

Opponent's review of the Doctoral Thesis

Candidate Claudio PAGANI

Title of the doctoral thesis Modeling of Masonry Structures at Multiple Scales

Study Programme

Tutor Prof. Andrea Vignoli, Prof. Maurizio Orlando, Prof. Milan Jirasek, Dr. Luca Salvatori

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Topicality of the doctoral thesis theme

Commentary: Very interesting topic, dealing both with real (high level Finite Element) applications and with theoretical analyses of constitutive equations.

The introduction is well-written and details nicely the bibliography on masonry, from a mechanical modeling point of view as well as from a numerical point of view. Claudio PAGANI takes some care to precise its own contributions compared to the international literature ones. Plasticity models for masonry are cited, one simply could have expected more details on existing Continuum Damage Mechanics models.

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Fulfilment of the doctoral thesis objectives

Commentary: Full fulfilment

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Research methods and procedures

Commentary: The first half of the PhD thesis concerns simplified—but sophisticated and efficient, which is a strong point of the work—constitutive models for masonry. They are well described, developed, identified and analyzed by Claudio PAGANI. The final part of the PhD thesis concerns three-dimensional constitutive equations, also described with care and deep understanding. It includes a novel (2D) strain localization analysis. One would just have expected a better transition/link between the two different scientific approaches.

<input type="checkbox"/> excellent	<input checked="" type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Results of the doctoral thesis – dissertant's concrete achievements

Commentary: The thesis is made of six chapters (2 to 7, plus an introduction and a conclusion). The chapter 2 (on the mechanics of masonry at the different scales, it includes testing) and 3 (a review of the mechanical models, again at the different scales, for masonry structure analysis) are introductory chapters. The author's approach of masonry computation, by an Equivalent-Frame method, is applied to seismic analysis of masonry walls in chapter 4; it is compared to

finite element computations in order to properly model the response of irregular masonry walls submitted to seismic loading. The numerical analysis of masonry piers is performed in chapter 5. Chapters 6 is more theoretical, chapter 7 more « computational ». The analytical strain localization analysis of an advanced orthotropic multisurface plasticity model (Lourenço-De Borst-Rots model for masonry) is performed in chapter 6. In final chapter 7, a microstructural analysis of a masonry unit cell under periodic boundary conditions is performed. Even if the last two chapters have a strong theoretical character, Claudio PAGANI takes the time to run sensitivity analyses and to address (applied) engineering questions.

The results of chapter 4 and 5 have a strong interest for engineering (seismic) applications. They go up to the computation (by EF Seismic vulnerabilities predicted by Equivalent-Frame method and by finite elements) of the seismic vulnerabilities of a masonry wall with openings, and to the estimation of rift capacity. An efficient sensitivity analysis of the different stiffnesses, the shear stress and of the ultimate drift with respect to compression ratio and to aspect ratio, is provided. The more theoretical results on strain localization are very technical but well written so that one sees well the originality of the work (the ability to deal with a complex, orthotropic, constitutive model). Both the plastic- plastic and elastic-plastic (non usual) strain localization analyses are given.

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Importance for practice and for development within a branch of science

Commentary: A strong effort is made to make the PhD results usefull for engineers.

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Formal layout of the doctoral thesis and the level of language used

Commentary: Excellent.

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
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Remarks

The author discusses the results obtained, in a systematic manner. The sensitivity analyses provided are appreciated as they emphasize both the amount of work realized and the taste of Claudio PAGANI to address in fine applied mechanics questions. The nature of Claudio PAGANI's work is various as the strain localization analysis is fully theoretical and as the final chapter 7 deals with homogenization procedures and with finite element computations. My only (small) regret would be that more attention could have been paid to the coupling with damage, and more generally to the role of damage and of its induced anisotropy on the results. But more PhD' time would have been necessary.

Final assessment of the doctoral thesis

The work is original, nicely from several ways: from the applied (engineering) mechanics point of view (by the applications given in chapters 4 and 5), from the theoretical mechanics point of view (chapter 6) and from the computational mechanics point of view (chapter 7).

The candidate can be admitted to the final examination.

Following a successful defence of the doctoral thesis I recommend the granting of the Ph.D. degree

yes <input checked="" type="checkbox"/>	no <input type="checkbox"/>
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Date: October 22, 2021

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