Recenzja spełnia wymagane formalne

Ph.D. THESIS OPINION

Przewodniczący Rady Dyscypliny
Inżynieria Lądowa, Geodezja i Transport
Politechniki Śląskiej
prof. dr hab. inż. Piotr Folęga

Name of the reviewer: **Prof. Arkadiusz Kwiecień, Ph.D., D.Sc., Eng.**

Affiliation of the reviewer: **Faculty of Civil Engineering, Cracow University of Technology, ul. Warszawska 24, 31-155 Kraków, Poland**

Title of the thesis: **Behavior of external clay brick façade walls made of lime-based mortars – experiments and simulation approach of irregiular settlements and seismic type cyclic shear loads**

PhD Candidate: **MSc. Eng. Amando Zagaroli**

Report:

This PhD thesis review report was prepared on the basis of an letter from Prof. Piotr Folęga, Ph.D., D.Sc., Eng., the Head of the Council in the Discipline of Civil Engineering, Geodesy and Transport, dated on July 18, 2025, and the review agreement No. UMC/2517/2025, prepared to the application No. 2415/UMC/RBO-3/2025, who commissioned me to prepare a review of the PhD Thesis of MSc. Eng. Amando Zagaroli. The PhD thesis manuscript of Amando Zagaroli was attached to these documents.

Subject and general characteristics of the dissertation with elements of assessment

The subject of the assessment is the doctoral dissertation of Amando Zagaroli " Behavior of external clay brick façade walls made of lime-based mortars – experiments and simulation approach of irregular settlements and seismic type cyclic shear loads", supervised by Prof. Jan Kubica, Ph.D., D.Sc., Eng.. The manuscript of the dissertation is a paper book written in English, with 178 pages in A4 format consisting of: a list of presentations and publications arising from this PhD study, a table of contents and 8 main chapters. The chapters cover: Introduction, Literature critical review, Experimental campaign, Numerical simulations, Analytical or semi-analytical methods and procedures, Summary and conclusions, Directions for further research, Appendix. The manuscript is ended with bibliography (with 260 positions), one page abstract and lists of figures and tables. The doctoral dissertation was prepared in frame of the SUBLime, funded by a Marie Skłodowska-Curie Action, European Training network – Innovative Training Network (ETN ITN).

The topic undertaken by the PhD Candidate is sound and with practical value. Lime mortars have been used for centuries in building engineering and were replaced mostly by cementitious mortars in the last century. Advantages of lime has not only an environmental impact, as a natural material supporting decarbonization effort, but also is useful due to its compatibility with other building materials, is durable and thus sought in cultural heritage preservation. In opposite to stiff cementitious mortars, lime mortars manifest more flexible properties with ductility, especially required in seismic areas.

Wpłynęło dnia 8.10.2025 r.

Despite of lower strength in comparison to cementitious mortars, lime mortar can manifest more promising features because introduces in masonries better resistance to deformations caused by vertical (settlement) or horizontal (seismic) loads. To assure enough stiffness, strength, deformability and failure mechanism of masonries, mortar mixtures containing higher contents of air lime as a partial substitute for cement binders are elaborated. Complex research including experimental, numerical and analytical analysis in this field are needed, thus this PhD thesis covering these requirements is important, especially when a comprehensive experimental characterization at different scales is considered. The main aims of the thesis are clearly and precisely specified at the beginning by the PhD candidate, in form of three thesis contributing to the development of more sustainable and structurally efficient masonry systems suitable for modern construction and renovation scenarios. I can confirm that the thesis were proven by elaborations presented in this PhD manuscript.

A doctoral dissertation layout is clear and covers all important issues grouped in 7 main chapters. The introduction introduces the research topic, outlines its scientific and practical relevance and defines the main hypothesis guiding the study. Next, critical review of the literature related to the main topics of the elaborated research is presented. This part is especially valuable, because gives readers comprehensive overview and introduction to the state of the art of the presented problem.

The most important is the part covered by Chapter 3, focused on experimental research with a multiscale approach. Investigation of small-scale and large-scale specimens is well elaborated. Setups, methodologies and results obtained are properly selected and presented, as well as supported by photos, tables and graphs, with a particular focus on the elaboration of global mechanical parameters for masonry walls. Chapter 4 complements the previous chapter with numerical modeling of the tested walls using finite element macro-modeling approaches. The models are quite well calibrated based on the experimental results from small-scale tests. They are employed to simulate the behavior of walls under vertical and lateral loading conditions, and verified accurately by experimental results of large-scale tests.

Practical value is visible in Chapter 5, where a comparative evaluation of the experimental result against existing analytical and semi-analytical models, including those provided by Eurocodes, is presented. It should be pointed out critical assess of the reliability and predictive accuracy of these models. Chapters 6 and 7 summarizes the key findings of the research, discusses the main conclusions and reflects on the implications for the sustainable masonry constructions, with showing the possible future research directions, limitations and application of air lime-based masonry. The Appendix at the end presents data reports, including statistical analyses related to the experimental tests described in the previous subsections.

This work is an important contribution to scientific research in this field, along with practical verification and discussion of standard and design requirements, which is necessary to implement the proposed solutions in practice, ensuring the safety of structural applications. The Author of the dissertation practically published the results of his research in indexed journals and recognized conference proceedings, hence his contribution in this field is currently noticed.

Detailed discussion of the dissertation content and critical remarks

Detailed comments and critical remarks presented below aim at improving this valuable work, when published further in indexed journals (strongly recommended). The most important remarks are marked with *** and must be included, when applied in a journal manuscript. The comments marked with * are recommendations of the reviewer before publication of the results in scientific journals and conference materials, due to better engineering understanding of the presented results and comparisons.

Remarks:

1.*** Page 13 – Figures 7 and 8 should be improved with visible font size of axes' description and unit descriptions (e.g. [%] in graphs (b)).

2. Why the load control was applied in some tests, whereas the displacement control in others? This do not allow somebody to compare results with proper accuracy when materials sensitive to displacement ratio are tested.

3. Page 16, Table 1 – Why compression strength of bricks from the XVIII/XIX century is so high in comparison to the other ones presented in this table?

4. Page 16 – The impact of earthquakes touches also (often more) other European nations, like Turkish, Balkans and Swiss nations.

5.* Page 21, Eq. (1) – lack in description of f_b and f_m.

6.* Page 26 – "Based on the studies .... response of walls" – this sentence has a grammar mistake. What does mean "so"?

7.*** Page 37, Eq. (13) – "k" or "κ"?

8.* Page 48 – The applied shape factor was 0,75, whereas it should be 0,53 = 215x102/[(2x215+2x102)*65]. Does it influence the results?

9.* Page 54, Table 12, Fig. 50 – How were the presented stress values calculated from forces? There is not any equation in the text or in the Appendix.

10.* Page 54 – How was fracture energy calculated?

11. Page 58, Table 14 – Why number of samples differs each other (range of 3-9)?

12.* Page 61, Table 16 – Should not be "Masonries" instead of "Clay bricks"?

13. Please comment on differences in maximum load presented in Fig. 64 and 65 between LVDT and DIC.

14.* Figure 66 – For what was used DIC, when its results are not presented nor compared with LVDT ones?

15. Subchapter 3.3.1 – Why the distance "s" is equal to 350 mm, instead of 300 mm? What was the criterium in choosing the applied distances "s"?

16. Fig. 69 – The statement that the applied scheme reflect the uneven settlement fully is doubtful. It is valid when the passing mining deformation curve in soil supports a wall at two bottom corners (arch effect occurs – dead load (gravity) [G] and additional load [P] act in the same arrow direction on the

presented scheme). When it supports a wall only on the wall's one half and the second half is "hanging", the cantilever effect occurs (dead load (gravity) [G/2] and additional load [P/2] act in the same arrow direction in nature, but in the presented scheme in opposite one).

17. Why angular strains are presented ones in [rad] or [mrad] – vertical loads and as a drift in [%] – horizontal loads. Should not it be consistent in the whole manuscript?

18.* Fig 76a, 81a, 86a, 91a – there is lack of information that there are presented average curves.

19.* Page 100 – "A similar trend is observed ...". Rather opposite one.

20.* Fig. 122 – The description of horizontal axis should be normalized and presented as a drift in [%].

21. Page 108, line 3 – "FEM" instead of "fem".

22.* Subchapter 4.1 – How was adjusted the size of the models' meshes in relation to an error?

23.* Page 110, Fig. 131 – "The results indicate ...". Rather opposite one.

24. Chapter 4 – Finally, why this chapter was presented, when the adjusted models were not used for further simulations? Was it presented only to show that the models can be adjusted with some accuracy?

25.* Page 126 – "In our study ...". Who did this study? The PhD Candidate or somebody else? Was it an independent work?

I have to underline that the subchapter 3.4 is very valuable and presents condense analysis and summary of the experimental part. It confirms scientific adulthood of the PhD Candidate. Also the comparison of predicted and experimental results in Table 26 with comments below has very high practical value, being recommended to do modifications in current standards.

Final evaluation of the thesis

Summing up all the material contained in the doctoral dissertation as well as the results of research and analysis, I believe that the PhD Candidate Amando Zagaroli has undertaken to solve a difficult problem in scientific terms and needed for practical applications. The presented results of own research are original and contain a lot of scientific novelties, are of high cognitive value and contribute significantly to expanding knowledge on mortar mixtures with higher contents of air lime as a partial substitute for cement binders and its role in masonry behavior under vertical and horizontal loads.

In the doctoral dissertation, no hidden borrowings and so-called plagiarism of other works were found. The achievements of other scientists, discussed in detail, cited in the dissertation and used in the analyses, are frequently cited. At the same time, I can say that the PhD Candidate has made a significant, individual and independent contribution to the development of the concept, the implementation of the experimental part, the development and interpretation of the results presented in the dissertation. The applied methodology used in the research and the obtained results are original and valuable scientifically.

In the latter aspect, the remarks presented in this review report has minor weight, but I hope that this shortcoming will be eliminated in the further research work of the PhD Candidate. Amando Zagaroli

showed extensive knowledge in the field of experimental research related to deep investigation of masonry with the use of mortars with higher contents of air lime, as well as their elaboration and analytical analysis, required in engineering practice. Defense of PhD thesis is the first step in scientific career, thus I believe that he will develop his scientific workshop in the future.

The PhD Candidate Amando Zagaroli has successfully achieved the assumed goal of the work and generally confirmed the thesis. Nevertheless, before publishing the results of this dissertation in scientific journals or monographs (I strongly encourage him to do it), the PhD Candidate should consider the possibility of supplementing and clarifying the comments contained in the critical remarks presented in this review report.

Despite the critical remarks and doubts presented, I state that the doctoral dissertation submitted for review is an original solution to the scientific problem, and the PhD Candidate Amando Zagaroli has demonstrated general theoretical, experimental and practical knowledge in the given scientific Discipline of Civil Engineering, Geodesy and Transport and the ability to independently conduct scientific work and thus meets the requirements for PhD theses. The quality of the submitted work matches the standard of a dissertation in respectable international research institutions and meets the requirements for doctoral dissertations in accordance with the applicable Act of 20 July 2018, "Law on Higher Education and Science" - Journal of Laws of 2024, item 1571, as amended (zgodnie z obowiązującą Ustawą z dnia 20.07.2018 roku „Prawo o szkolnictwie wyższym i nauce" - Dz. U. z 2024r., poz. 1571 z późniejszymi zmianami).

Therefore, I submit for admittance of the PhD Candidate Amando Zagaroli for public defense and his application for the degree of doctor of technical sciences in the Discipline of Civil Engineering, Geodesy and Transport. Possible distinction of this work should be discussed just after the defense by the members of the Council in the Discipline of Civil Engineering, Geodesy and Transport and by the reviewers present there.

Overall Evaluation:

Positive: As the reviewer, I propose to the PhD board the admission of the thesis of PhD Candidate Amando Zagaroli for public defense, with minor revisions, presented in details in this review report.

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*wyłączenie jawności w zakresie danych osobowych oraz prywatności osoby fizycznej na podstawie art. 5 ust.2 ustawy z dnia 6 września 2001 r. o dostępie do informacji pub;icznej (tj. Dz. U. z 2016 r. poz. 1764)

Marzena Gaura