POLITECNICO DI TORINO
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<u>Honors theses</u>

Seismic Analysis of the L'Aquila City Hall

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ABSTRACT

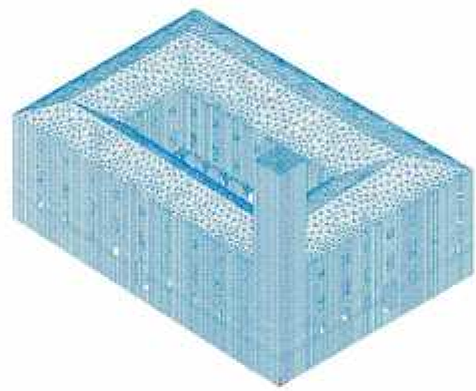
The thesis is dedicated to the realization of a FE model of one of the most important buildings of the L'Aquila, the City Hall, also called Margherita Palace, badly damaged during the seism of April, 6th, 2009, with the aim of an optimal programming of rebuilding and restructuring. The analysis has been lead in such a way that the calculation could take into account the most possible accurate description of the historical heterogeneity, the various works and of the materials historical stratification lasting eight centuries that characterize the building. The work starts therefore from a synthesis of the historical-architectonic process that has produced the building in the context of the city and arrives to a FE model of the structure. Some results of the analysis able to produce some preliminary strategies and proposals for restructuring are at last introduced.

HISTORICAL BACKGROUND

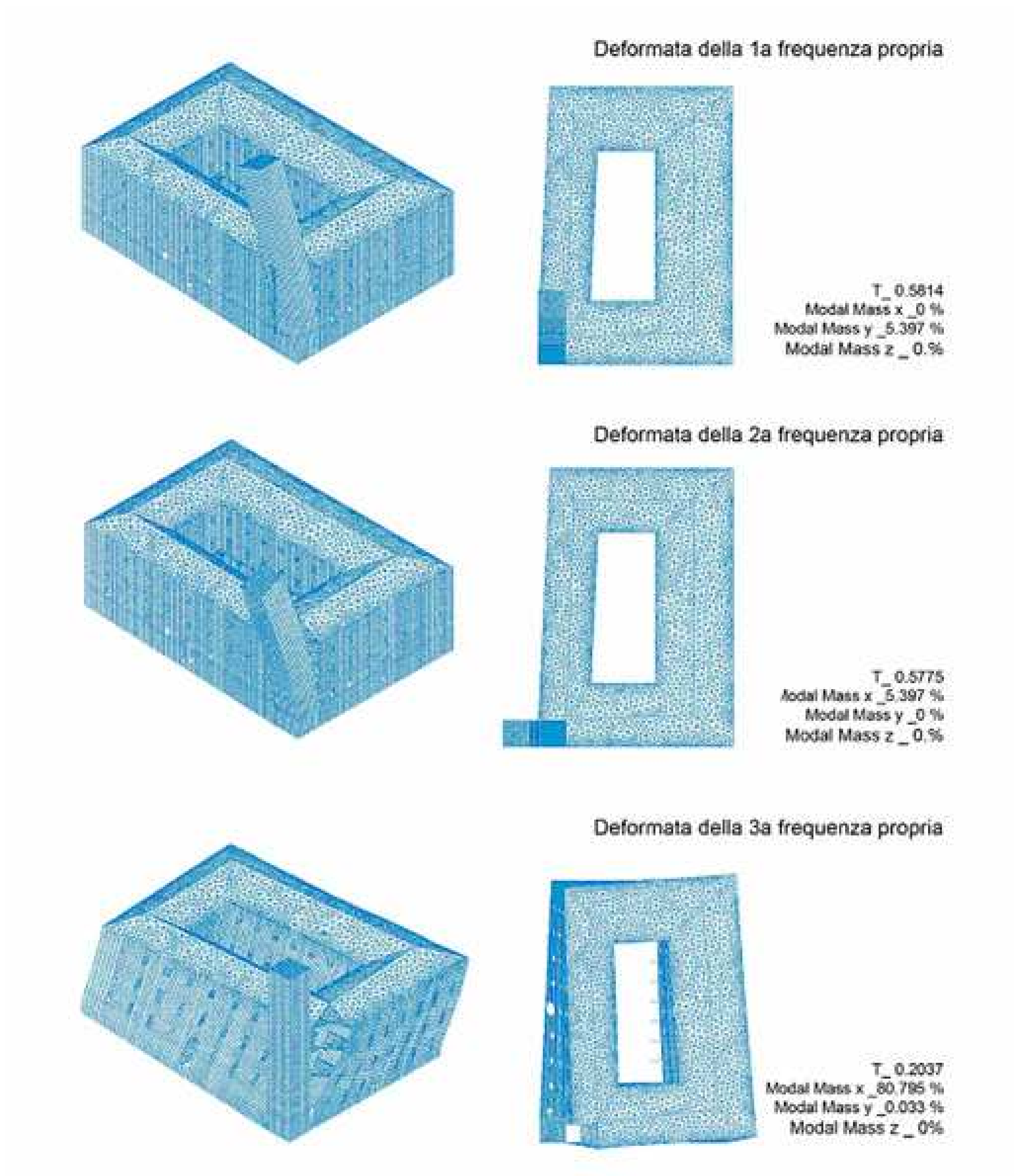
The complex of the City Hall is composed of two bodies, characterized from a separated historical-constructive evolution, the civic Tower, and the Margherita Palace. The first one still existed before the foundation of the city in 1254, and was then isolated. The civic tower was then 70 m tall, but when reconstructing it after the earthquake of 1703, has been lowered and again it has in 1838. Still today the tower conserve the three-and-half medieval stories in which it was subdivided. The rest of the complex comprised the palace of the Municipality, the Camera Aquilana and the Residence of the Captain. The construction of the City Hall of the L'Aquila began in 1294 and saw a series of restorations and reconstructions of which the more important dates back to 1572 when Margherita of Austria, governor of the city, choose it for her residence and entrusted for the rearrangement the Fonticulano architect that produced an unit volume around a courtyard, with porch on three sides and with the quarter characterized by a scenic double open stairway.
In the 90s the main building was consolidated by means of a belt in reinforced concrete under the roof. The strongest seismic events have been taken place in 1349, 1461 and in 1703. According to some, the earthquake of 1461 had an epicenter position similar to that of the earthquake of magnitudo Richter 5,8 of April 6th, 2009.

THE MODEL AND THE RESULTS

The analysis has been carried out using the FE code ADINA. The modeling process is begun with the analysis of the building aiming to a complete characterization of the most important structural elements. With a 3D Rhinoceros model of the buildings we have studied the geometry and the interactions between the various structural elements in order to understand the interaction between the various structural elements. The final model has 66.965 nodes, 92454 shell, 577 beam and 8 truss elements. The beam elements have been used for the gallery pillars, the reinforced cement belts and the architraves over the openings, the truss elements for the sequences of arch and vaults.

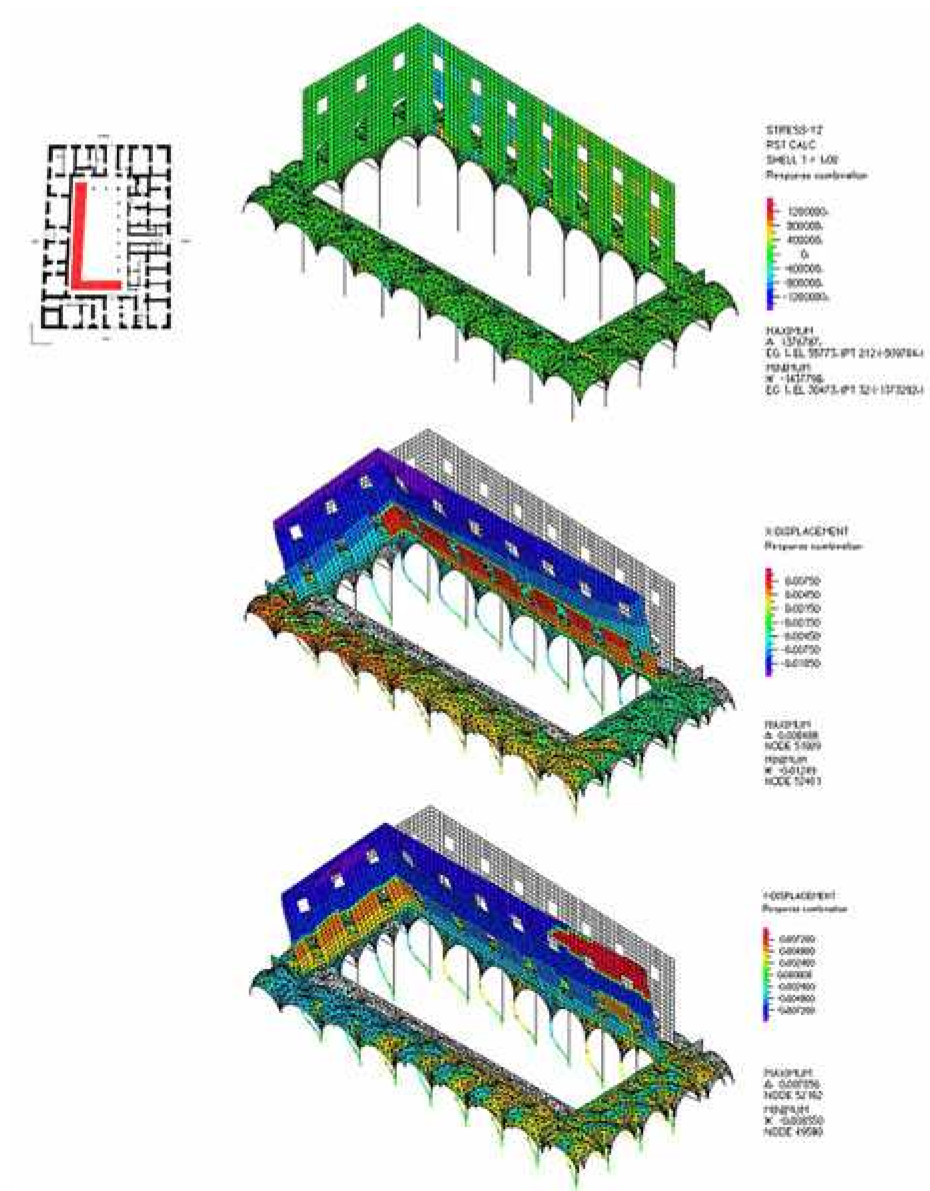


In lack of experimental data, we have used literature values for the mechanical properties of the materials.



In figure 2 we present the images of the deformations related to the first 3 modes of the model. The first two modes involve mainly the Tower and are characterized by a low participating mass (of the order of 5% of the total mass). The third mode has a participating mass of 80% in the X-direction and is a translational and rotational one, therefore depicting a flex-torsional action, involving the entire building.

The seismic response has been obtained from a multimodal spectral analysis.



The direction of the shear stresses, see figure 3, qualitatively characterizes the path of the actual damages on the masonry. The presence of damages in the gap bands is justified from the minor thickness of the masonry and therefore from the minor resistance to the shear stresses of the bands regarding the main masonry walls.

The present thesis work gives the premises for the structural analysis needed to the planning of every restructuring and consolidation activity of the L'Aquila City Hall. The modal analysis has put into evidence that, in every direction, the participating mass is concentrated on a small number of fundamental modes. Therefore the total response of the structure could be obtained with a non-linear dynamic analysis (that considers the non-linear material behavior) taking into accounts only the first two modes for the tower and the third, fourth and fifth mode for the building.

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