Mazars' Damage Model for Masonry Structures: a Case Study of a Church in Italy

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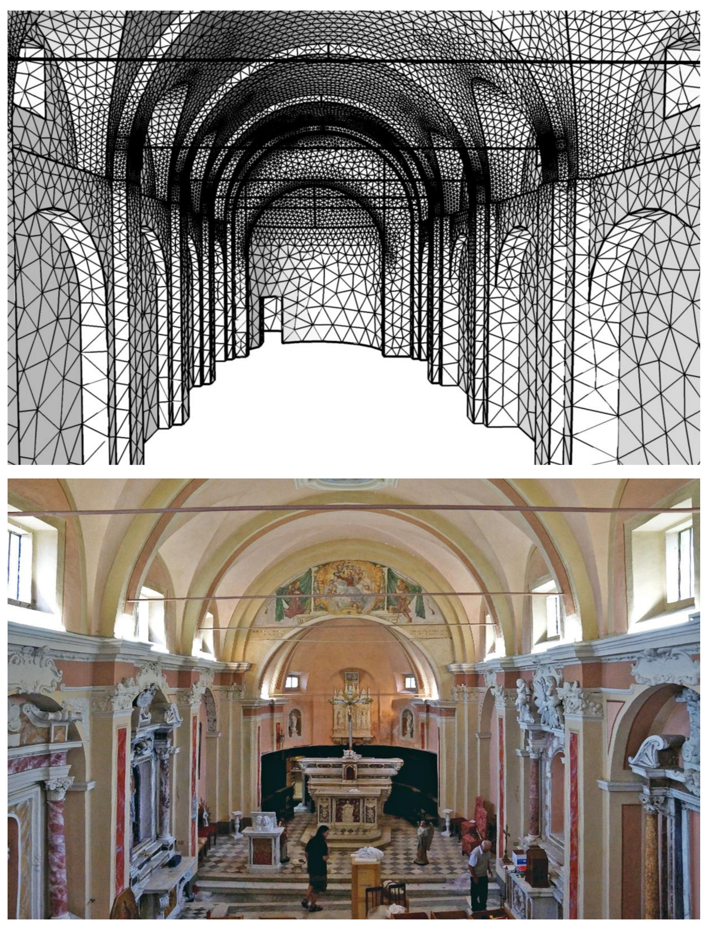
INTRODUCTION: Seismic assessment and structural analysis of heritage structures plays an important role in safeguarding their integrity and conservation.

In this work, Mazars' damage model is used to study the dynamic properties of a masonry church in Lunigiana under self weight and seismic loads. A high fidelity 3D model was built starting from floor plans and site photography.



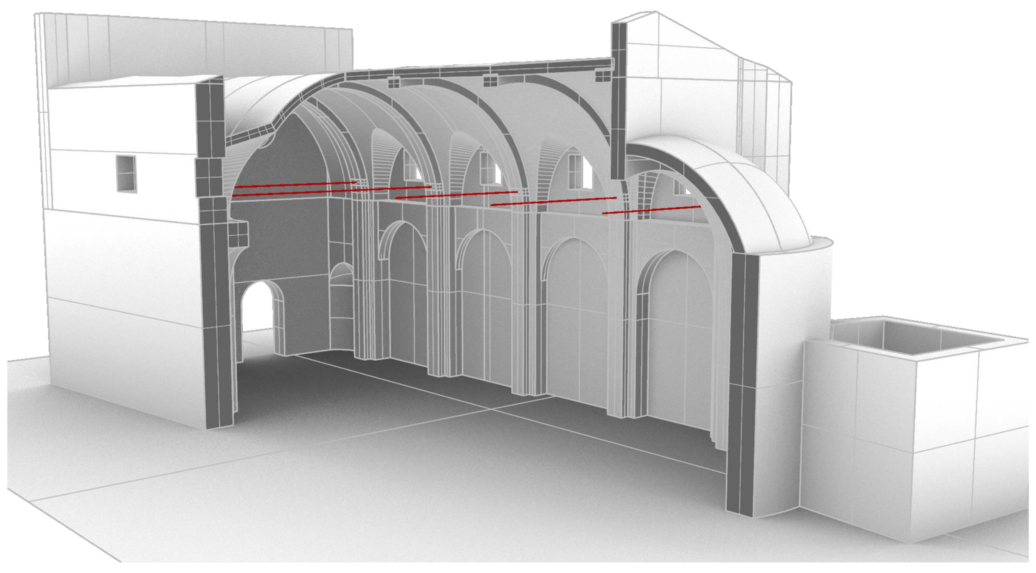
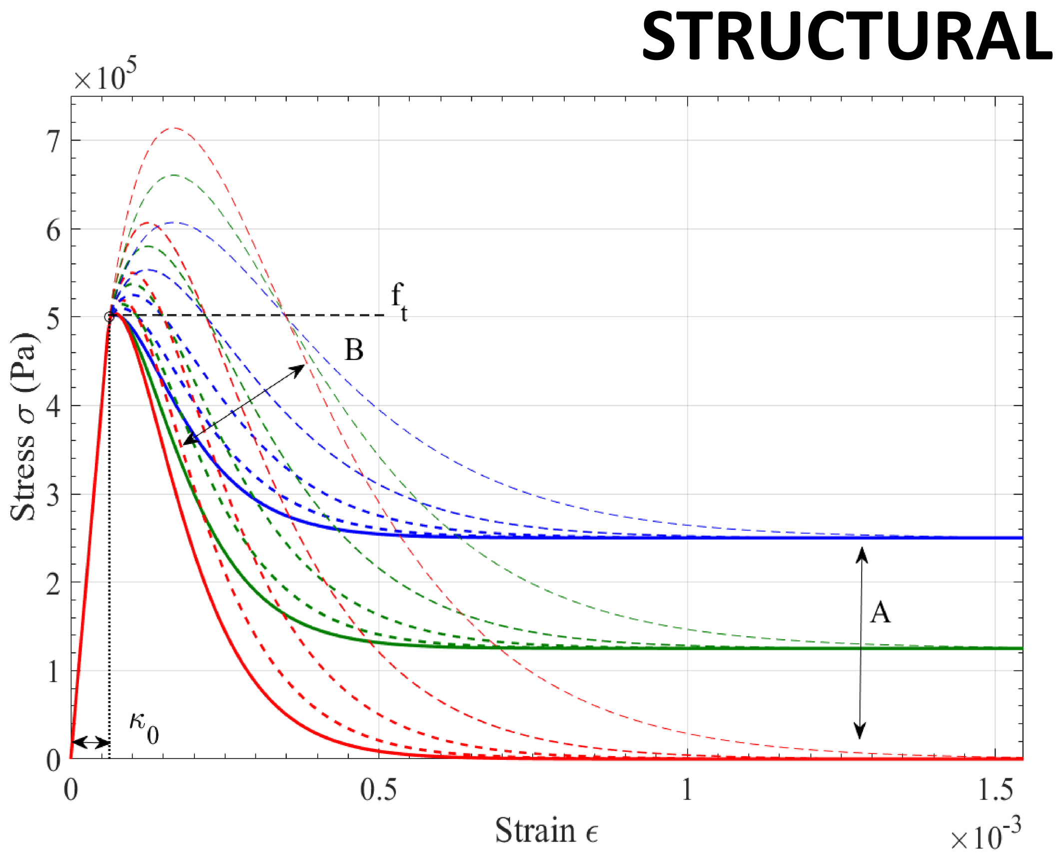


Figure 1. Site photography, geometric model and FE mesh for the church of San Prospero di Monzone, Lunigiana – Tuscany.

STRUCTURAL MODELING:



Mazars' concrete model is introduced via COMSOL® *External material* functionality by linking the relative DLL.

Steel tie rods are modeled via the Shell interface and connected to the Solid Mechanics via the built-in multiphysics functionalities. An initial static study is performed by ramping self weight loads, both with and without tie rods. The results displayed crack patterns compatible with photographic evidence and a reduced crack extension for the tie rods case.

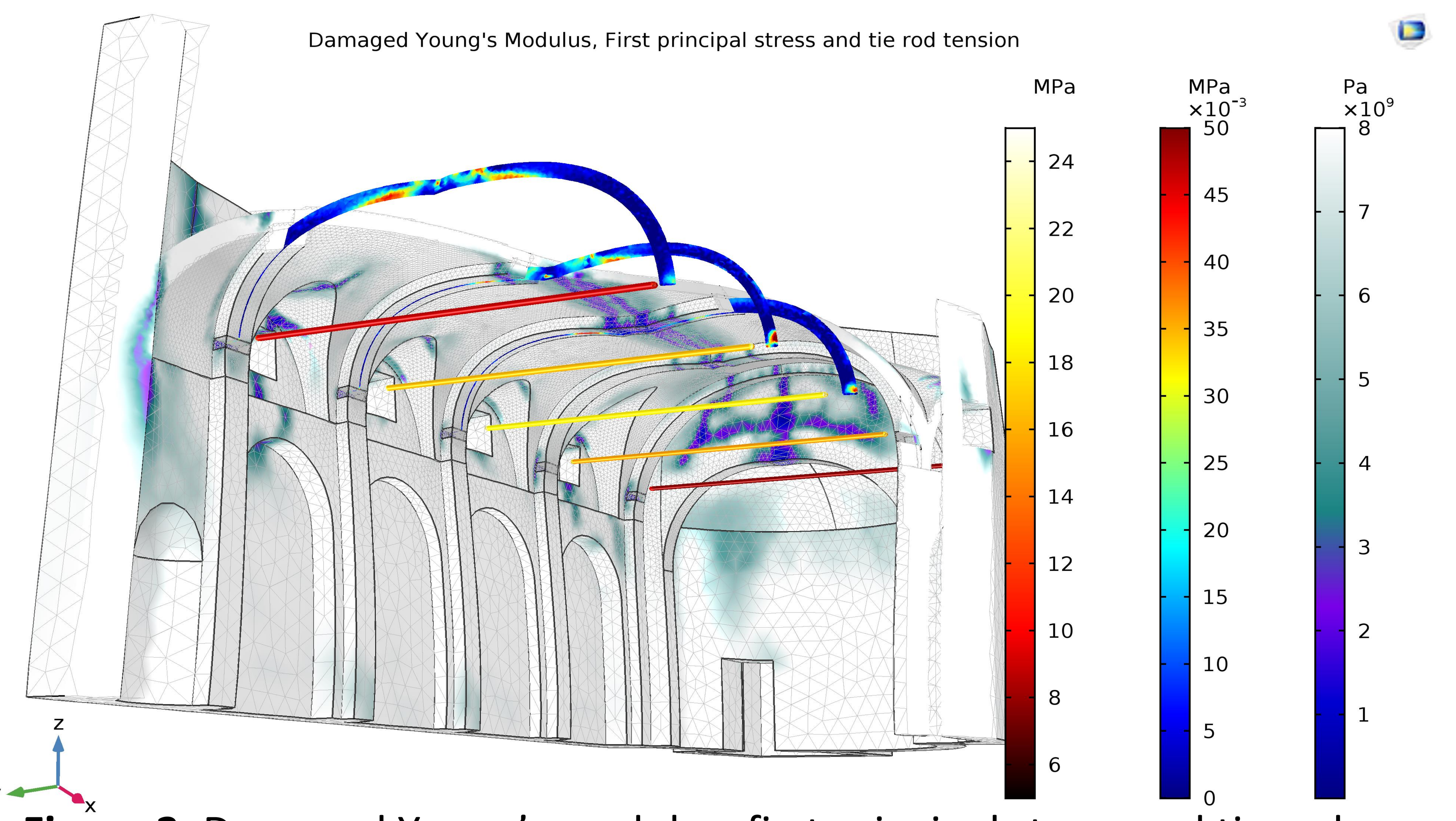


Figure 3. Damaged Young's modulus, first principal stress and tie rods tension for self weight load.

MODAL AND DYNAMIC ANALYSES: Modal analyses were performed both from an undamaged, elastic condition and damaged structure by self weight using the static solution as the modal solver's linearization point. Results display a substantial drop in frequency values, that is mildly reduced in the tie rods case.

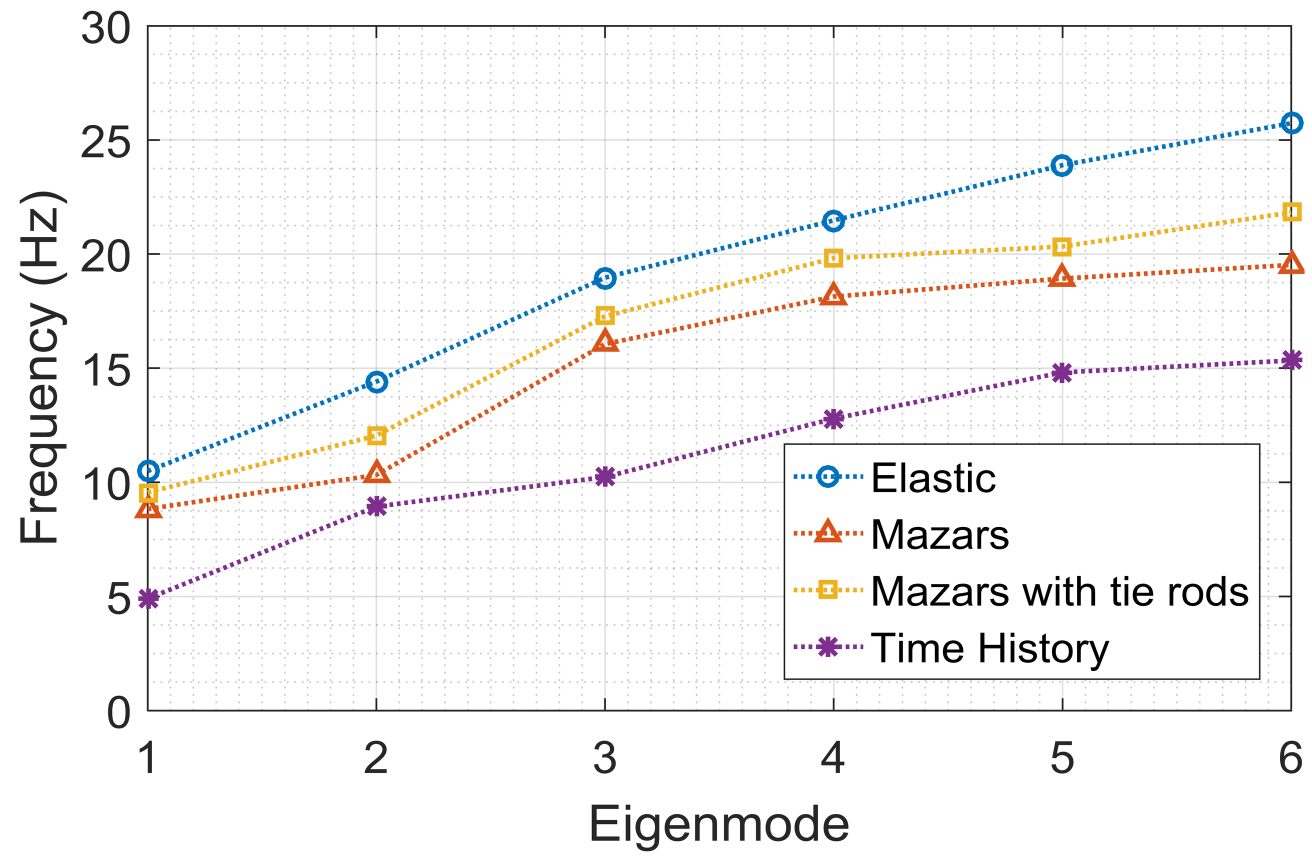


Figure 4. Eigenfrequency values for the different modeling hypotheses.

The model was then subjected to an acceleration history of the 2013 earthquake performed from a nearby station and the structure displayed additional damage. A final modal analysis was performed at the end of the time history and the structure displayed a further stiffness reduction and a modal shape variation between the second and the third mode.

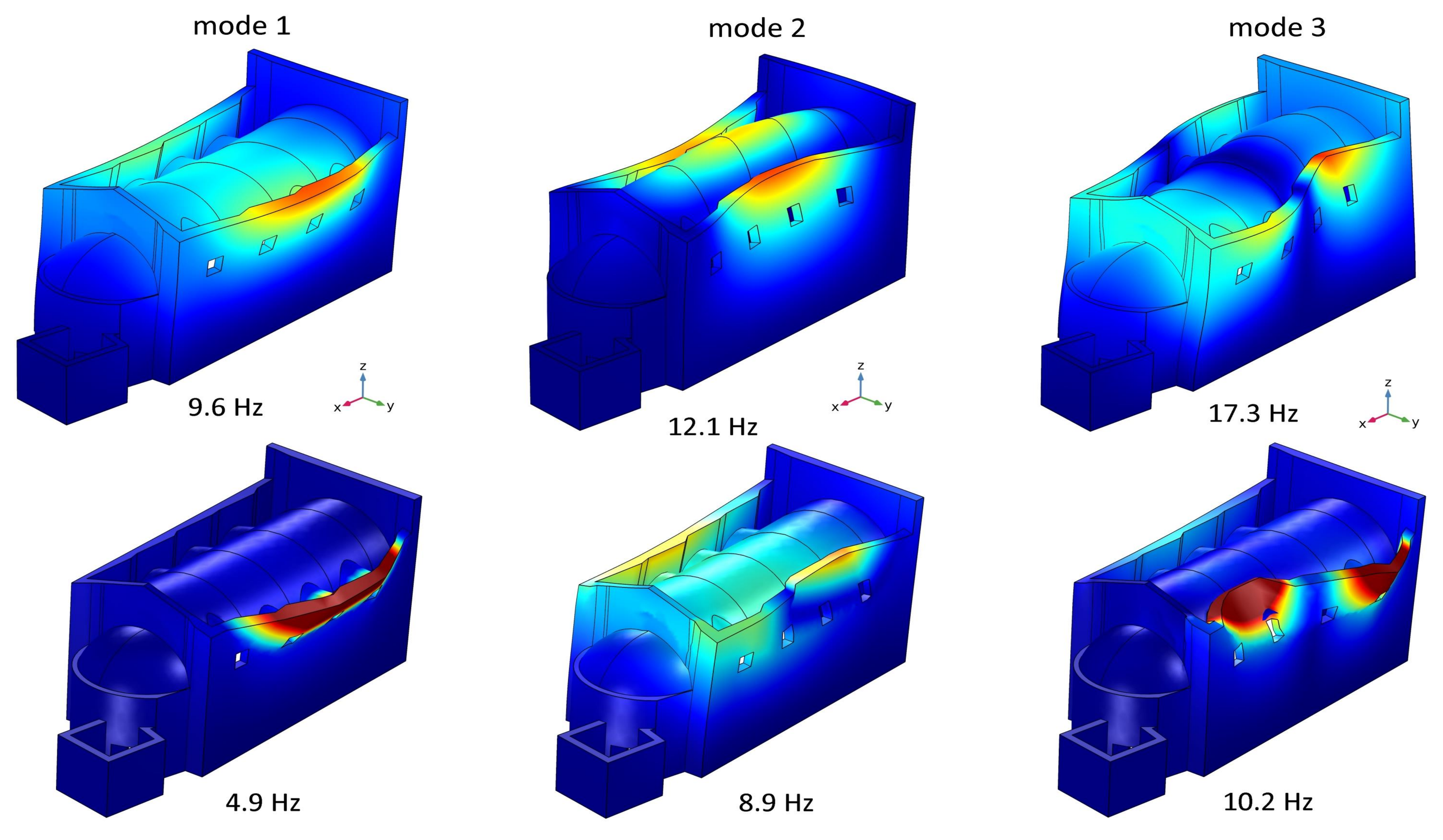


Figure 5. Mode shapes of the model equipped with tie rods under the self-weight, before (upper) and after the shaking (lower).

CONCLUSIONS: Mazars' model is able to capture structural damage in masonry structures and COMSOL® allows to study their dynamic properties after damage. Further developments to accurately model cyclic loads may be achieved by implementing the Author's μ model.

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