Recenzja spełnia wymagania formalne

Review of doctoral dissertation

Wrocław University of Science and Technology
Faculty of Civil Engineering

Reviewer:
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REVIEW OF DOCTORAL DISSERTATION

Armando Zagaroli, MSc, Eng.
entitled: "*Behaviour of external clay brick façade walls made of lime-based mortars - experiments and simulation approach of irregular settlements and seismic type cyclic shear loads*"

Polish title
"*Zachowanie się zewnętrznych, ceglanych ścian fasadowych wykonanych na zaprawach na bazie wapna — podejście eksperymentalne i symulacje nieregularnych osiadań i cyklicznych obciążeń ścinających typu sejsmicznego*"

1. Formal basis

The formal basis for this review is provided by:
- Resolution of the Discipline Council for Civil Engineering, Geodesy and Transport of the Silesian University of Technology of 17 July 2025,
- Letter from the Discipline Council for Civil Engineering, Geodesy and Transport of the Silesian University of Technology of 18 July 2025, signed by the Chairman of the Council, Prof. Piotr Folęga, PhD, Eng.

2. Subject and general description of the dissertation

The subject of the review is the doctoral dissertation by Armando Zagoroli, MSc, Eng. entitled: "*Behaviour of external clay brick façade walls made of lime-based mortars - experiments and simulation approach of irregular settlements and seismic type cyclic shear loads*" (Polish title: "*Zachowanie się zewnętrznych, ceglanych ścian fasadowych wykonanych na zaprawach na bazie wapna — podejście eksperymentalne i symulacje nieregularnych osiadań i cyklicznych obciążeń ścinających typu sejsmicznego*"), supervised by Prof. Jan Kubica, PhD Eng.

The dissertation was submitted in the form of a concise, double-sided report and has a total of 173 pages. The publication was written in English and contains 64 tables and 160 figures. It consists of 7 chapters, three appendices, and a bibliography containing a total of 260 references. The content of the dissertation is preceded by a list of conference presentations and publications related to the doctoral dissertation, and an abstract in English is also included.

The research was conducted as part of the Horizon 2020 Marie Skłodowska-Curie ITN SUBLime project ("Sustainable applications of building lime through circular economy and biomimetic approaches"), which aims to investigate the role of air lime-based materials in new generation masonry construction.

The layout of the dissertation is clear, characteristic of scientific and research publications, and the editing is correct.

3. Substantive assessment of the dissertation

3.1 Subject and purpose of the dissertation

The scientific problem addressed in the dissertation is the analysis of the behaviour of unreinforced external ceramic brick façade walls made of lime mortar, with particular emphasis on their performance in the case of irregular vertical settlements (such as those caused by ground settlement or mining activity) and cyclic loads in a plane, which are representative of seismic impacts.

The aim of the dissertation was to conduct experimental and numerical studies that could form the basis for both future guidelines and practical applications. To this end, a comprehensive research methodology combining laboratory experiments and numerical modelling was implemented. The experimental programme was developed on the basis of a multiscale approach, including tests of materials: mortar, bricks and full-scale wall simulations.

Three theses were formulated in the study:

1. Despite their lower mechanical strength, mortar mixtures with a higher air lime content, as a partial substitute for cementitious binders, can still provide adequate structural parameters for masonry walls, especially in the façade layers of cavity or diaphragm walls, while offering environmental benefits.
2. Changes in the air lime content of mortar significantly, though positively in terms of crack resistance, affect the overall behaviour of masonry walls, particularly in terms of stiffness, strength, deformability and failure mechanisms.
3. Simplified numerical models, as well as existing standards and analytical recommendations can describe the mechanical response of masonry elements made of air lime-based mortars, although they may require calibration or adjustment to ensure an adequate level of safety and reliability.

3.2 Characteristics and evaluation of individual chapters of the dissertation

Chapter 1: *Introduction* proposes the subject of the research, presents its scientific and practical significance, and defines the main hypothesis underlying the study. The main objective of the dissertation and its general scope are formulated and the tasks that allowed the objective to be achieved are set out.

Chapter 2: *Literature review* presents a critical review of the literature on the main research topic. It covers the physical, chemical and morphological properties of masonry materials, including comparisons of contemporary and historical bricks and clay mortars. It also discusses the mechanical behaviour of masonry under complex loading conditions and discusses numerical modelling strategies, in particular finite element methods, used to simulate masonry structures.

Chapter 3: *Experimental investigations* describes the materials selected for testing and the experimental programme designed to investigate their mechanical parameters. The chapter details the test setups, methodologies and results obtained from both small- and large-scale tests, with a particular focus on the development of global mechanical parameters for masonry walls.

Chapter 4: *Numerical simulations* presents numerical modelling of the tested walls using finite element macro-modelling methods. These models were calibrated based on experimental results from small-scale tests and used to simulate the behaviour of walls under vertical and horizontal loads.

Chapter 5: *Analytical or semi-analytical methods and procedures* presents a comparative assessment of experimental results with existing analytical and semi-analytical models, including those contained in Eurocodes. The reliability and predictive accuracy of these models were critically evaluated.

Chapter 6: *Summary and conclusions* contains a discussion of the results of the research, summarises the conclusions drawn from the analyses, summarises the key research results, discusses the main conclusions and discusses their significance for sustainable masonry construction.

Chapter 7 presents possible directions for future research aimed at addressing the limitations identified in this study and furthering the knowledge and applications of air lime-based masonry.

In my opinion, the research methodology presented in the dissertation and verified experimentally is accurate and correct in terms of content. The analyses presented refer to both domestic and international literature. The subject matter seems to be topical and necessary. There are also just a few publications

devoted to this subject. The thoroughness of the research and its applicability in design are also noteworthy. The doctoral dissertation certainly presents the Doctoral Student's general theoretical knowledge in the field of civil engineering, geodesy and transport.

4. Critical comments

First of all, I would like to emphasise that the critical comments on the reviewed dissertation presented in this section are provided for the purpose of discussion and to organise the presented content in the hope that they will be useful and will be used in the preparation of scientific publications for journals on this subject.

A significant part of the critical comments has already been provided in section 3.2 when reviewing individual chapters. Below, they have been collected and systematised, and some of them are presented in the form of questions. Thus:

4.1. The title of the dissertation contains everything that is in the dissertation.
4.2. The publication is written in fairly good language, taking into account stylistic, grammatical and punctuation rules.
4.3. The subject of the research is not specified.
4.4. What were the limitations of the research methodology used?
4.5. What simplifications were used in the simulation models?
4.6. Which phenomena (cracking, scratching, loosening) proved to be the most critical under cyclic loads?
4.7. What were the greatest difficulties in mapping irregular settlements and seismic loads in the simulations?
4.8. How was the accuracy of the numerical models verified against the results of experimental research?
4.9. What are the main differences in the behaviour of masonry walls built with lime mortar compared to cement mortar?
4.10. Are the observed damages reversible (e.g. through repair) or do they lead to a permanent loss of the load-bearing capacity?
4.11. How can the test results be used in the renovation and maintenance of historic buildings?
4.12. How can the conclusions help in assessing the safety of walls in seismic regions?
4.13. What further research would be needed to better understand the behaviour of brick walls in seismic conditions?
4.14. Was the impact of environmental factors (moisture, temperature, mortar ageing) on the research results considered?
4.15. To what extent can the results of the research be used in engineering practice?

5. Conclusions

The doctoral dissertation submitted for review by Armando Zagaroli, MSc, Eng. entitled: "*Behaviour of external clay brick façade walls made of lime-based mortars - experiments and simulation approach of irregular settlements and seismic type cyclic shear loads*" (Polish title: "*Zachowanie się zewnętrznych, ceglanych ścian fasadowych wykonanych na zaprawach na bazie wapna — podejście eksperymentalne i symulacje nieregularnych osiadań i cyklicznych obciążeń ścinających typu sejsmicznego*"), supervised by Prof. Jan Kubica, PhD, Eng., is a solution to an original scientific task concerning the analysis of the behaviour of external ceramic brick façade walls made of lime mortars, irregular settlements and cyclic seismic shear loads.

I believe that the objective presented in the dissertation has been achieved and the scientific task formulated has been solved. The doctoral dissertation therefore demonstrates the Doctoral Student's ability to conduct independent scientific research.

It should be noted that the Doctoral Student demonstrated a good knowledge of the current state of scientific and technical knowledge in the field of the presented subject, which has been studied for some time at the Faculty of Civil Engineering of the Silesian University of Technology. This testifies to the scientific maturity of the Doctoral Student and, above all, to the quality of the school from which he comes. This undoubtedly had a positive impact on the publication as a whole and provided an opportunity to learn programming and conduct scientific and experimental research. The conducted research has expanded the existing knowledge base. On this basis, a critical analysis of the results obtained was carried

out, they were analysed and conclusions were drawn. However, the entire publication demonstrates the Candidate's readiness to conduct independent scientific and research work. The dissertation makes a significant contribution to the development of knowledge in the field of civil engineering, surveying and transport, is of scientific and practical importance, and has partially systematised knowledge on the behaviour of external ceramic brick façade walls made of lime mortar, irregular settlements and cyclic seismic shear loads. In addition, the doctoral dissertation presents an original solution to a scientific problem or an original solution in the application of the Doctoral Student's own research results in the economic sphere.

6. Review summary

In my opinion, the reviewed dissertation by Armando Zagaroli, MSc, Eng. entitled: "*Behaviour of external clay brick façade walls made of lime-based mortars - experiments and simulation approach of irregular settlements and seismic type cyclic shear loads*" (Polish title: "*Zachowanie się zewnętrznych, ceglanych ścian fasadowych wykonanych na zaprawach na bazie wapna — podejście eksperymentalne i symulacje nieregularnych osiadań i cyklicznych obciążeń ścinających typu sejsmicznego*"), **meets the requirements for doctoral theses** specified in the Act of 20 July 2018 Law on Higher Education and Science — **and therefore I request that it be admitted for public defence.**

Yours sincerely,
[illegible signature]
Prof. Krzysztof Schabowicz, PhD, Eng.