Analisys of the Alpha Combination Rules in the Seismic Response of Typical Building of Mexico City

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1. Abstract

Mexico City's building code considers rules to include the bidirectional building response in the seismic design process. The so-called α combination rules account for the impact of 100% and α times the ground motion acting in orthogonal directions. Thus, it allows estimating the forces a structure will resist. Here, based on fully 3D ground motion simulations including the soil-structure interaction, we present a preliminary analysis of the uncertainty in the α parameter in soft soil deposits in Mexico City. The study is performed for a typical structure located in the Lake zone coupled with a realistic velocity model of the basin and a detailed model of the building. The seismic wave propagation and the building response is performed using the Finite Element Method.

2. Summary of Seismic Design

Mexico City's NTC2004 building code proposes two ways for the seismic design: the static an dynamic analysis.(Figure 1).

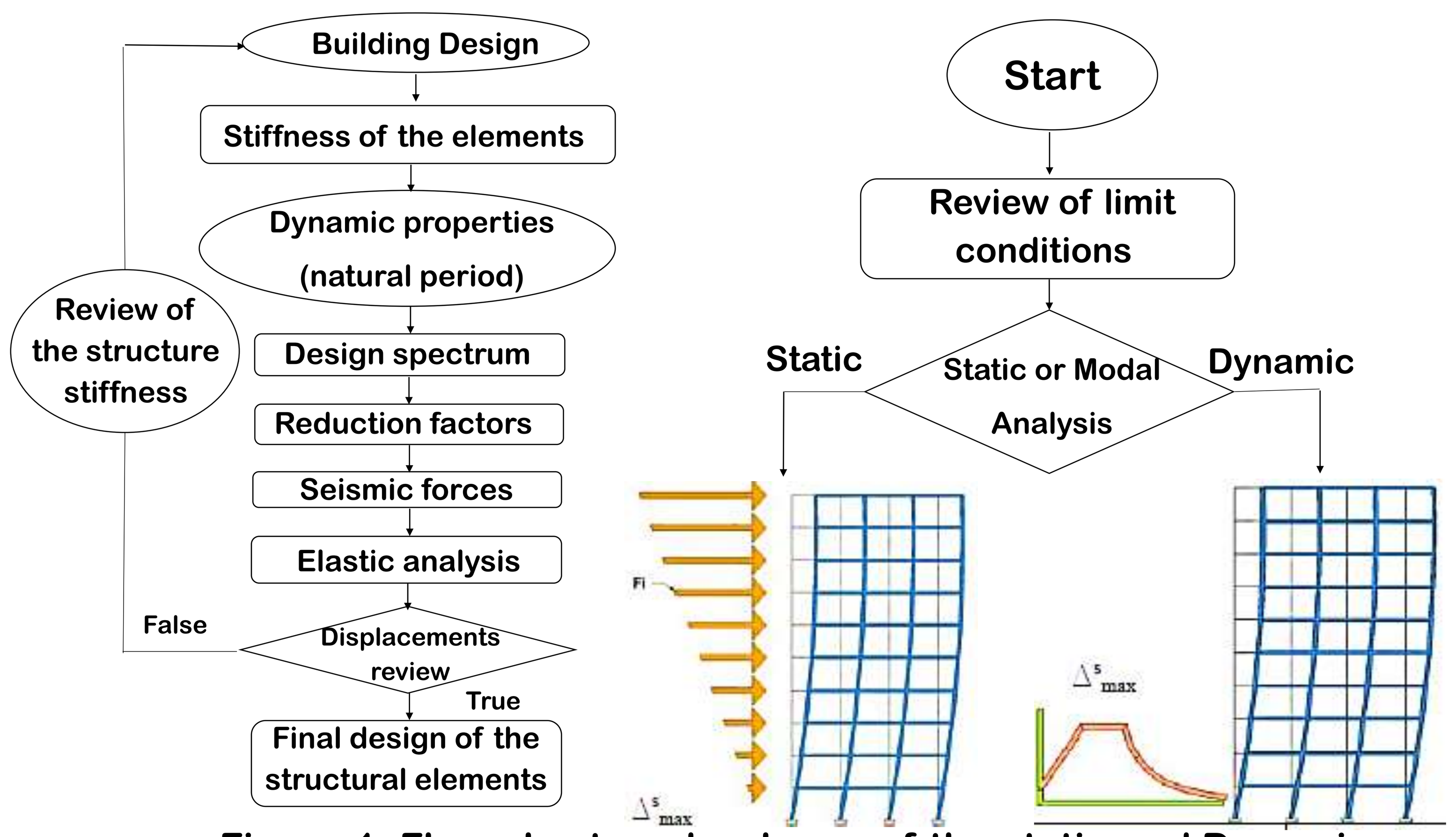


Figure 1. Flow chart and scheme of the static and Dynamic Building design.

3. The Alpha combination rules

The NTC2004 code considers rules to include the bidirectional building response in the design process. The common combination rules are: SRSS, CQC3 and the α rules (Figure 2).

$$SRSS = R = \sqrt{R_1^2 + R_2^2 + R_3^2}$$

$$R = [(R_1^2 + R_2^2 + R_3^2) - (1-\gamma^2)\left(R_1^2 - \frac{1}{\gamma^2}R_2^2\right)sen^2 + 2\left(\frac{1-\gamma^2}{\gamma}\right)R_{12}sen\theta cos\theta]^{1/2}$$

=CQC3 (combination rule)

$$\theta_{cr} = \frac{1}{2}tan^{-1}\left[\frac{\frac{2}{\gamma}R_{12}}{R_1^2 - \frac{1}{\gamma^2}R_2^2}\right]$$

α combination rule

100% and α times the ground motion acting in orthogonal directions

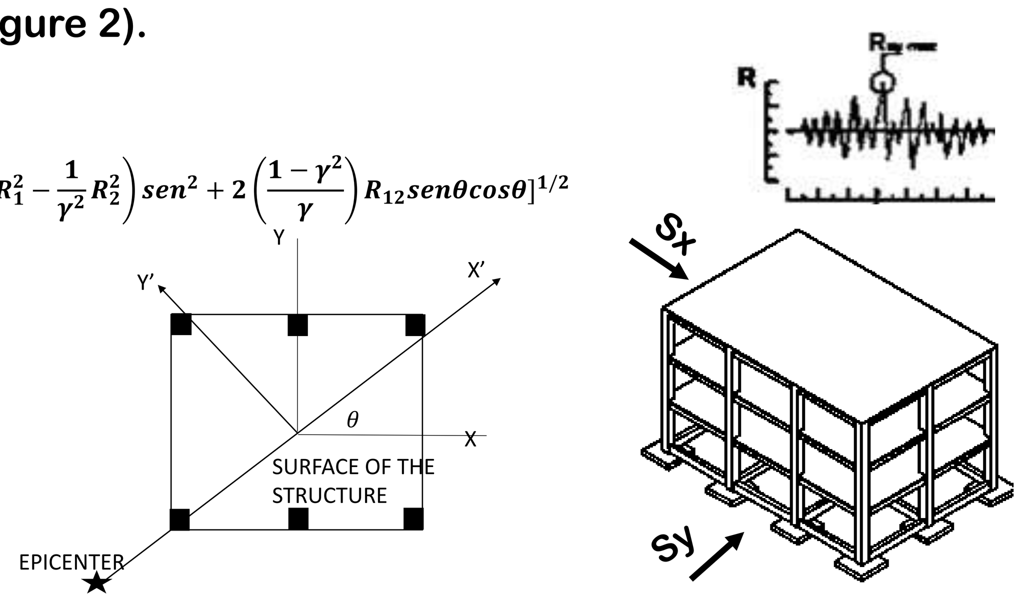


Figure 2. Bi-directional responses during earthquake loading.

4. Mexico City Basin

Mexico City is over a sedimentary basin, the first 30 meters are a compressible clay deposits. The thickness of the soft soil and the geological structures affect the seismic waves propagation causing site effects. The study area is the Cuauhtémoc municipality located in the downtown of Mexico City.(Figure 3).

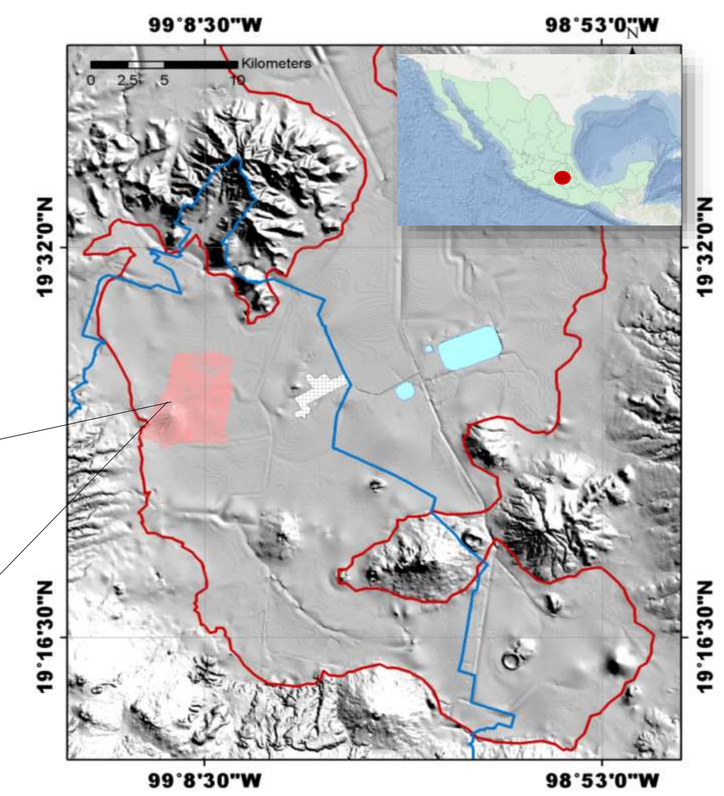


Figure 3. Mexico City Basin

5. Typical Building

We use LiDAR images and the building inventory polygons of Mexico City (Figure 4A) to obtain the typical building of the Cuauhtemoc municipality.

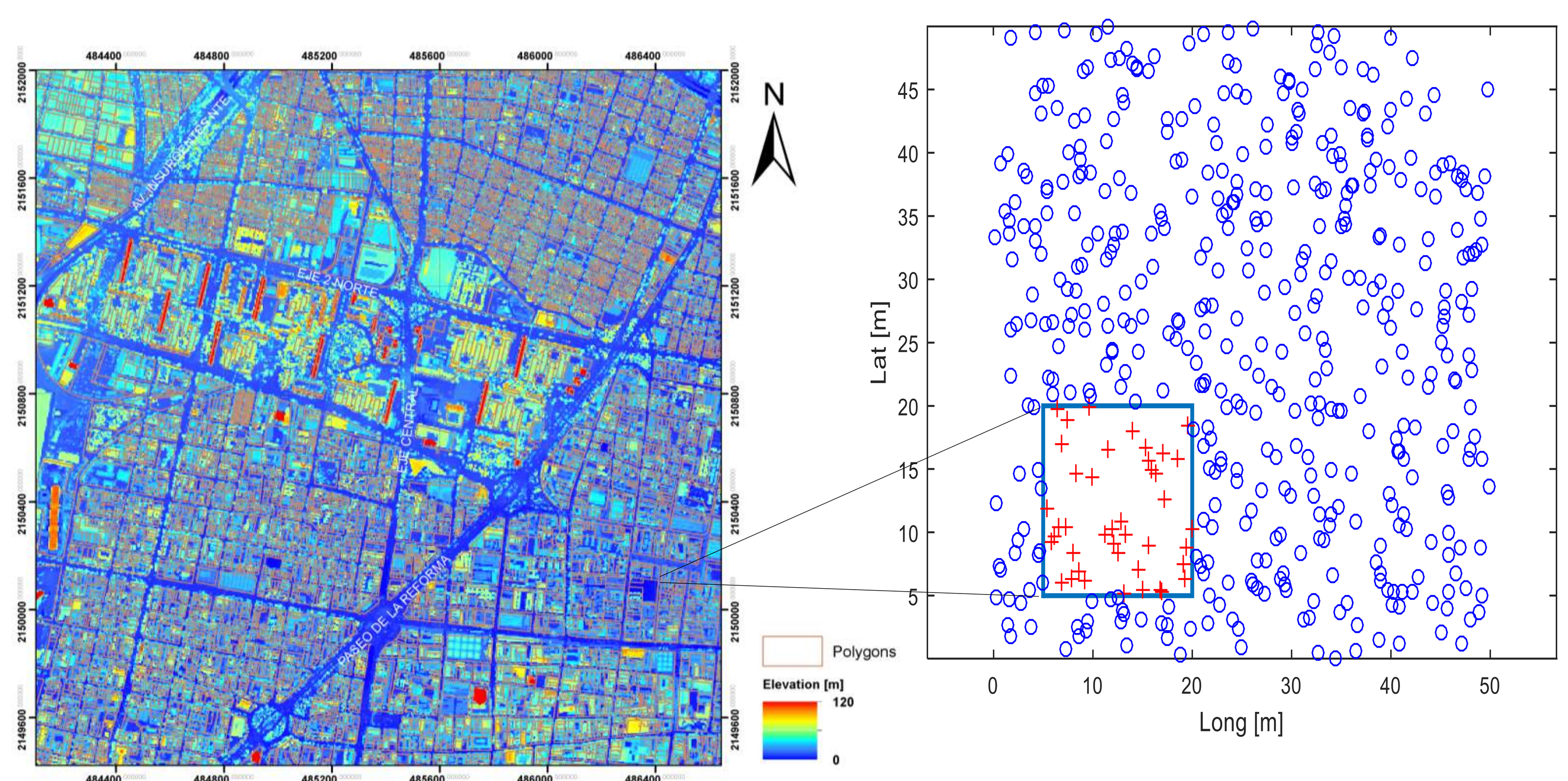


Figure 4. A) LiDAR images and cadastral polygon of the analyzed área. B) Result of the algorithm to get all pixels inside the polygon.

Finally, the typical building has 3 floors and 150 square pixels, (Figure 3C).

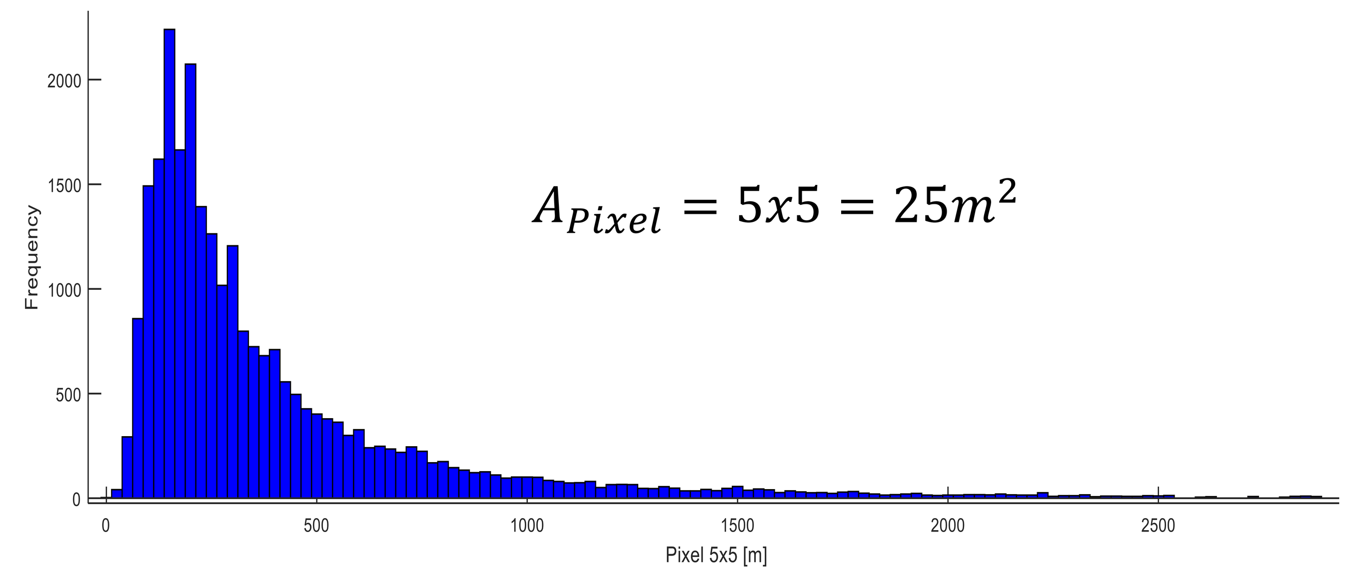
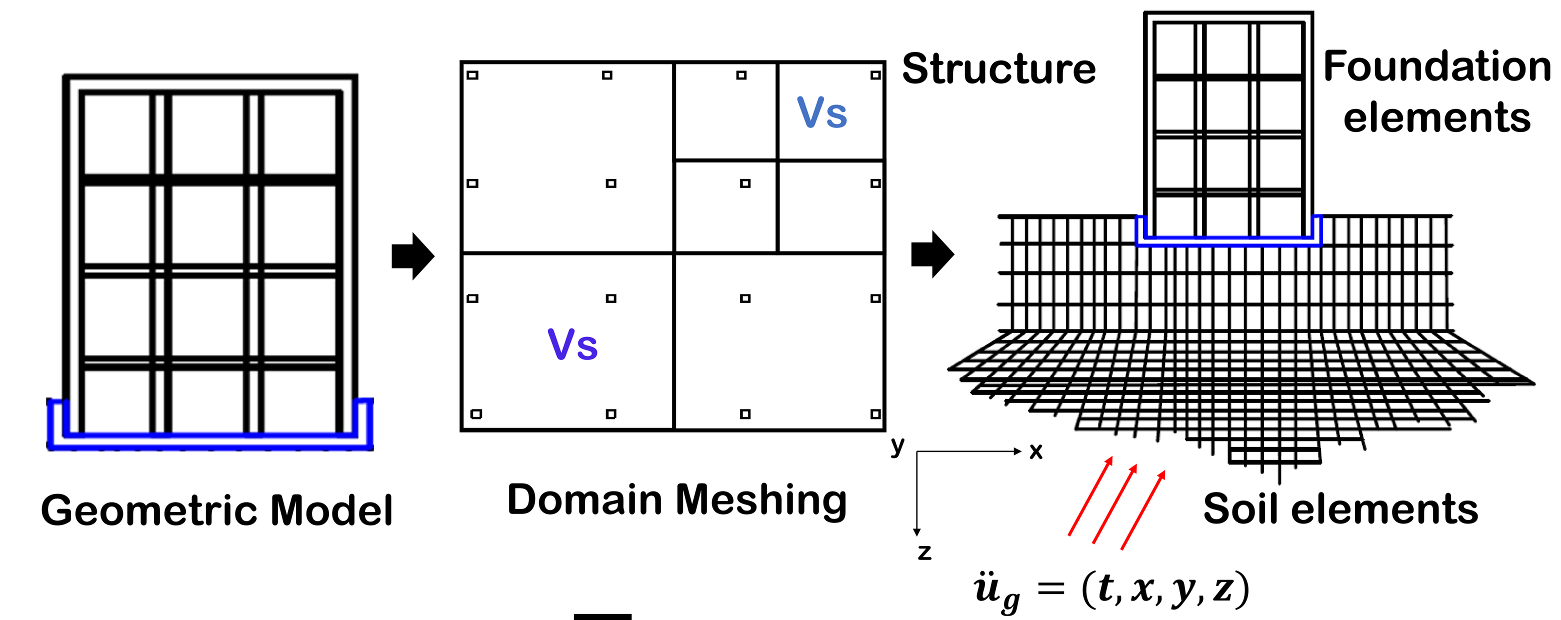


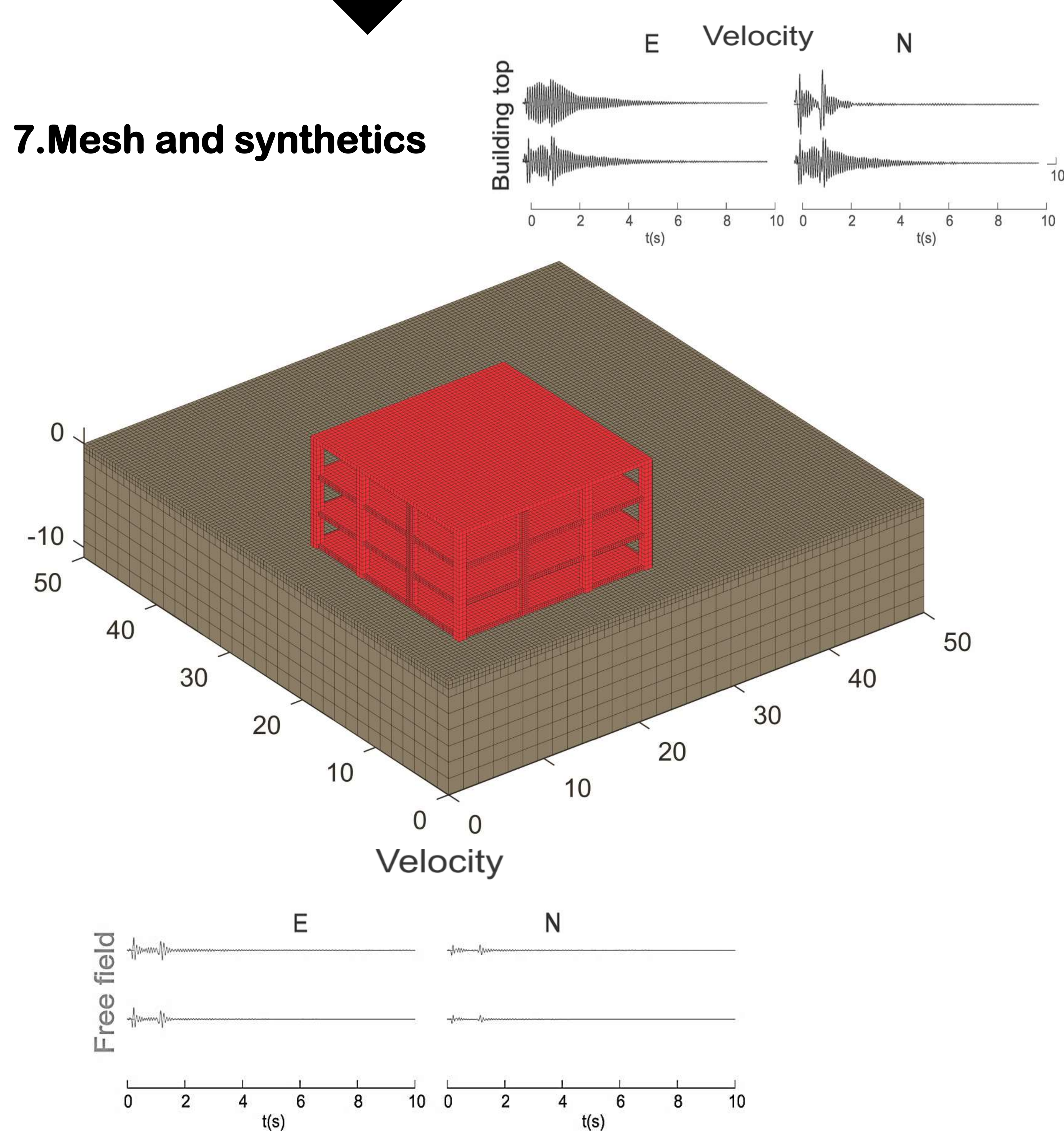
Figure 4. C) Frequency of building's área in downtown of Mexico City.

6. Building Model

We mesh and simulate the ground motion using the octree-based Hercules (Finite Element Method software). (Figura 5).



7.Mesh and synthetics



8. Final Coments

We have set up a system to analyze the alpha combination rules using fully 3D ground motion simulations including soil-structure interaction. The next step is to obtain the synthetic seismograms as well as stresses and bending moments for several representative cases.

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