APPLICATION OF GID ON THE MODEL OF ONE TEMPLE OF THE HISTORICAL CENTER OF PUEBLA'S CITY

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Abstract: *The historical center of Puebla's city is part of the list of the world patrimony of the UNESCO since 1987, because Puebla's city was the second more important city in the Nueva España; the majority of the constructions were made with unreinforced masonry, on the other hand the Mexican Republic is frequently affected by earthquakes with epicenters near to the pacific coast where exist subduction zones. The finite element method requires the elaboration of models that take in account the problems relational with the geometry, the material's behavior and the boundary conditions. In the document is presented the complete model of the temple and also two and three dimensional models in which were divide the structure to realize the partial studies. The models were processed with the use of the SAP2000 software obtaining the vibration modes, the deformation and the stresses diagrams for gravitational and seismic loads.*

1 INTRODUCTION

Puebla's city was founded in 1531 and its historical center was included by the UNESCO (1987) in the list of the world-wide Patrimony with 2619 classified historical buildings. The construction of the historical buildings is located between centuries XVI and XIX, the majority of them built with unreinforced masonry, formed by units of stone or brick and meetings of mortar, that's why the material is a heterogeneous compound with a nonlinear behavior.

The conservation of the historical patrimony of the city implies the study of vulnerability of buildings built with masonry; in special form, the study of the ancient temples of the city that are in use is required and which they showed vulnerability in the seismic events of 1973 and 1999; both of them with epicenters distances less than 170 km of the Puebla's city and with mechanisms of normal fault. It is worth noting that the problem of damages in ancient constructions of unreinforced masonry and in particular in the case of temples, is not circumscribed to the urban area of the Puebla's city, since in relation to the earthquakes of 15 and 21 of June and of the 30 of September of 1999, the FONDEN[i] reported damages in one thousand three hundred ancient constructions in seven states of the Republic.

The evaluation of the seismic vulnerability of an ancient construction implies the study of the answer of the structure and the estimation of damages before on one important seismic demand, presenting diverse challenges:

- The elaboration of the structural model.
- To consider the history of the construction with additions or retirement of elements.
- The quantitative evaluation of the resistance of the structure it's more difficult because it's not easy to get experimental results of the structural elements and from the materials that constitute them.
- The dynamic behavior is complex to be modeled with the models of concentrated masses employees in skeletal structures.
- The behavior obtained in a linear elastic analysis only represents the departure point for a study that considers the behavior nonlinear of the material.

2 STRUCTURAL MODELS

Is required to establish a mathematical model that represents of the best possible form the real problem but at the same time the model must be simple and easy to analyze. The model definition implies to take in account the geometry, the material's behavior and seismic actions that could act on the structure.

The damages after one earthquake help to define the collapse mechanisms that must be considered to know the answer in a limit analysis, this is also applied to the temples, since the absence of one continuity cause frequently partial collapses in weak zones, that may be were not known.

In the case of ancient buildings not always the most advisable is to work with complete three-dimensional models that include all the elements that constitution the structure[ii]. Two-dimensional models can be used to obtain satisfactory results of the structural behavior of the macro element in the plane.

The location, the dimensions, aspect ratio, the continuity or not of the different structural elements are the departure point for the elaboration of the structural model. For the modeled one of the material two options exist, the micro and the macro modeled, using the homogenization technique. The analysis methods depend on the target, on the information successfully obtained in relation to the materials and to the degree of deterioration of such, of the costs, the complexity, the importance and the size of the structure.

With relation to the analysis, Croci indicates the convenience of making a first elastic analysis to detect the zones of tension where the cracking based on the loads will appear later and an analysis nonlinear, step by step, increasing the loads to locate the border of the

resistance dominion and to determine the rigidity of the structure in each stage, eliminating the participation of the elements that have reached a state limit[iii].

3 MODELS AND ANALYSIS

After the topographical survey, were done the drawings in AutoCAD, considering the simpler geometric characteristics without modifying the structural concept; the files exported to the GID[iv] for their discretation using plate elements with nodes on its three apexes and linear approximation and with the aid of this preprocessor the meshing one was made having in account the thickness of the walls; later the meshing model was returned to the AutoCAD to operate it and to be able to import it from the SAP2000, where is assign the material information, the conditions of border and the loads for the required analysis (figures 1 to 5). The complete model have more of 60 000 elements.

4 CONCLUSIONS

The GID is a very useful tool to make the meshing one of models with complex geometries allowing the engineer to dedicate more time to the revision and to the interpretation of the results obtained after a finite element analysis.

REFERENCES

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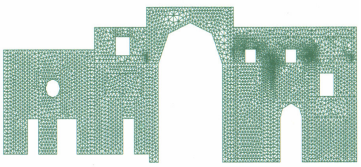

Figure 1: Plane models (GID)

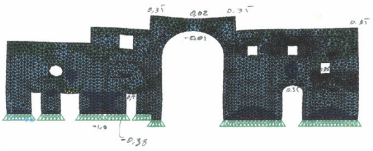

Figure 2: Two-Dimensional Masonry Wall

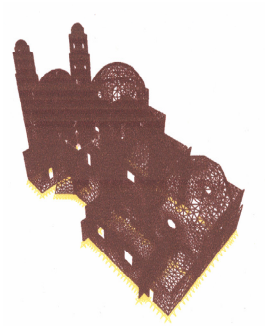

Figure 3: Complete Model

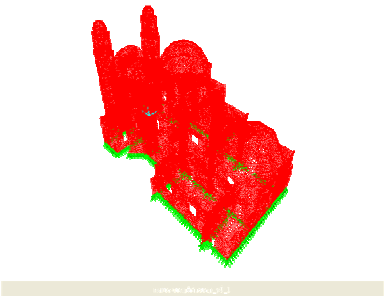

Figure 4: First Natural Mode

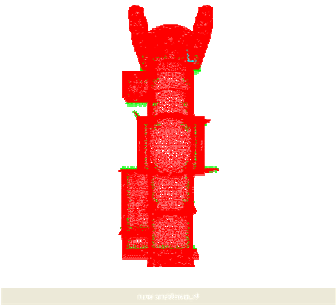

Figure 5: Third Natural Mode