil is needed to define the structures intensity design coefficient. Although there are some cities in Mexico with seismic zonation studies (Iglesias et al, 1995), for most of them the inspection of the site to get a broad estimation of the soil type is the only alternative. In general, if the building is on a topographical elevation it is considered on firm soil, for other cases it is considered on intermediate soil and on soft soil only if there is additional information.

The determination of the natural periods of soil and structures, by means of microtremor analysis techniques, allows a better knowledge of them, enhance the precision of the second level evaluation and, in some cases, leads to reclassify the soil.

Third Level Evaluation

The first and second levels of evaluation are based on cheap, simplified and rapid methods that allow us to identify those cases in which it is a priority to perform the detailed evaluation at a higher cost.

The detailed evaluation is based on obtaining the seismic capacity of the structure using the conventional methods of analysis and design of the professional practice. The results may lead to a retrofitting project or to the demolition of some of the upper floors. In many cases the last alternative is very attractive, because the telephone modernization has changed the old electro-mechanic devices to new digital equipment, with less weight and volume, leaving great empty spaces in the telephonic centrals.

Results

It was decided to begin this work studying the 415 telephonic centrals built before 1986 that had not been retrofitted yet. In doing this, it was considered that the earthquake capacity of buildings in Mexico increased after the 1985 earthquake, as a consequence of the changes introduced in the engineering practice. These 415 centrals, together with the 111 that have been retrofitted to date, control almost 80% of the telephone service in Mexico.

Initial Classification

The hierarchical classification of the 415 centrals defined the 20 categories shown in table 2:

Table 2. Classification of the telephonic centrals.

Priority	Category	Centrals	Priority	Category	Centrals
1	D-1	5	11	B-2	3
2	D-2	2	12	C-5	58
3	D-3	1	13	B-3	4
4	C-1	28	14	A-1	21
5	D-4	1	15	B-4	14
6	C-2	4	16	A-2	15
7	D-5	25	17	B-5	79
8	C-3	12	18	A-3	7
9	B-1	24	19	A-4	19
10	C-4	32	20	A-5	61

Based on these results, a plan for using the screening methodology over six groups of decreasing priority was developed for the years 1999 and 2000:

Table 3. Plan for the seismic evaluation of the telephonic centrals.

Group	Categories	Centrals	Year
1	D1, D2, D3, C1, D4, C2, D5	66	2000
2	C3, B1, C4	68	2000
3	B2, C5	61	2001
4	B3, A1, B4, A2	54	2001
5	B5, A3	86	2002
6	A4, A5	80	2002

Simplified Evaluation

Due to the fact that most of the centrals are far from Mexico City and the cost to visit them is higher than that of their evaluation analysis, the first and second level evaluations will be done for the first three groups to avoid a second visit. For the groups with less priority, the second level evaluation will be done only in those cases recommended by the first level result.

A total of 91 telephonic centrals from groups 1 and 2 have been evaluated to date, according to the plan of table 3. The obtained ratios K/KS vary between 0.17 and 6.30. In 44 centrals, 48% of the total, the ratio K/KS is greater than one and are not considered for a detailed evaluation, the average security level "S" for these centrals is 2.71 and 3.67 for the rest.

Determination of Natural Periods

To enhance the results of the second level evaluation it was decided to obtain the natural periods of the soil and the structure from those centrals with a ratio K/KS less than 0.70. The natural periods have been determined for 17 of the 91 studied centrals and only in one case the results led to reclassify the soil type as soft soil, thus increasing the priority of the central.

Conclusions

A methodology to study the seismic vulnerability of TELMEX telephonic centrals has been presented. The results obtained to date, from applying this methodology to a group of 415 telephonic centrals, illustrates the advantages of this procedure for defining rational plans for the evaluation and retrofitting of groups of buildings while optimizing the economic resources. When the first stage of this project is finished, the seismic vulnerability of the centrals that control 80 % of the telephone service in Mexico will be notably reduced.

References

CFE (1993), "*Manual de diseño de obras civiles. Diseño por sismo*", Comisión Federal de Electricidad, México.

Esteva, L. and Ordaz, M. (1988), "Riesgo sísmico y espectros de diseño en la República Mexicana", *Memorias del Tercer Simposio Nacional Sobre Ingeniería Sísmica,* SMIS, October 30-31, Guadalajara, Jalisco, pp. 420-458.

Figueroa J. (1963), "Isosistas de macrosismos mexicanos", *Revista Ingeniería*, Vol. 33: 1, pp. 45-67.

Iglesias J. (1989), "Evaluación de edificios de concreto en la Ciudad de México", *Construcción y Tecnología*, Vol. 2: 15, pp. 19-26.

Iglesias J. et al. (1995), "Seismic zonation of cities in Mexico", *Proceedings of the Fifth International Conference on Seismic Zonation,* EERI, October 17-18, Nice, France, pp. 573-579.

Noreña F., Castañeda, C. and Iglesias J. (1989), "Evaluation of the seismic capacity of buildings in Mexico City", *Earthquake Spectra,* EERI, Vol. 5:1, pp 19-24.

Trigos J.L. (1988), "Riesgo sísmico, construcciones y reglamentos en México", *Memorias del Tercer Simposio Nacional sobre Ingeniería Sísmica*, SMIS, October 30-31, Guadalajara, Jalisco, pp. 323-345.