

Simplified seismic assessment of monument applying the 3D time evolution presentation

Authors: Meta KRŽAN¹, Roko Žarnić²

¹ Slovenian National Building and Civil Engineering Institute, Ljubljana, Slovenia, meta.krzan@zag.si

² University of Ljubljana, Faculty of Civil and Geodetic Engineering, Ljubljana, Slovenia, roko.zarnic@fgg.uni-lj.si

Forum topics	<input type="checkbox"/> Energy in 21st Century	<input checked="" type="checkbox"/> Cultural Heritage in Digital World
	<input type="checkbox"/> Engineering Capacity Building	<input type="checkbox"/> Disaster Risk Management & Governance for Resilient Communities
	<input type="checkbox"/> Construction 4.0	<input type="checkbox"/> BIM Lifecycle, Facility & Asset Management

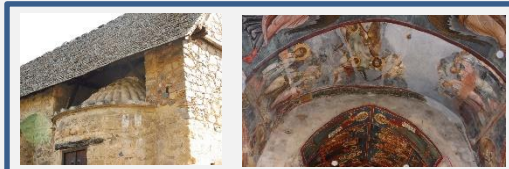
Abstract: (250 to 500 words: for each heading use the bullet points or narrative - the submission including graphics should not exceed one page)

Problems - Issues / Challenges-Needs	In order to perform numerical seismic analyses, which predict the behavior of structures during earthquake with adequate accuracy, many data needs to be considered to build a sufficient model. For monuments, this task is even more difficult, since there might be very limited information (if any) on the structural system, built in materials, details etc. available. Furthermore, monuments have often been constructed in more phases in different periods and subjected to structural changes through time. Due to its age and exposure to different environmental influences and events, monuments may already possess different types of damage. All this information is essential to determine the proper geometric and material characteristics of the monument for evaluation of the seismic resistance of the structure and of its assets (valuable non-structural elements) and furthermore to design (appropriate) intervention measures.
Solutions - Methods / Results - Findings	In the paper, application of seismic assessment approach using the case of stone masonry Asinou Church in Cyprus will be presented. The structure of the church has developed since 1105 in several steps until today and has valuable wall paintings. In the paper it will be demonstrated how the seismic resistance of church considering structural parts from different periods can be assessed by simplified performance-based approach introduced by EU FP7 project PERPETUATE (2010-2012, http://www.perpetuate.eu). For the input parameters, the recently introduced multimodal capturing of geometry and monument surface appearance with indoor and outdoor 3D laser scanner combined with high resolution digital and infrared camera provides improved accuracy and quality of data needed for monument assessment. Special attention will be paid to explanation of application of 3D information captured by integrated instrument.
Novelty - Value / Relevance to ...	The presented case is one of the case studies carried out within the on-going project EU H2020 INCEPTION (http://www.inception-project.eu). Project realizes innovation in 3D modelling of cultural heritage through an inclusive approach for time-dynamic 3D reconstruction of artefacts, built and social environments. It enriches the European identity through understanding of how European cultural heritage continuously evolves over long periods of time.
Forum statement	"The nondestructive data collection can in combination with data obtained by digital tools be very useful for the definition of the input parameters for numerical models used for seismic assessment of cultural monuments."

Keywords: (up to 5 keywords)

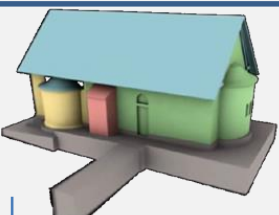
Cultural monument, assessment, earthquake resistance, time evolution, 3D model.

Graphics: (please use the gray area below for *representative graphics* or *graphical summary*: select the gray area below and paste your graphics)

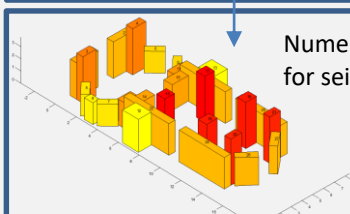


3D time evolution model

- 1105
- 1200
- 1300
- 1959

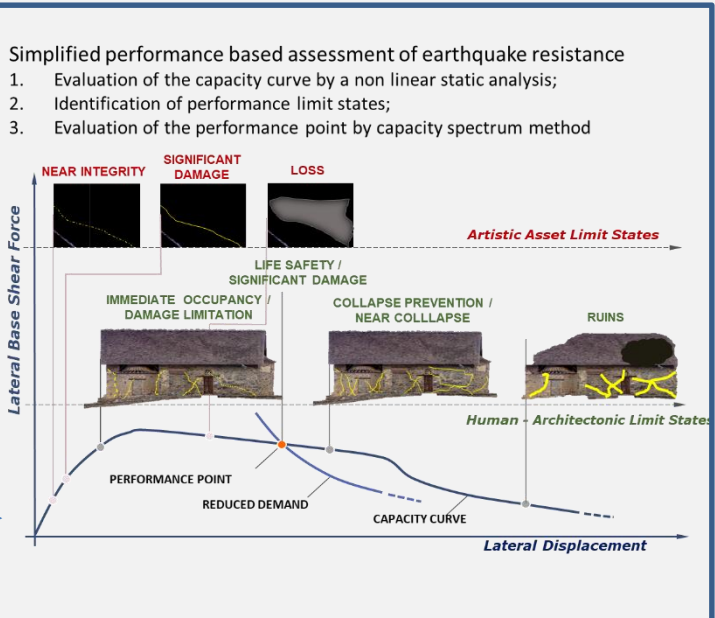


Numerical model for seismic analysis



Simplified performance based assessment of earthquake resistance

1. Evaluation of the capacity curve by a non linear static analysis;
2. Identification of performance limit states;
3. Evaluation of the performance point by capacity spectrum method



The graph plots Lateral Base Shear Force against Lateral Displacement. It shows a Capacity Curve (solid line) and a Reduced Demand curve (dashed line). The Performance Point is marked where the demand equals capacity. Three levels of damage are shown: NEAR INTEGRITY, SIGNIFICANT DAMAGE, and LOSS. Corresponding cross-sections of the church are shown above the graph, illustrating the state of the structure at different points on the capacity curve. Limit states are categorized as 'Artistic Asset Limit States' (top) and 'Human - Architectonic Limit States' (bottom).