A BIM-BASED METHODOLOGY FOR THE SEISMIC PERFORMANCE ASSESSMENT OF EXISTING URM-RC **BUILDINGS:**

Expeditious modelling and analysis framework

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Presentation summary

Part 1: Thesis timeline and publications

Part 2: Proposed seismic assessment methodology



Original thesis timeline M1: Publication of a conference article (finishing at 30 November 2021) about mixed typologies Apr 30 M3: Publication of an article about the M1: Publication of a journal article about performed numerical analysis mixed typologies Jul 31 May 28 M4: Publication of an article M2: Publication of a journal article about a about the developed new approach for the N2 method methodology Dec 30 May 31 2021 2017 Oct Mar Aug 2019 Jun Nov Sep Feb Jul Apr Todav Jul 1 T1 – State of the art T2 – Development of a BIM-based methodology for the seismic performance assessment T2.1 – Definition of the information and modelling requirements for the assessment methodology T2.2 - Development of a BIM plug-in for the automatic creation of EFM T2.3 – Definition and implementation of the parameters to evaluate the seismic vulnerability of the structure T2.4 – Implementation of an easy-to-use tool for the strengthening and design checking (Politecnico di Milano) T3 - Seismic assessment of the EUCENTRE prototype buildings T3.1 - Creation of the BIM models of the EUCENTRE prototype buildings T3.2 – Advanced numerical modelling (FEM) T3.3 – Simplified numerical modelling (EFM) T3.4 – Validation of the assessment methodology T4 – Seismic assessment of a representative URM-RC buildings (Politecnico di Milano) T4.1 – Selection and modelling of representative mixed URM-RC case-study buildings T4.2 – Advanced numerical modelling (FEM) T4.3 – Simplified numerical modelling (EFM) T4.4 – Parametric study T5 – Dissemination M1: article about M2: article about a M3: article about M4: article about Final writing of the numerical the BIM-based the thesis mixed typologies new approach for the N2 method analysis of URM-RC methodology

building typologies

Updated thesis timeline M1: Publication of a journal article about (finishing at 31 August 2022) mixed typologies May 28 M2: Publication of a journal article about a new approach for the N2 method Dec 30 M4: Publication of an article M1: Publication of a conference article M3: Publication of an article about the about the developed about mixed typologies performed numerical analysis methodology Apr 30 Jul 31 Mar 31 2022 2017 Oct Mar Jul Aug 2019 Jun Nov Apr Sep Feb Dec May Toda T1 – State of the art T2 – Development of a BIM-based methodology for the seismic performance assessment T2.1 – Definition of the information and modelling requirements for the assessment methodology T2.2 – Development of a BIM plug-in for the automatic creation of EFM T2.3 – Definition and implementation of the parameters to evaluate the seismic vulnerability of the structure T2.4 – Implementation of an easy-to-use tool for the strengthening and design checking (Politecnico di Milano) T3 – Seismic assessment of the EUCENTRE prototype buildings T3.1 – Creation of the BIM models of the EUCENTRE prototype buildings T3.2 – Advanced numerical modelling (FEM) T3.3 – Simplified numerical modelling (EFM) T3.4 – Validation of the assessment methodology T4 – Analytical formulation for the seismic performance assessment of URM-RC buildings T5 – Seismic assessment of a representative URM-RC buildings (Politecnico di Milano) T5.1 – Selection and modelling of representative mixed URM-RC case-study buildings T5.2 – Advanced numerical modelling (FEM) T5.3 – Simplified numerical modelling (EFM) T5.4 – Parametric study T6 – Dissemination M4: article about Final writing of M1: article about M2: article about a M3: article about the numerical the BIM-based the thesis mixed typologies new approach for analysis of URM-RC the N2 method methodology building typologies

Current impact

• Articles in International Journals



Intervened URM buildings with RC elements: typological characterisation and associated challenges

Lopes, G. C., Vicente, R., Ferreira, T. M., & Azenha, M. (2019). Bulletin of Earthquake Engineering, 1-33.



Displacement-based seismic performance evaluation and vulnerability assessment of buildings: The N2 method revisited

Lopes, G. C., Vicente, R., Ferreira, T. M., Azenha, M., & Estêvão, J. (2020). *Structures (24), 41-49.*



Numerical simulations of derived URM-RC buildings: assessment of strengthening interventions with RC

Lopes, G. C., Mendes, N., Vicente, R., Ferreira, T. M., & Azenha, M. (2021). (*Journal of Building Engineering*)

Conference articles



BIM-based methodology for the seismic performance assessment of existing buildings

Lopes, G. C., Vicente, R., Ferreira, T. M., Azenha, M., & Rodrigues, H. (2020). ENCORE 2020.



Desafios e direções de investigação na identificação e caracterização de tipologias de edifícios de alvenaria intervencionados com recurso a betão armado

Lopes, G. C., Vicente, R., Ferreira, T., & M., Azenha, M. (2019). *SÍSMICA 2019*.

Articles in National Journals



BIM-based methodology for the seismic performance assessment of existing buildings

Lopes, G. C., Vicente, R., Ferreira, T. M., Azenha, M., & Rodrigues, H. (2020). *Revista portuguesa de engenharia de estruturas 2020.* Part 1: Thesis timeline and publications

Part 2: Proposed seismic assessment methodology Expeditious modelling and analysis framework



Goals / Contributions





Robustness of the models



Automation and simplification of processes



Convenience in engineering practice

Validation strategy of the seismic assessment methodology

- Comparison amongst different types of:
 - Building geometries (pier H/D ratio, opening ratio, number of storeys)
 - Material properties

Case-study URM-RC buildings

- EUCENTRE buildings Model from experimental seismic table test campaign (unreinforced and reinforced typologies)
- 2 storey building Model from laser scanning survey + ambient vibration testing
- 3 storey building Model based on statistical study of the Portuguese building stock (Lovon, H., et al. 2021)
- 5 storey building Model follow the minimum dimensions recommended by the Health Regulation for Buildings (RSEU, 1903)



Validation strategy of the seismic assessment methodology

- Comparison amongst different types of:
 - Building geometries (pier H/D ratio, opening ratio, number of storeys)
 - Material properties
 - Analysis methods (experimental and numerical), based on:
 - Damage observation (damage patterns, failure modes and severity of cracking)
 - Modal analysis (modal shapes, frequencies)
 - Pushover analysis (target displacement, stiffness, capacity)

BIM-based seismic assessment methodology



BIM-based seismic assessment methodology



Modelling approach – irregular opening layout

• Usually, adjacent spandrels are combined into one



 However, adjacent spandrels may be separated by the storey level



- The discretization criteria is able to cope with:
 - very irregular opening patterns
 - vertical and/or horizontal misalignments
 - spandrels with different heights
 - spandrels with different thicknesses

BIM-based seismic assessment methodology



Analytical formulation – effective lateral stiffness / elastic deflection

• Usually, computed as one of two extreme cases



However, lateral stiffness should depend on the zero-moment coefficient



Analytical formulation – N-V interaction diagram

• Usually, the plastic hinge diagram is computed for the plastic moment with constant axial force



 However, the plastic hinge diagram should consider the elastic and postelastic branches and depend on the variation of the axial force



Contributions / Goals

- Speed of the analysis: EFM vs FEM



- Robustness of the model creation plug-in:
 - Able to handle irregular opening layouts
 - Not dependent on software version compatibility



- Automation and simplification of processes
 - Modelling, analysis, and results



- Convenience in engineering practice:
 - Choice of a widely known commercial software
 - Integrated multidisciplinary workflow: Architect Engineer Contractor – Client – User

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Thesis title: A BIM-based methodology for the seismic performance assessment of existing URM-RC buildings

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