SCENARIOS OF LOSSES AND REAL TIME MAPS OF DAMAGE BY BUILDING LEVEL FOR MEXICO CITY

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ABSTRACT :

In this work we present a procedure to obtain scenarios of losses and real time maps and damage results building by building for Mexico City. This is possible due to the availability of seismic hazard modeling including site effects for the lakebed zone, given the source and the magnitude of the earthquake or the strong ground motion at a reference site, and the structural information of all buildings in the city. This building information comes from the city tax database and it includes geocoded polygons of each structure, number of stories, year of construction and quality of maintenance. This allows us to compute scenarios of losses to first identify those buildings at the highest risk and then to propose to the authorities emergency planning options and mitigating measures. We also take advantage of the already working shake maps technology to add real time building by building estimation of losses. We present an example with maps of the central part of the city for a postulated earthquake similar to the 1985 Michoacan earthquake.

KEYWORDS: Mexico City, losses, scenarios, GIS, maps, emergency planning

1. BUILDING INFORMATION

We have obtained from the Mexico City government a database of all the building stock. This geocoded information has street, polygons of blocks and, within these blocks, polygons of each private or public property. Within each property, there are polygons with structural information such as year of construction, number of stories, main use and a qualification of the maintenance. This database is continuously checked and renewed.

1.1. Structural Type and Dynamic Characteristics

With the previous information, we have assigned a particular structural type considering standard practices and uses. For instance, most housing buildings in the city with less than four floors are build with confined masonry, while other type of uses such as banks, private or public offices, malls, and others, are build with steel or concrete frames. We also have assigned to each building a dominant period, Ts, using well known trends in terms of the number of stories (Ordaz *et al*., 2000).

As will be shown later, we will evaluate the structural response using the continuous Miranda and Taghavi (2005) method so we need to assume additional information such as damping and the parameter α. For structures with Ts<1.5 sec, α=0 since the building may be considered to have a flexure beam response. For more flexible buildings, α was set as a function of the structural type as shown in Table 1.

Table 1. Values of parameter α in terms of the structural type

Structural Type	α
Masonry	0
Columns with flat slab	5
Columns and beams	20

The damping was assumed in terms of the structural type and year of construction as shown in Table 2.

Table 2. Values of damping in terms of the structural type and year of construction

Structural type	Damping (%)	
	Before 1985	After 1985
Masonry	7	4
Concrete	4	2
Steel	3	1

Alternatively to the information given by the government, we have been completing our own database either with full or sidewalk inspections. In this way, we fill actual information such as structural type, irregularities, among others.

2. METHODOLOGY

The formal way for obtaining seismic scenarios should be based in the estimation of losses thru the computation of interstorey drift of every building for a specific earthquake. This earthquake should be either recorded or postulated by a characterization of a representative strong ground motion. For an historic event from which one has strong ground motion records (for Mexico City we have at least 30 records of earthquakes of M<7 at CU, a reference station located in the UNAM campus that has been recording since 1964) it is well documented how to obtain a distribution of the strong ground motion within all the city taking into account in a reasonable precise way the site effects at least for more than 120 instrumented sites. Then, it is possible to interpolate this motion (Ordaz *et al*., 2000) for obtaining strong ground motion at every desired site, that is, at every building in the city. Once this strong ground motion is defined, one can obtain the dynamic elastic and inelastic response of every building using analytical models. In this work, we have used a continuous model taking into account the contribution of the first six modes (Miranda and Taghavi, 2005).

The process described above is similar to well-known methodologies of estimating the structural response and losses of individual buildings and portfolios. However, trying to do this in real time may not be feasible due to computational time; therefore, a more simplified way should be used.

What we have done in this work is to obtain the seismic demands in small regions within the city, based on the dominant period of the site obtained from recorded accelerometric stations. These regions are shown in Figure 1 for the central part of Mexico City; the motion at each zone is going to be represented by one station, the one that we consider the best for that specific region. In Figure 1, for example, stations 55, 72 and 01 represent the motion for certain zones according to the dominant period of the soil and the local amplification.

Figure 2 shows the same part of the city as Figure 1 where colors have been drawn in order to show the proposed regions where specific accelerograms are going to be used. Of course, this implies a calibration model that needs to be continuously tested and improved every time an earthquake affects the city.

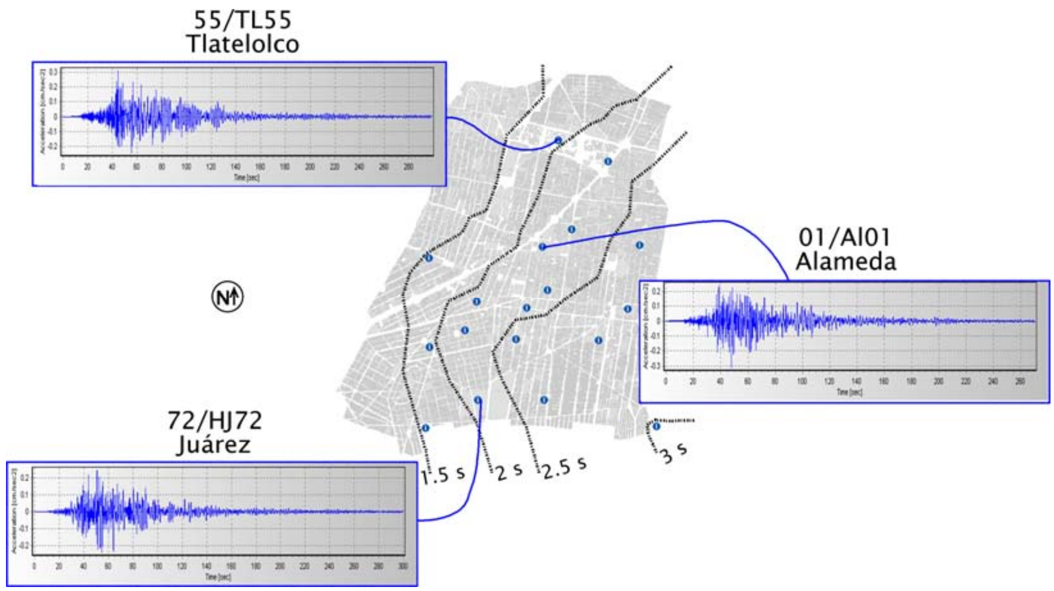

Figure 1 Central part of Mexico City with lines of equal dominant period and accelerometric records that we have considered as representative for determined regions. As examples, records from the 19/04/99 earthquake are shown for stations 01, 55 and 72

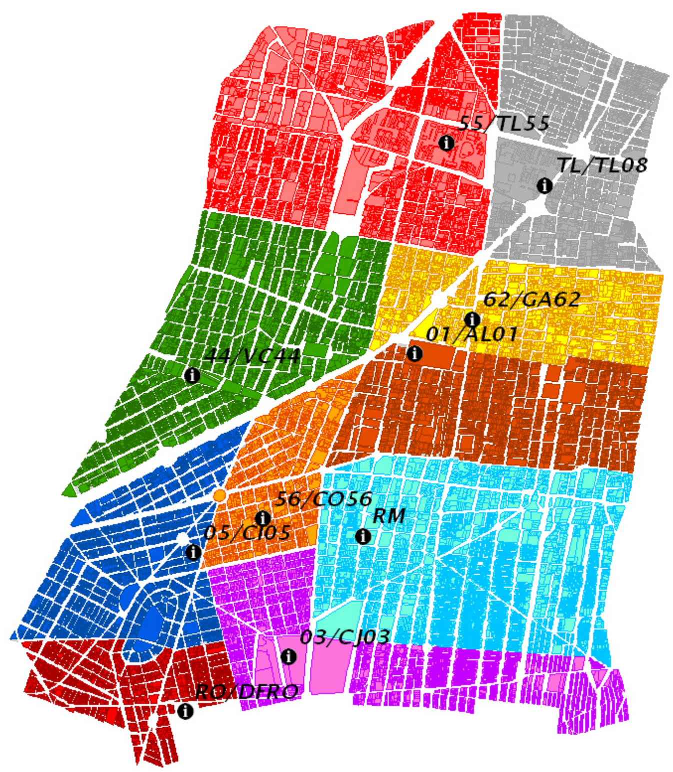

Figure 2 Central part of Mexico City where colors show the regions where a specific accelerogram is going to be used to compute the structural response of all buildings within each region. The selected accelerometric stations are shown for each region

Figure 3 shows an example of the software that we have been using to estimate these maps. We have been computing losses and comparing them with historic earthquakes such as the 1985 one. The program works with an accelerogram as input and with the process described above it draws maps and print tables of the results for each building.

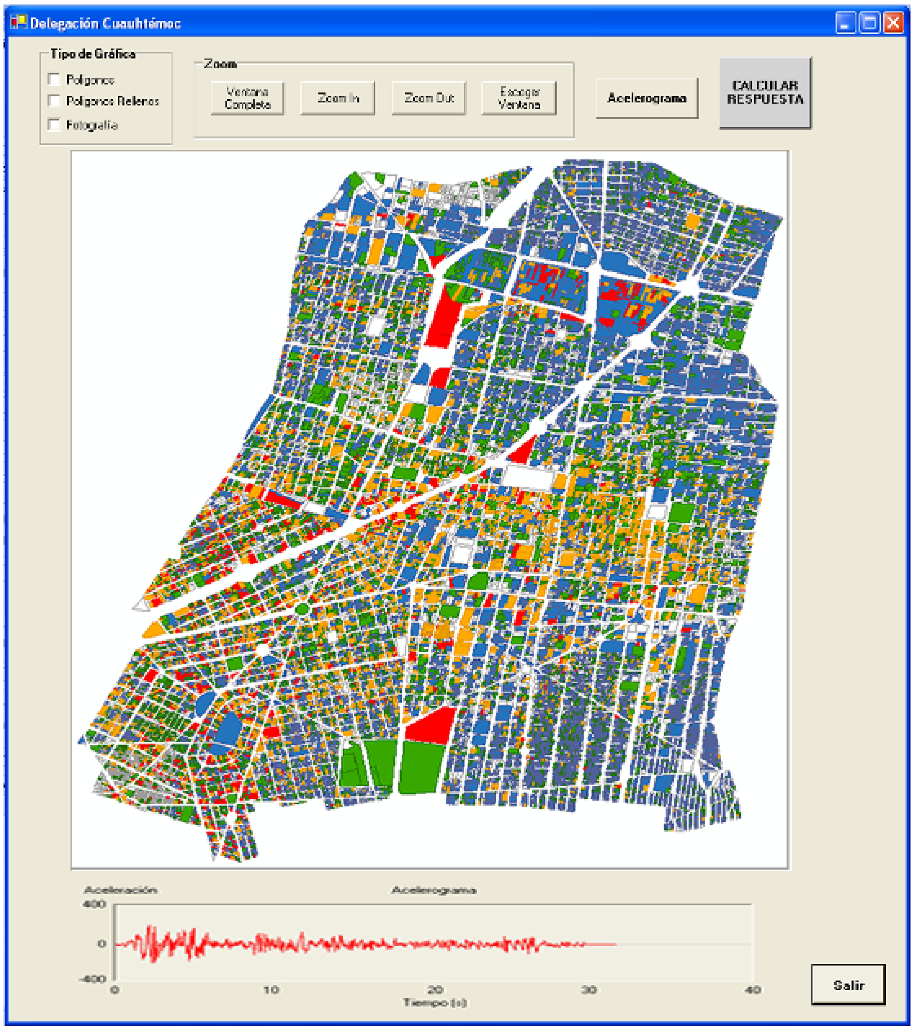

Figure 3 Example of the software to estimate maps of losses. It shows losses for the accelerogram drawn at the bottom of the figure

3. RESULTS

Due to the political nature of this project which results are still been evaluated by local authorities, only partial results are shown here. Figure 4 shows the response of all buildings in terms of interstorey drift for the 1985 earthquake taken the accelerogram recorded at the firm site CU (UNAM campus). The plot shows buildings with largest demand colored in red, followed by orange and yellow.

Considering the limits and the approximation of the estimates, Figure 4 should be taken with caution, and only as a warning of buildings at the highest risk but never as a way to spend money and directly mitigate. Red buildings should be tested and analyzed by capable engineers in order to better asses their response and eventually retrofit them. On the other hand, Figure 4 may help authorities to set an emergency plan for every possible or realistic scenario. It is clear that damage will be concentrated at certain zones, streets and neighborhoods. Emergency units and rescue teams should know this in advance in order to get fast to these places and try to save lives during the first hours after an earthquake has hit the city.

Another example of the output building by building is shown in Table 3 and Figure 5 where results for the June 19, 1999 are shown. The buildings with the largest estimated losses are shown in Figure 5, together with its reference number, and Table 3 shows the main characteristics of the first five buildings and where they are.

Figure 4 Map of the maximum interstorey drift of structures in Mexico City centre

Table 3. Example of the structures with the largest estimated losses for the June 19, 1999 earthquake

Reference	Use	Year of construction	Stories	Structural system	Soil Period	Structural period
002-011.04	Office	1974	29	Steel frames	2.1	2.6
002-026.05	Office	1988	26	Steel frames	2.5	2.3
004-221.01	Mall	1986	2	Steel frames	2.1	2.3
004-223.01	Office	1960	5	Concrete frames	2.1	2.6
004-235.01	Housing	1960	28	Steel frames	2.1	2.6
…	…	…	…	…	…	…

Figure 5 Map of the maximum interstorey drift of structures in Mexico City centre for the June 19, 1999 earthquake

4. SHAKE MAPS FOR MEXICO CITY

Shake maps are already available for Mexico City (Alcántara and Ordaz, 2008) and during the last subduction earthquake they were computed and sent thru internet to local authorities and engineers and academics involved in the project. Figure 6 shows an example of the output of the maps for two structural periods. Maps similar to those shown in Figures 4 and 6 are planned to be sent for the next earthquake using the same shake maps technology.

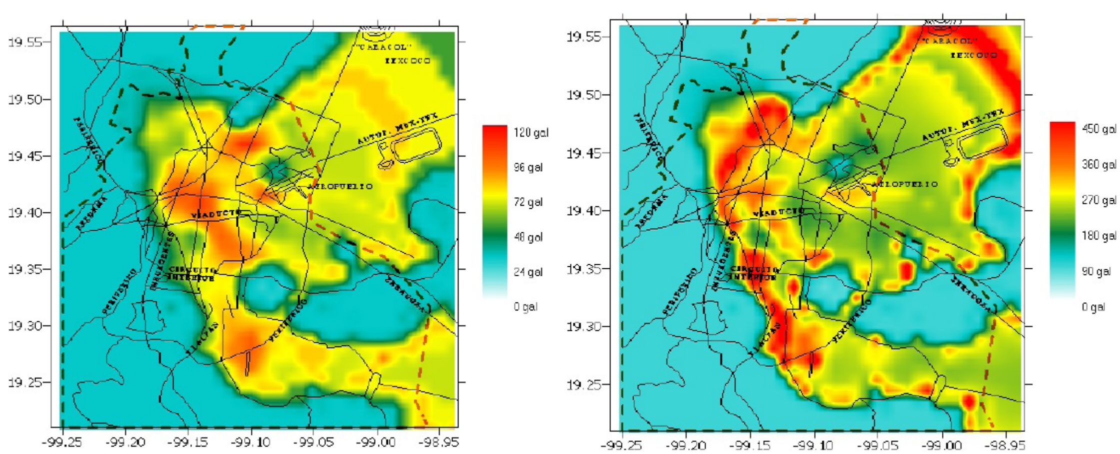

Figure 6 Shake maps for Mexico City for a given scenario (Alcántara and Ordaz, 2008) for ground motion (left) and for a structural period of T=2.0 sec (right)

5. CONCLUSIONS

We have presented a summary of the procedure to obtain scenarios of losses and real time maps and damage results building by building for Mexico City. This computation is possible due to the availability of seismic hazard modeling including site effects for the lakebed zone, given the source and the magnitude of the earthquake or the strong ground motion at a reference site and the structural information of all buildings in the city. This building information comes from the city tax database and it includes geocoded location, number of stories, year of construction and quality of maintenance. This allows us to compute scenarios of losses to first identify those building at the highest risk and then to propose to the authorities emergency planning options and mitigation measures. We also take advantage of the already working shake maps technology to add real time building by building estimation of losses. We present an example with maps of the central part of the city for a postulated earthquake similar to the 1985 Michoacan earthquake.

REFERENCES

Alcántara L. and Ordaz M. (2008). Personal communication.

Miranda E. and Taghavi S. (2005). Approximate floor acceleration demands in multistory buildings. I: Formulation. *Journal of Structural Engineering, ASCE*, **131:2,** 203-211.

Ordaz M., Miranda E., Reinoso E. and Perez-Rocha L. (2000). Seismic loss estimation model for México City. *XII World Conference on Earthquake Engineering*, Auckland, New Zeeland.