13th World Conference on Earthquake Engineering
Vancouver, B.C., Canada
August 1-6, 2004
Paper No. 945

SEISMIC VULNERABILITY ASSESSMENT FOR *COLONIA ROMA* IN MEXICO CITY

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SUMMARY

Cities with soft soil alluvial deposits which are affected by earthquake activity are those near seismic epicentral regions. Many of these cities are significant in population. Historical and antique buildings, unreinforced adobe and masonry structures, with more than one hundred years old are easily encountered with signs of seismic patterns carved upon them.

Mexico city is affected by at least 5 seismic sources, where amplifications of ground motion have been observed, peek ground motions are found to be greater, in some cases, in *Colonia Roma*, (*Roma*).

A methodology to evaluate the seismic vulnerability for *Colonia Roma* in Mexico city is discussed in this paper. The methodology includes: a definition of a studied zone (*Colonia Roma*); a detailed database of its residential and public buildings; this article also presents response spectral characteristics and attenuation relationships for peak ground acceleration for inter-plate, intra-plate and shallow-crustal earthquakes, earthquake hazard analysis, and seismic vulnerability assessment; estimations of losses and damages in specific regions of the studied zones; and earthquake risk scenarios. This information will be useful to government agencies, which should be aware of the expenses that they should provide in order to mitigate damages in future earthquakes in Mexico city.

INTRODUCTION

The mexican earthquakes occurred in 1985 caused severe damage in Mexico city, damages were spread in different zones of the city, particularly in the *Colonia Roma*, which is one of the oldest urban sectors in the city. The *Colonia Roma* is located near the downtown area of Mexico city, it is located in the soft soil (zone III), lakebed zone of the city, *Reglamento de Construcciones del Distrito Federal*, [1]. This sector of the city has been considered as one of the most vulnerable of the city, due to the ground motion amplification, and the local settlements observed in some of the structures of the *Roma*, these are some reasons why the buildings have shown poor seismic behavior.

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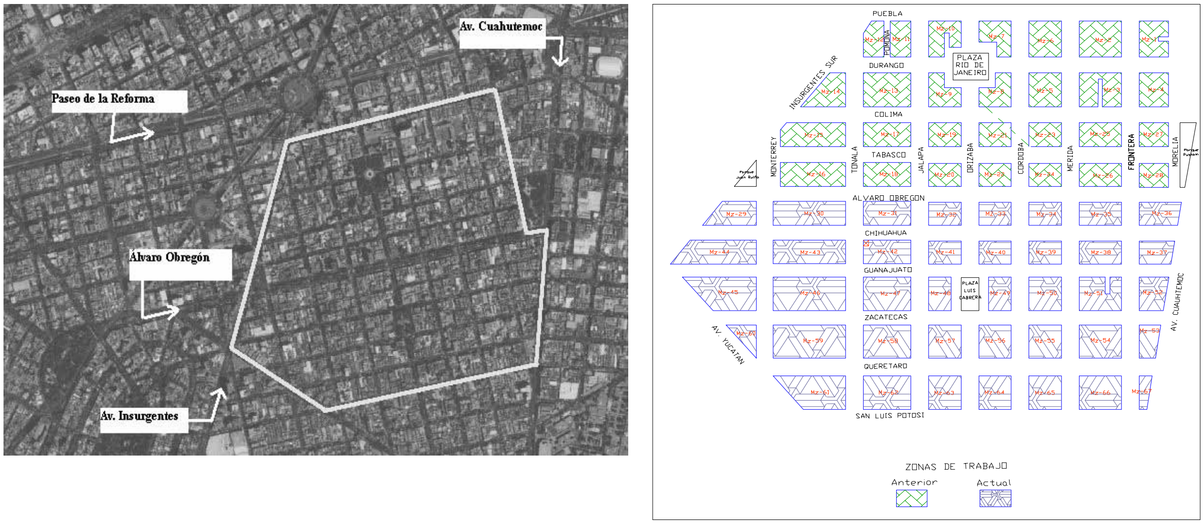


Figure 1. Studied zone for the *Colonia Roma*.

A structural census along with a structural characterization were constructed for more than 1400 structures in the *Roma*, damage grades and vulnerability classes were established for every building. The structures were studied in one of the most affected areas by the 1985 and other historical earthquakes. This is one of the most studied zones of Mexico city, and many seismic research have been conducted since 1957.

In this paper attenuation relationships are presented for Mexican earthquakes. Three types of earthquakes are considered, inter-plate, intra-plate, and crustal-shallow earthquakes. Subduction zone inter-plate earthquakes have been considered as shallow angle thrust events, that occur at the interface between the subducting and overriding plates, such as the 1985 September earthquake (M8.1). Intraplate earthquakes, high angle normal faulting events, occur within the subducting plate, responding to downdip tension in the subducting plate. Examples include the 1997 January earthquake (M7), and the 1999 June earthquake (M7). Shallow crustal earthquakes that occur in the upper 5 to 20 km of continental crust. Examples include the February, 25 1996 (M7.1), and the July, 17 1997 (M6.9).

Some researchers have published attenuation relationships (e. g. Iwasaki et al. [2]; Crouse [3]) indicating that ground motions from inter-plate and intra-plate events, are substancially larger than those from shallow-crustal events. However, other authors believe that the ground motions from interface earthquakes and shallow crustal events are similar, at least in Japanese earthquakes (Fukushima and Tanaka [4]). In this paper we study the data of Mexican earthquakes with moment magnitude larger than M6, in order to define attenuation relationships for these three different groups.

METHODOLOGY

Studied zone

The methodology used in this study involved field work by trained technical personnel, that demands human, technical and economical resources. The selected zone of the Roma, (figure 1), was selected by a bibliographic research on the 1985 earthquake, [5], the buildings reportedly damaged, and the statistical research for masonry structures conducted by Otani and Endo [6], in 1985.

Census

It was necessary to design formats in order to use them by trained personnel, and to collect the information of buildings in a clear, complete and quick manner. In the format it was included the typical characteristics of structures: Location, Structural information, Non structural elements, and Photograph information.

Database

The data collected was put into a digital database, which is useful to gather, resume, correlate and depict data into charts and graphics, the database formats shows the general information for every building.

In the database the structures were gather together by material of construction; however, every type of material (masonry, concrete and steel), shows different structural characteristics for the same group; in the table presented below there are different characteristics for every construction material, table 1.

Table 1. Structural characteristics

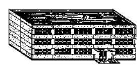
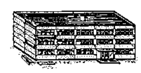
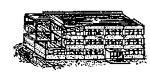
Use by story	Construction material	Structure	Floor system	Foundation
Housing	Steel	Bearing walls	Sheet steel	Box girder
Garage	Reinforced masonry	Frames	Slab	Adobe footing
Commercial first floor, housing for upper floors	Unreinforced masonry	Concrete walls	Waffle slab	Stone footing
Commercial and housing first floor	Precast concrete	Solid slab	Wooden floors and clay tiles	Foundation piles
Community services	Concrete	Frames and bearing walls	Others	Wooden piles
Commerce	Others	Combined structure	Without roof	Without foundation
Public service		Waffle slab	*Vigueta y bovedilla*	Simple spread footing
No structure		*Vigueta y bovedilla*		Mat foundation
		Wooden walls		
		Wooden floor system		
		No structure		

CLASSIFICATION OF THE STRUCTURAL CHARACTERISTICS OF THE *COLONIA ROMA*

Vulnerability classes and damage degrees

According to the European Macroseismic Scale (EMS), (Grünthal, [7]), the vulnerability classes are: A, highest; B. High; C, medium; D. low; E, lower; F, no vulnerability. There are 5 damage degrees (DD), according to EMS, in this paper it was included the DD for masonry and concrete structures. The DD for masonry structures in the EMS do not exactly represent those of the *Roma*, which have been recognized as heterogenic masonry structures; however the EMS is also a graphic scale, which has been used with some considerations, regarding those differences in masonry structural techniques used in the *Roma*. Regarding the concrete structures of the *Roma* and those DD of the EMS, there were no significant differences between them, and the graphic scale was used without further considerations, table 2.

Table 2. Damage degrees

Type of structure	**DD 1**	**DD 2**	**DD 3**	**DD 4**	**DD 5**
Masonry					
Concrete					

Masonry structures of the *Colonia Roma*

The quality of the materials is very heterogeneous in the masonry structures in the zone of study for the *Roma*, it depends on the materials (clay, concrete, etc) and on the fabrication methods involved in the production of the different types of bricks. In the studied zone it was possible to identify many of those bricks: adobe, stone, concrete, clay, extrusion bricks, among others. The mechanical properties for the masonry is very different from brick wall to brick wall, that it would be very difficult to determine the mechanical and seismic properties from one to another. For example, the mortar used in the brick walls is very important in the mechanical and seismic properties, that using a poor quality mortar with heavy concrete bricks can lead to poor bearing resistance stresses on the concrete brick wall. Those characteristics should be taken into account in order to define the proper vulnerability classes for masonry structures.

Structural elements that provide lateral strength to walls is another characteristic to be considered in the proper seismic behavior of masonry structures, it depends on quantity, quality and accurate seismic design of them. In the masonry structures found in the *Roma* there are antique buildings without or with scarce lateral resistance elements; and therefore all these structures have different seismic behaviors. There are also masonry structures made of heavy thick brick walls, but with flexible floor systems, that have shown poor seismic performance, and then their seismic resistance is questionable.

Concrete structures of the *Colonia Roma*

Concrete structures are also very different in the *Roma* depending on their seismic design, and therefore it is difficult to establish a simple classification guide for them. However, a classification has been constructed, based on: seismic design, age of construction, level of technical and engineering advice; all these factors are important to assess the earthquake resistance values of the concrete structures. It is also observed that many of the heavily damage or collapsed structures in the 1985 earthquakes, were substituted by concrete structures which were designed and constructed with new seismic codes, and so it is considered that these buildings will show accurate seismic performance in future earthquakes.

RESULTS

Table 3. Masonry structures for *Colonia Roma*

Structure type		**Stories**		**Floor System**		**Foundation**		**Use by story**	
Bearing walls	955	0	13	Sheet steel	20	Combined footing	225	Housing	499
Combined Structures	5	1	151	Slab	538	Masonry footing	736	Garage	36
Walls	40	2	518	Wooden beams and clay tiles	396	Without footing	35	Commercial FF, Housing	184
		3	273	Vigueta Bovedilla	4	Simple spread footing	4	Community services	53
		4	41	Others	1			Commerce	91
		5	2	Without roof	40			Public service	117
		6	1					No structure	20
		>6	1						

Table 4. Concrete structures for *Colonia Roma*

Structure type		Stories		Floor System		Foundation		Use by story	
Concrete frames and bracing elements	4	1	1	Slab	388	Mat foundation	248	Housing	157
Concrete frames	140	2	12	Waffle slab	40	Box girder	175	Garage	3
Concrete walls	17	3	52			Foundation piles	3	Commercial FF, Housing UF	137
Concrete frames and masonry walls	267	4	110			Simple spread footing	2	Community services	43
		5	134					Commerce	25
		6	59					Public service	63
		7	21						
		8	23						
		>8	16						

1439 structures were studied at the *Roma*: 959 masonry structures (66.6%), 428 concrete structures (29.7%), 8 steel structures (0.6%). In this paper the only concrete and masonry structures will be the only structures considered, but the whole information will be available in a future research investigation report at the Universidad Autónoma Metropolitana.

Table 5. List of earthquakes used in this study.

No	Date	M_w	Depth	Lat. N., -Lon. W	No. stations	Fault type	
1	64/07/06	6.7*	100	18.030, 100.770	-	Intra-plate	C
2	65/08/23	7.0*	33	15.380, 96.120	-	Inter-plate	B1
3	68/08/02	7.1*	33	16.070, 98.100	-	Inter-plate	B1
4	78/11/29	7.8	16.1	16.000, 96.690	-	Inter-plate	B2
5	79/03/14	7.4	26.7	17.490, 101.26	11	Inter-plate	A
6	80/10/24	7.1	63.4	18.030, 98.290	-	Intra-plate	C
7	81/10/25	7.2	31.8	17.880, 102.15	-	Intra-plate	C
8	82/06/7[a]	6.9	10.7	16.170, 98.360	-	Inter-plate	B1
9	82/06/7b	6.9	18.6	16.260, 98.510	-	Inter-plate	B1
10	85/09/19	8.1	21.3	18.081, 102.942	30	Inter-plate	A
11	85/09/21	7.5	20.8	18.021, 101.479	26	Inter-plate	A
12	86/04/30	6.9	20.7	18.024, 103.057	15	Inter-plate	A
13	88/02/2	5.8	47.8	17.494, 101.57	28	Intra-plate	C
14	89/04/25	7.0	15.0	16.603, 99.400	43	Inter-plate	B2
15	90/05/31	5.9	26	17.106, 100.893	54	Inter-plate	
16	93/05/15	6.0	38.5	16.430, 98.740	30	Inter-plate	B1
17	93/09/10	7.2	29.1	14.140, 92.820	10	Inter-plate	B2
18	93/10/24	6.6	21.8	16.540, 98.980	44	Inter-plate	B1
19	94/03/14	6.9	167.6	15.670, 93.010	-	Intra-plate	D
20	94/05/23	6.2	69.6	18.030, 100.570	54	Intra-plate	C
21	94/12/10	6.4	54.0	18.020, 101.56	53	Intra-plate	C
22	95/09/14	7.4	21.8	16.310, 98.880	36	Inter-plate	B2
23	95/10/09	8.0	5.0	18.740, 104.67	34	Crustal	E
24	95/10/21	7.2	163.8	16.920, 93.620	19	Intra-plate	D
25	96/02/25	7.1	5.0	15.830, 98.250	20	Crustal	E
26	96/07/15	6.8	22.4	17.450, 101.16	54	Inter-plate	A
27	97/01/11	7.2	40.0	17.910, 103.04	55	Intra-plate	C
28	97/05/22	6.5	55.5	18.41, 101.81	44	Intra-plate	C
29	97/07/19	6.9	5.0	16.860, 98.350	-	Crustal	E
30	98/02/03	6.3	24	15.69, 96.37	22	Inter-plate	B
31	98/04/20	5.9	59.9	18.37, 101.21	46	Intra-plate	C
32	99/06/15	7.0	69.2	18.180, 97.510	67	Intra-plate	C
33	99/06/21	6.3	48	17.99, 101.72	45	Intra-plate	C
34	99/09/30	7.5	46.8	15.950, 97.030	60	Intra-plate	C
35	99/12/29	5.9	50	18.02, 101.68	27	Intra-plate	C
36	03/01/21	7.6	32.6	18.220, 104.60	-	Inter-plate	A

Source : Servicio Sismológico Nacional, Harvard centroid moment tensor solutions y BMDSF. * = Ms

Masonry structures are divided into 2 groups: Reinforced masonry and unreinforced masonry structures. The reinforced masonry structure is the predominant type of construction in the studied zone (65%) of the Roma. The typical building is a low rise building (1 to 4 floors), used for commerce and housing purposes.

Concrete structures are made of concrete frames and concrete slabs, in some cases they have masonry walls, used as infill panels. The typical structure is a medium rise building, (5 to 10 floors), used for housing and business purposes. Those buildings with masonry walls reinforced with beams and columns with greater dimensions than those of the *castillos* and *dalas*, were considered as concrete structures.

ATTENUATION RELATIONS FOR MEXICAN EARTHQUAKES

Seismic Database

The data from 36 Mexican earthquakes occurred between 1964 and 1999, used in these investigation, are compiled in Table 5, where is indicated the moment magnitude, M_w, and the focal depth. The moment magnitudes in the database are between 6.0 and 8.1. The fault type is classified into three categories: inter-plate, intra-plate and crustal earthquakes. All these earthquakes have been recorded in zone I (hard and rock soils) of Mexico City, almost everyone recorded at the accelographic station at *Ciudad Universitaria* of UNAM. Location of the epicenters of the source were compiled from Mexican Base of Strong Earthquakes [8], other parameters of the earthquakes, focal depth, and moment magnitude, M_w, were compiled from special publications of *Harvard Centroid Moment Tensor Solutions*. Differences among Intra-plate, Inter-plate and shallow crustal earthquakes in recent publications of the Institute of Geophysical of the UNAM and of *Harvard Centroid Moment Tensor Solutions* are shown in figure 2. The distance from the source to the accelerographic site is the distance from the fault surface to the considered site, the distance from the epicenter was used when no further information was obtained. The strong ground motion data was recorded at free field stations, or stations within small buildings where soil structure interaction effects are negligible.

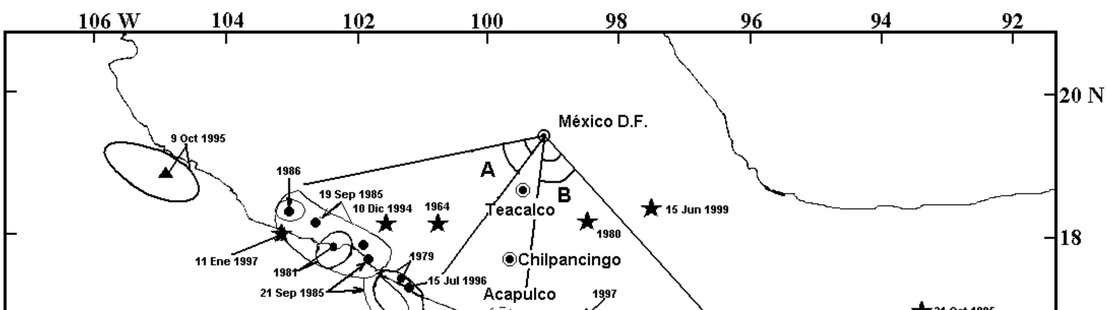


Figure 2. Mexico map showing the location of the earthquakes used in this study, the events are classified as: INTER-PLATE (circle). INTRA-PLATE (star), and SHALLOW-CRUSTAL (triangle).

Mathematical Model in regression analyses

Relations of attenuation for peak ground horizontal and vertical accelerations were evaluated with the selected information. The information corresponds to earthquakes with stations spatially distributed throughout the seismic wave passage from the source, which implies a total group of 25 events. These events can be identified in Table 6 by the number of recording stations, for this study seismic data from stations located at lakebed and transition zones of Mexico City (Zone III and Zone II) were not considered, as well as those located on compressible soft soils, like Chilpancingo; that is to say, this study considers stations on rock and hard soils.

The attenuation model used in the analysis is based on the distance to the fault, and is given by:

$$\log PGA = b - \log (DX + c) - k\, DX \qquad (1)$$

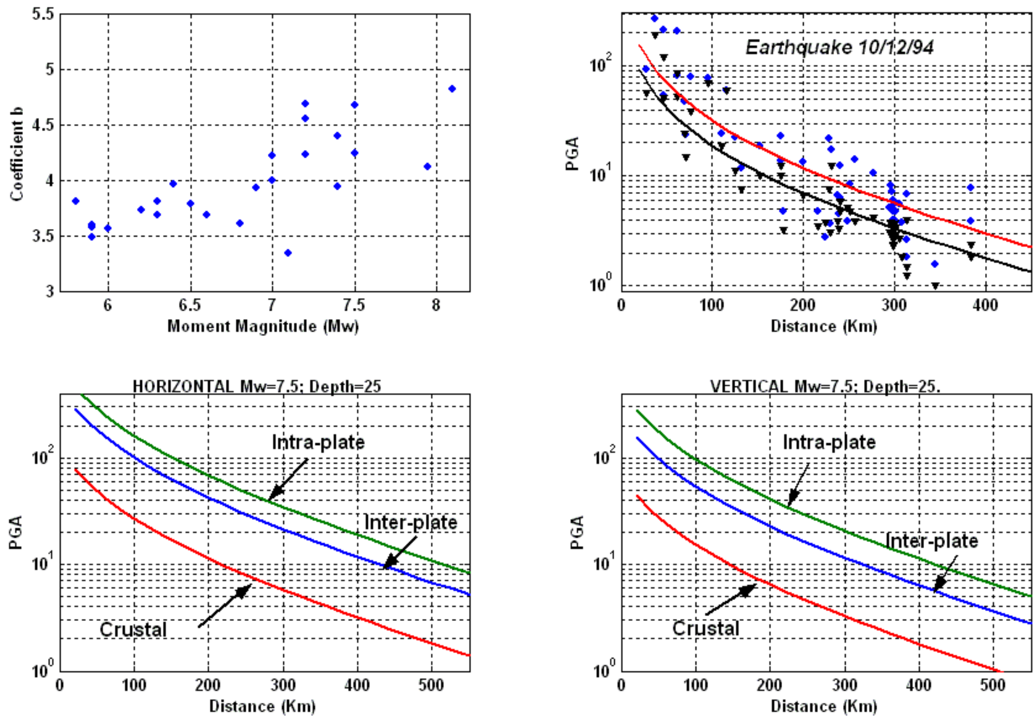


Figure 3. *Top and left*. Coefficient b vs. moment magnitude. *Top and right*. Example of fitting the data with the regression model. *Bottom*. Predicted attenuation curves.

Where, PGA is the peak ground acceleration, DX is the distance to the fault, in km. Coefficient b, is a factor of counterbalance for each earthquake. The second term considers geometric attenuation, whereas third term represents damping attenuation. Factor k was assigned equal to 0.0015 for inter-plate and crustal events, and 0.0025 for intra-plate earthquakes. Besides, coefficient c takes into account the saturation from the amplitude by proximity from the source, and considers a distance effective that is increased with the magnitude, and is given like:

$$c = 0.0055\ 10^{0.525\ Mw} \qquad (2)$$

Procedure

In the development of the attenuation functions, a two stages regression method was followed according to Si and Midorikawa [9]. First, the regression analysis with equations (1) and (2) is applied to each one of the 25 events, in order to determine the value of coefficient b. Then, with the moment magnitude, M_w, the fault type and the focal depth, coefficient b was defined with a second regression analysis, using the following equation:

$$b = aM_w + d\,H + \sum e_i\,S_i + f + \varepsilon \qquad (3)$$

Where H, is the focal depth in km; S_i the fault type; ε the standard deviation; a, d, e_i and f are coefficients of regression; S_i , a dummy factor, with the value of 1 for each fault type and 0 for others.

Table 6. Regresion coefficients (equation 3).

Component	**a**	**d**	**e_1**	**e_2**	**e_3**	**F**
Horizontal	0.6066	0.0021	-0.0944	0.1120	-0.6633	-0.1868
Vertical	0.6042	0.0019	-0.1735	0.0793	-0.7215	-0.3531

e_1 – Inter-plate; **e_2** – intra-plate; **e_3** – shallow crustal.

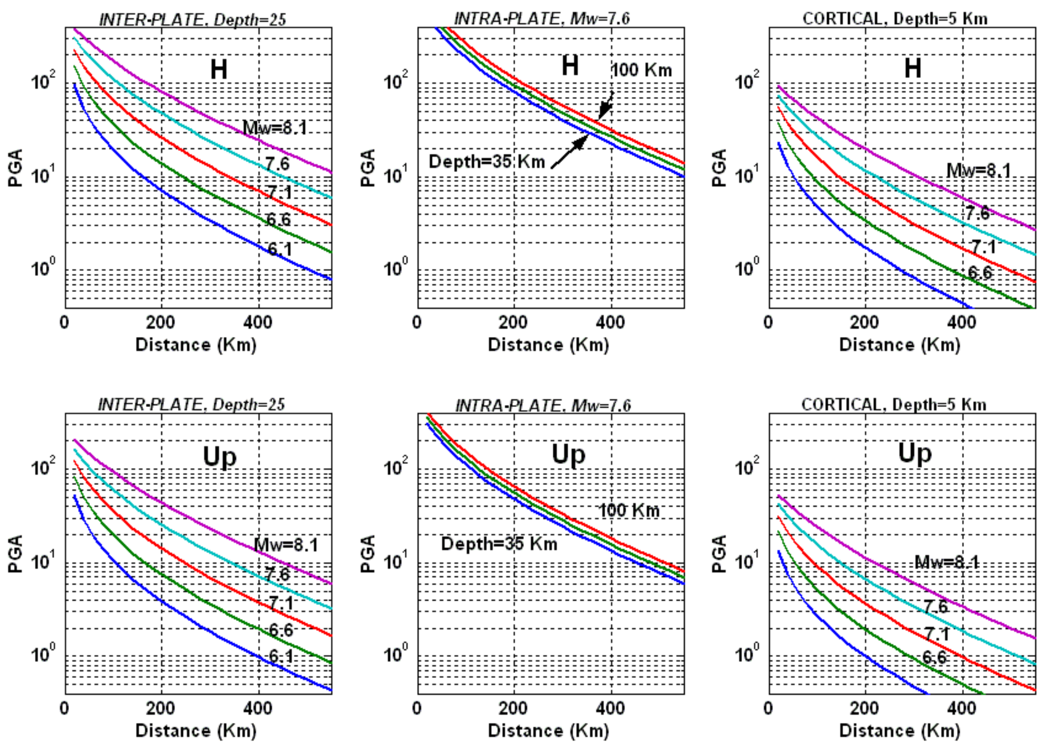


Figure 4. The effects of fault type and focal depth on strong ground motion.

Results

While applying equations (1) and (2) for the 25 selected earthquakes, the value of coefficient b for each case was determined, like an example, Figure 3 (above and right) show the curves of analysis of regression for the horizontal and vertical components of the earthquake of December, 10, 1994. In Figure 3 (above and left), a correlation between coefficient b and the moment magnitude is observed, nevertheless similar values of b for different magnitudes are obtained, and thus, other additional factors to the magnitude affect the movement; therefore, equation (3) is used as a second stage, the regression coefficients are indicated in Table 6.

The inferior part of Figure 3 shows the curves for the three groups, assuming a magnitude, M_w of 7.5 and a depth of 25 km. It is clearly seen that the earthquakes with intra-plate fault produce the highest acceleration values, on the contrary the shallow crustal events show lower acceleration values. For example, for a distance of 200 km, accelerations values are: 12, 40 and 68 cm/sec^2; therefore, for the same shallow events the acceleration values become the third part of an inter-plate acceleration value; and the inter-plate event generates acceleration values of 60 % of the intra-plate values. These results match with the acceleration values observed in the three crustal events studied in this group: October, 9 1995 (M_w=8.0), February, 25 1996 (M_w=7.1), and July, 17 1997 (M_w=6.9).

On the other hand, Figure 4, shows the attenuation curves for inter-plate earthquakes with magnitude values of 6.1 and 8.1 and with 25 km of depth. Figure 4 shows 6 curves for intra-plate events with magnitude 7.6 and depths between 35 and 100 km, the effect of the depth in the acceleration values is evident. For example according to Figure 4, in inter-plate events with distance of 200 km, the values of the accelerations are 75 and 110 cm/s^2 respectively for 35 and 100 km of depth. Shallow-crustal curves were calculated with Magnitudes between 6 and 8.1 and a depth of 5 km. The deeper the depth becomes the larger the acceleration values will be.

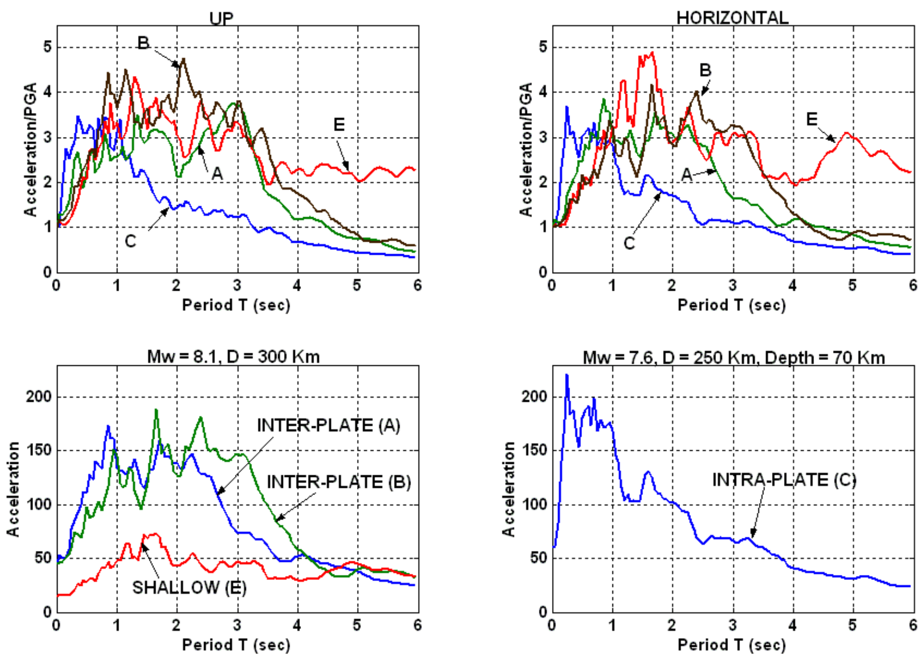


Figure 5. *Top*, comparison among average response spectra in the firm soil of Mexico City, for the different groups. *Bottom*, expected response spectra on firm soil.

SPECTRAL ANALYSIS

Acceleration Response spectra (2% of critical damping) of the vertical and horizontal components were calculated at stations SXCU, CU01, CUIP, CUP3, CUP4, CUP5, CENA, CHAS, CUIG and TACY. These stations are located in the Zone I of the southwest of Mexico City, site is located at *Ciudad Universitaria* of UNAM. The spectra were calculated separately for each one of the six groups indicated in Table 5 and in Figure 2. All the spectra were normalized with respect to the peak ground acceleration values. In Figure 5 (*top*), the average spectra for every component of the earthquakes (intra-plate (C), inter-plate (A and B) and very shallow crustal (E)) are compared. The most important aspects of this comparison are: 1) intra-plate events do not produce significant amplitudes in periods greater than 1 sec, but in shallow and inter-plate events, significant spectral ordinates are observed in high periods of the spectra (between 2 and 5 sec). 2) In events type A, B or E, the vertical spectral ordinates tendency is consistent in periods 2.5 and 3.5 sec. 3) In shallow earthquakes (E) there are high amplitudes between 4 and 6 sec, for the three components.

Calculated Response Spectra in *Colonia Roma*

Response spectra computed from several recorded motions at CO56 station, located in *Colonia Roma*, are shown in Figure 6. The curves correspond to six events of different intensities. The most intense event is the one of April 25 of 1989. These response spectra illustrate the pronounced effects of the Lakebed Zone soils: predominant soil periods are a consequence of a double resonance condition, amplification of the motion by the deep deposits and amplification by the superficial soil deposits. The CO56 site was underline by 35 m of soft clay soils with an average of 70 m/sec s-wave velocity; and by a consolidated clay soil layers of 1200 m with velocity values of 800 m/sec. Then four periods are considered: the fundamental major period of 2.9 sec, being the first set of periods; fundamental periods of deeper layers between 2.3 and 2.4 sec; and the fundamental natural vibration period of superficial deposits (shear beam) between 1.9 and 2.0 sec; and the second set of periods between 1.7 and 1.8 sec.

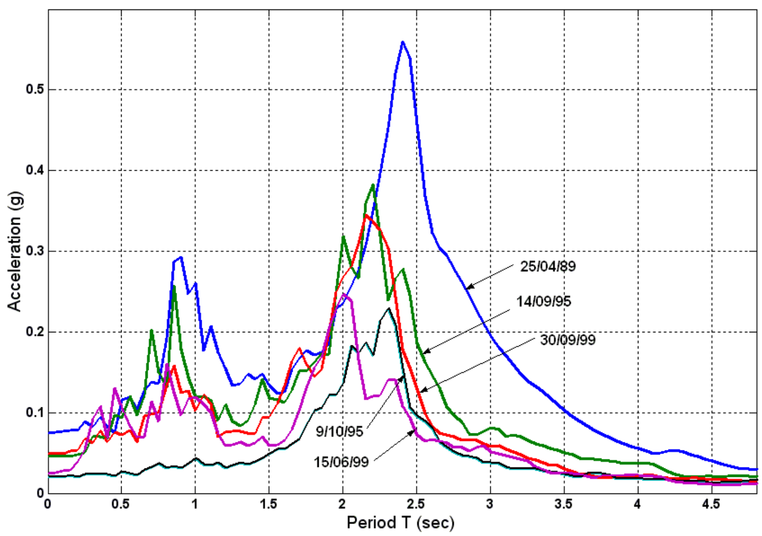


Figure 6. Response spectra (2% damping) computed from six recorded motions at CO56 station (*Colonia Roma*).

In the spectrum, in addition, the peak of the second part of the motion are conformed of four periods: 0.6 sec of the second mode of the superficial layers; 0.75 sec, is the period of the deep layers (Rayleigh waves identified in the vertical component); and 0.8 and 0.5 the two coupled periods.

When characteristic site periods are detected of each system in each site, it is possible to propose a general expression that defines response spectra, as has been studied by Gomez and Saragoni [10]. In order to define a response spectra in the *Colonia Roma*, and with basis in the peak ground acceleration, A_{max}, estimated above, spectral absolute acceleration of the ground is:

$$S_{ai}\,(T, \xi) = \log(A_{máx} / \xi) \;\; * \;\; \exp\,[\,-\,(2\pi / T_c \; + \alpha\,(T_c)^{1/2})^2 * (1 - (T/T_c)^2)]^2 \qquad (4)$$

Where:

S_{ai} - spectral acceleration at the considered site.
$A_{máx}$ - Maximum absolute acceleration of the ground.
T_c - predominant site period,
ξ - critical damping ratio of the spectra
α – is equal to 1 if $T < 3.0$ sec, and 3 if $T > 3.0$ sec

In order to obtain the complete response spectra, the effect of all the periods must be superposed, of the following way:

$$S_a (T,\xi) = \Sigma S_{ai} (T,\xi) \qquad (5)$$

The synthetic response spectra at *Colonia Roma* presented in Figure 7 was calculated for 5 % of the critical damping. Eigth curves were combined, one for each one of the periods defined in Figure 6, one of the superior system (2.1 sec), one of inferior (2.0 sec) and two of the complete system (2.6 and 1.6). The maximum peak ground acceleration was 0.23 g, according to the attenuation relationship obtained above on firm soil, and with basis in the ratio between the PGA recorded at the surface and at 102 m of depth in RMC station [4].

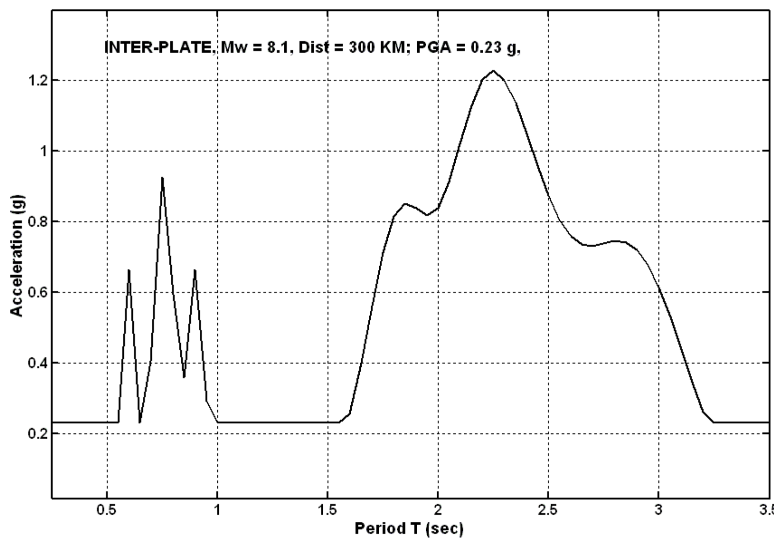


Figure 7 Calculated synthetic spectra of acceleration (5% damp.) in Colonia Roma of Lakebed zone, for an expected earthquake of Mw=8.1 with a distance of 300 km. The used periods were, T_{11}= 2.0 of the inferior layer, T_{21}= 2.1. T_{22}= 0.7 of superior layer and T_{31}= 2.6 and T_{32}= 1.6 of the set. The acceleration Maxima A_{max} it was 0.23 g

VULNERABILITY CLASSES AND DAMAGE DEGREES MAPS

Three types of maps were determined for the studied zone of the *Roma*: structural information and codes, vulnerability classes, and damage degree maps. These maps are useful because they show the spatial distribution of the structural, vulnerability and damage information for the 1439 structures studied in the *Roma*. The determination of the vulnerability classes, and the damage degrees will be used, along with a seismic hazard analysis, to establish damage degree maps for every risk scenery, and therefore emergency strategies could be assigned for particular zones and places of the *Roma*. If similar studies could be conducted in other urban sectors of Mexico city, then local and government agencies would be able to determine zones of maximum priority of emergency, and thus resources of rescue and emergency matter would be used accurately.

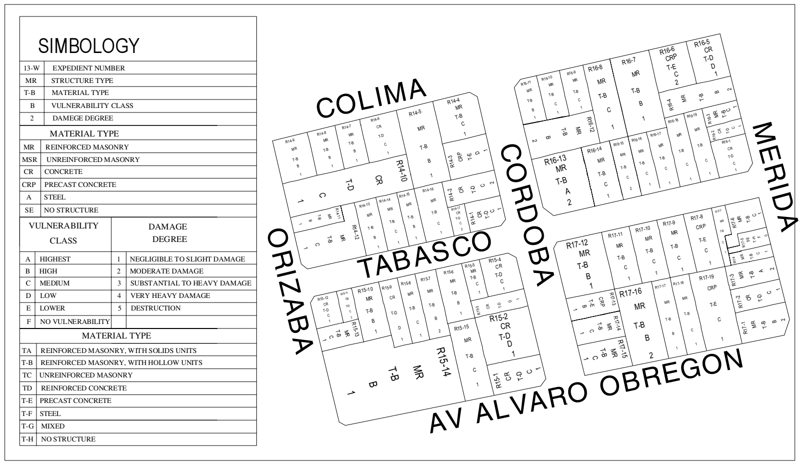


Figure 8. Information of the studied zone

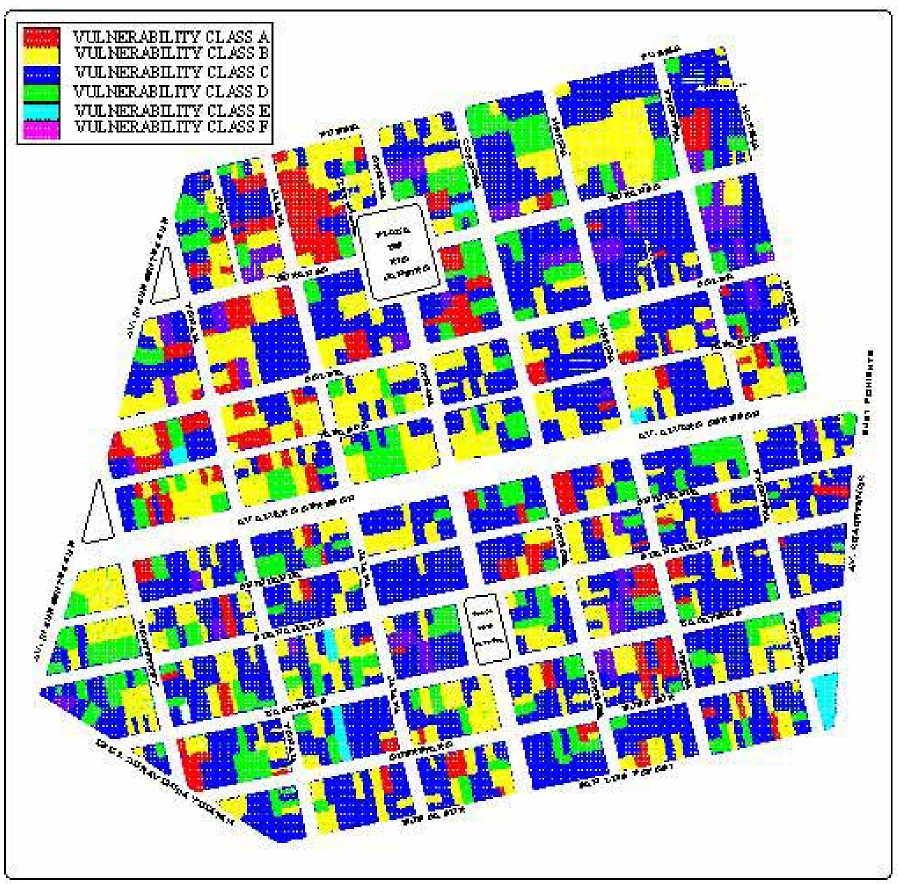


Figure 9. Vulnerability classes

***Colonia Roma* vulnerability classes and damage degree maps**

Vulnerability classes are shown in figure 9, the different types of vulnerability are depicted in the map, every type has a color pattern, the map was constructed assigning a vulnerability class to every structure.

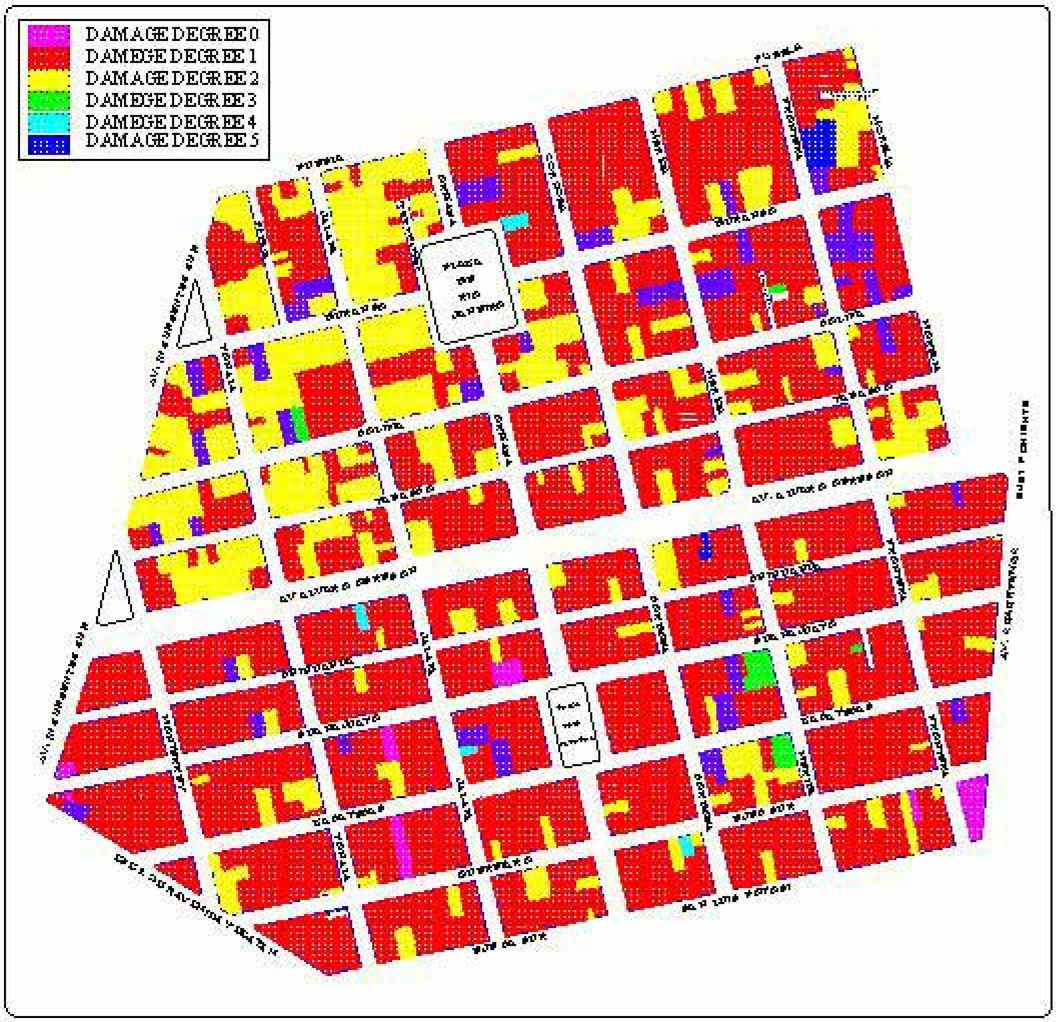


Figure 10. Damage degrees

Damage degrees are shown in figure 10, the color patterns represent a damage degree, and it can be observed the spatial distribution of the actual DD for every structure of the studied zone. This is a useful information for local and government agencies, such as *Proteccion Civil*, in order to establish prevention campaigns in the local community, and to reduce the vulnerability for buildings in the Roma.

Sometimes it was not possible to assign DD to structures, because no damages were encountered, but age of the building and poor maintenance lead to a DD equal to 1.

CONCLUSSIONS

In this paper a partial seismic risk study is presented for a specific zone of the *Colonia Roma*. Another paper pointing out the structural characteristics of the Roma has been carried out by Arellano, Juarez, Gomez-Bernal and others, [11], this research will be continued in the *Colonia Roma* of Mexico City. The Mexico city has sectors that have been considered as vulnerable, and these studies should be carried out in other zones of the city; it also should be considered the diversity of structures and types of construction materials that exist in the city. In the subsequent phases of the study of vulnerability and seismic risk, it is important to select all of the characteristics of the structures in the *Roma*. The characteristics could be obtained with a census and a database in other zones of the *Roma*, and thus complementing the DD and vulnerability maps, so that the maps of risk will cover a greater geographical extension. However, a great percentage of structures in the *Roma* are made of masonry, with diversity in the characteristics of material and in their structural settings; this procedure requires of large economic and human resources. The advantage of this procedure is that provides maps, as the ones shown in this paper, detailing classes of vulnerability, actual degrees of damage for each risk scenery. In an economical point of view and according to government priorities, it is important that these types of study should concentrate in the type A structures of the mexican seismic codes.

This information is very useful, because preventive (reduction of seismic vulnerability) and emergency (shelters) measurements could be put into action in order to reduce the public resources use in earthquake events. These types of seismic risk studies help to understand the seismic behavior of structures, and in general the global seismic behavior of structures in certain zones of the city, which are known to be vulnerable, so that strategies can be organized in order to reduce damages in future earthquakes, as those that periodically affect Mexico city.

AKNOWLEDGEMENTS

The present study has been carried out by the *Area de Estructuras* and undergraduate students of civil engineering of the *Universidad Autónoma Metropolitana, Unidad Azcapotzalco*.

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