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Reviewer's report for the PhD thesis of Mr Farzin Kazemi entitled *Seismic retrofitting strategies for buildings using innovative approaches*

1 Formal and legal basis, subject of the review and review structure

This review has been prepared pursuant to a commissioned task undertaken in response to a letter with reference number 659/WBLiŚ/2025 dated 11 September 2025, received from Prof. Ewa Wojciechowska, Chair of the Scientific Discipline Council *Civil Engineering, Geodesy and Transport* at Gdańsk University of Technology, concerning the appointment of a reviewer in the proceedings for the conferment of the doctoral degree upon Mr Farzin Kazemi.

The legal basis for the proceedings is (as per original document title): art. 190 ust. 2 z dnia 20 lipca 2018 r. *Prawo o szkolnictwie wyższym i nauce* – hereafter referred to as UPSWiN, (Dz. U. 2023 r. poz. 742, z póź. zm.).

I received the whole set of documents related to the proceedings, including the PhD thesis, results of the plagiarism check and the main PhD supervisor's statement, on 23 September 2025 by traditional post.

The subject of this review is the doctoral thesis entitled *Seismic retrofitting strategies for buildings using innovative approaches*. The thesis consists of:

- title page;
- principal supervisor statement;

- statement from Mr Farzin Kazami – PhD thesis author;
- description of the PhD thesis with basic bibliographic details including summaries in Polish and English;
- acknowledgements;
- table of contents;
- summary in Polish;
- summary in English;
- list of ten papers presented as the main scientific outcome of the doctoral studies together with the relevant publishing policy;
- journal metrics for the ten papers presented as the main scientific outcome of the doctoral studies and authors' contributions;
- six numbered chapters;
- list of references (129 items);
- list of all published papers;
- list of papers presented at conferences;
- ten papers presented as the main scientific outcome of the doctoral studies.

This review has been prepared in accordance with the guidelines published in June 2022 by the Council for Scientific Excellence in the document *Reviews in Academic Promotion Procedures. A Guide*, available at: https://www.rdn.gov.pl/dobre-praktyki.poradnik-recenzje-w-postepowaniach-o-awans-naukowy.html.

This review is structured as follows. Chapter 2 provides a brief discussion of the scope of the doctoral thesis and the content of each of the papers presented as a scientific achievement. The assessment of the thesis is presented in Chapter 3. The comments, not all of which are critical, are divided into general comments, presented in Chapter 3.1 and referring to the work as a whole, and detailed comments, presented in Chapter 3.2 and referring to the content found on specific pages of the dissertation. The summary and conclusions are given in Chapter 4.

This document contains 11 pages.

2 Thesis scope

The doctoral thesis is concerned with the development of seismic retrofitting strategies for buildings and simplified seismic assessment and design tools. The ten papers presented as a scientific achievement are briefly outlined below.

Paper I presents a study on the behaviour of adjacent reinforced concrete and steel frames under seismic excitation leading to pounding. The numerical incremental dynamic analysis (IDA) was performed with models varying with respect to the number of stories and separation distance between the frames. The findings show that pounding substantially increases internal forces and deformations in structural elements, leading to reduced seismic capacity. The resulting fragility curves indicate heightened vulnerability and a greater likelihood of severe damage or collapse when buildings interact during strong ground motions. Probability factors are provided to account for the pounding effects without the need to perform detailed numerical simulations.

Paper II is a continuation of Paper I. It presents a study on the use of viscous dampers installed between adjacent reinforced concrete and steel frames to mitigate the effects of earthquake-induced pounding. The numerical analyses are performed on the same or similar frame models as those used in Paper I. Interestingly, the results indicate that linear viscous dampers generally outperform nonlinear ones. Furthermore, the performance of both structures with the potential to collide should be considered when selecting damper locations. This was explained by the observation that retrofitting can reduce the collapse probability of taller frames but may increase the failure risk for shorter ones.

Paper III presents a study on the use of bolts made from shape memory alloys (SMA) to enhance the seismic capacity of buildings. A hysteresis model was adopted to capture the behaviour of SMA materials within the numerical analysis framework. The study postulates that incorporating SMA bolts can improve the seismic performance of steel moment-resisting frames. Their superelastic behaviour may also help mitigate uncertainties in the actual rigidity of beam–column connections.

Steel moment-resisting frames (SMRF) are also a subject of the study presented in **Paper IV**. The capacity of infill masonry walls (IMW) in improving the seismic performance of SMRF is investgated under different IMW locations and for different soil types. It is shown that, by changing the fundamental vibration frequency, hence vibration period, the IMW-enhanced frames can significantly affect the failure probability. An extension of this work is presented in **Paper V**, that being the consideration of semi-rigid connections.

Paper VI presents a study on steel buckling-restrained braced frames supplemented with viscus dampers (VD) and shape memory alloys (SMA) within the cores. The inclusion of these devices and materials, when considered individually, in most but not all cases improved the seismic performance of the frames. However, the best solution was achieved by combining VA

and SMA. Building upon these findings, **Paper VII** presents the design and implementation of a double-stage yield steel slit buckling-restrained brace. An experimental campaign was conducted using small-scale specimens to evaluate the performance of these devices under controlled laboratory conditions. Various topological arrangement were investigated from which few were selected for further optimisation. The optimised solutions were shown to have a superior hysteretic behaviour.

Papers VIII, **IX** & **X** propose machine learning-based approach to the prediction of, respectively, seismic performance of steel moment-resisting frames, reinforced concrete buildings and shear walls.

3 Thesis assessment

To systematise the assessment, the comments have been divided into general comments referring to the work as a whole, presented in Section 3.1, and detailed comments referring to the content presented on individual pages of the thesis, presented in Section 3.2, with page references marked by the letter P (e.g. P1 refers to the first page of the thesis). It should be noted that not all comments are critical in nature. Some of them serve to reinforce the claims made by the thesis author.

3.1 General comments (denoted GC)

(GC#1) The format of the reviewed PhD thesis is rather unusual for the Polish system of academic degrees, as it is presented as a collection of journal publications rather than a traditional monograph-style dissertation. While this format is acceptable for a PhD thesis, it requires the inclusion of appropriate auxiliary sections. Specifically, an introductory chapter should be provided to outline the research topic, explain the motivation for the work, identify existing knowledge gaps, define the specific research questions and objectives, and present the adopted research methodology. A concluding chapter should likewise be included to evaluate the extent to which the presented work answers the research questions and meets the stated objectives. Together, the introductory and concluding chapters should frame the thesis as a coherent whole and provide the necessary integration across the individual publications. In its current form, the thesis does not fulfil some of these requirements, or does so only to a limited extent.

(GC#2) There is a significant difference in writing quality between the ten papers presented as the scientific achievement and the remainder of the thesis. The numbered chapters contain numerous overly complex, compound sentences that are difficult to follow. The arguments within many paragraphs tend to wander across various subjects and lack cohesion. A more serious issue, however, lies in the frequent logical shortcuts and unclear causal relationships, which render the narrative vague and hard to interpret. Several examples of these problems are provided in Section 3.2 of this review.

(GC#3) The thesis is heavily reliant on OpenSees software for structural analysis under earthquake excitation. OpenSees is a popular community-developed open-source tool used in earthquake engineering. It includes a number of predefined models of materials and elements, and solvers or/and numerical frameworks for various types of analyses. It would be worth to make a statement in the introductory section of the thesis to what extent these built-in capabilities of OpenSees were utilised, and whether the results presented in the papers necessitated implementation of custom-built models. This would help to clarify the author's contribution in this respect.

(GC#4) The seismic retrofitting of buildings can affect dynamic structural behaviour not only in the case of base-force excitation, but also under wind action. It would be useful to discuss this, however briefly, to point out this auxiliary effect.

(GC#5) To add structure to the introductory section, it would be useful to introduce subsections dealing with the major topics addressed in the papers, for example: seismic performance assessment, pounding of buildings, rigid and semi-rigid connections, infill walls, braced frames, soil-structure interaction. All these topics are discussed on P7-P12 – that is only 6 pages in total, but in little detail.

(GC#6) The introductory chapter should reach conclusions about the current state of knowledge. In its current form, it is more of a collection of (sometimes loosely) related topics and does not offer much in terms of critical overview and, perhaps more importantly, synthesis of the current state-of-the-art.

(GC#7) The classification of machine learning (ML) models is not sufficiently systematic. For example, the relevant paragraph on P10 mentions supervised learning, but neither unsupervised nor semi-supervised learning is discussed, even though both paradigms have been applied in earthquake engineering. This omission is particularly notable given the author employs ML models in publications VIII, IX, and X.

(GC#8) The *Methodology and modeling* section should precede the presentation of the paper contents. This is not the case in the current thesis structure as the content of each individual paper is outlined in Section 2: *Objectives and scope of research*, and then described in more detail in Section 4: *Results and discussion*. This scattering of information across multiple chapters may confuse the reader and does not aid comprehension.

(GC#9) The quality of drawings is generally high, which is commendable.

(GC#10) Considering the number of abbreviations used in the thesis, to improve readability, it would be worth to add a list of abbreviations.

(GC#11) The information presented in Section 4: *Results and discussion*, is often incomplete. This is to say that the various concepts and scope of the conducted work are not sufficiently explained. This could be fixed, to some extent, by relating the information in that section to the relevant information presented in Section 3: *Methodology and modeling*. For example, small and large segments of the SSD-BYD are denoted within Fig. 13, but not explicitly defined in Section 4.7. Linking these sections would improve readability of the thesis.

(GC#12) The concluding section is rather disappointing. The conclusions lack sufficient specificity and verge on being trivial. They do not adequately reflect the scope or significance of the work that has been carried out.

(GC#13) It is not entirely clear from some of the papers whether the analyses were conducted on 2D or 3D structural models. In several cases, only translational modes appear to have been considered, with torsional and out-of-plane responses neglected. Consequently, the generality and applicability of the presented results may be uncertain.

(GC#14) The most valuable contributions of the doctoral thesis are twofold. The first is the investigation of the SSD-DYB device, carried out through both theoretical and experimental approaches. The second is the application of machine learning tools, which – given the high computational demands of seismic performance analysis, can significantly improve the efficiency of seismic design and assessment of buildings. Nevertheless, it should be emphasised that publishing ten papers in reputable journals during a doctoral project is exceptionally rare in the field of structural dynamics and represents a significant achievement.

3.2 Detailed comments (denoted DC)

(DC#1) P7: *two categories of external and internal forces* this statement is ambiguous

(DC#2) P7: Adding a viscous damper (FVD) or any other coupling device between steel structures can help in preventing structural pounding, but it also dynamically couples the structures. Is it conceivable that this could, in some circumstances, lead to the amplification of structural response, e.g. in certain modes?

(DC#3) P7: This statement does not make any sense: *In addition, implementation of FVDs in between all floor levels of steel and reinforced concrete (RC) structures can be a cost-effective approach rather than using FVDs in each of the structures, and this can prevent it from being engineering application (...).*

(DC#4) P8: The conjunctive adverb *However* is misplaced in the first paragraph, throwing the reader off the intended (or so I believe) line of argument.

(DC#5) P8 & P41: To be able to start a sentence from *On the other hand*, there should be a preceding *On the first hand*.

(DC#6) P9: *The buckling-restrained braced frame (BRBF) is known as a structural lateral-resisting system that provides unbuckling conditions during severe ground motion excitation.* This sentence is incorrect. What are *unbuckling conditions*?

(DC#7) P9: *proper function*?

(DC#8) P9: *acceptable promising efficiency*?

(DC#9) P9: source of Figure 1?

(DC#10) P10: *experienced experts*?

(DC#11) P10: *The prediction of the seismic (...) with inputs and outputs.* MLs use data as inputs, to predict outputs. This sentence is imprecise.

(DC#12) P10: *The accuracy of a model can be determined by comparing the predictions and outputs for the testing datasets.* This sentence is also imprecise. The model validation relies on the comparison between model outputs, trained on one dataset, with another dataset. This is clearly presented in Fig. 20 on P29.

(DC#13) P12: I hardly think the aim of the thesis is to propose *novel retrofitting strategies (...) intended to reduce the computational modelling procedure (...).* I believe these are two separate issues, which for some reason the author tried to squeeze into one (compound) sentence.

(DC#14) P15 and elsewhere: There is lack of consistency in that the main software package for computational simulation is referred to as *OpenSees* and *Opensees* (e.g. Fig. 6 on P18, Fig. 11 in paper VIII). The former version is appropriate and should be used throughout.

(DC#15) P15: *at* both ends, not *in both ends*

(DC#16) P15: *In the fiber model (. . .)* appears to be the first instance where fiber models are mentioned. To facilitate understanding and avoid an abrupt introduction, these models should be briefly explained beforehand. Better yet, they should be introduced before the IMK hinge models, to highlight the benefits of the latter approach.

(DC#17) P16: The two beam to column connections should be clearly denoted within Fig. 3. That same figure contains dimensions which are explained neither in the figure caption nor in the relevant paragraph.

(DC#18) P17: Fig. 5 contains the same information as already presented in Fig. 4. Furthermore, the word *with* in the figure caption is sparse.

(DC#19) P19: It seems the BNWF model presented in Fig. 9 does not include dashpots, as stated in Section 3.1.4, but non-linear springs only.

(DC#20) P21: *(...) can be achieved by equation (3)* can be obtained from equation (3)?

(DC#21) P22: Repetition of information between the sentences starting from *The as-built U-shape (...)* and *To prepare the dissipative device (...).*

(DC#22) P29: *three categories* I suggest adding *, namely* afterwards, to improve this sentence.

(DC#23) P29: *that effectively zeroing them out* this sentence is grammatically incorrect.

(DC#24) P29: *Heatmap* why starting from the capital letter?

(DC#25) P30: What is the *target variable*? Has it been introduced prior to this point? A few sentences below, the term *prediction target* is used. How does it correspond to the target variable?

(DC#26) P30: *auto-sklearn* is a toolkit for the automated ML. This should be clearly explained.

(DC#27) P32: Has the term *base learner* been used before? If not, it should be introduced.

(DC#28) P33 & P43: *Stacked* in Fig. 24 caption and elsewhere – why starting from the capital letter?

(DC#29) P33: *alone ML models*? It would be better to refer to these models as *bare* or even better *simple* ML models.

(DC#30) P34 & P36 and elsewhere: The terms *near-filed*, *nearfield* and *far-field* are used throughout the thesis. However, the words *filed* and *field* have different meaning. I believe the correct option is *field*.

(DC#31) P36: *Moreover, SMA bolts can be replaced in semi-rigid connections of existing buildings for retrofitting purposes (...)* Is this statement correct? In its current form, it suggests that SMA bolts, which are already implemented in a structure, can be replaced.

(DC#32) P37: *Paper V investigated steel damaged buildings due to constructional defects on the rigidity of connections (...)* It would be better to brake this compound sentence into two simpler sentences, starting from: The performance of steel buildings in which connections' rigidity was compromised due to constructional defects was investigated in Paper V.

(DC#33) P37: design assumptions, rather than *designed assumptions*

(DC#34) P37: *(...) capability of the structure in lateral loads.* This statement is incorrect. It would be better to say: capacity of the structure to carry lateral loads.

(DC#35) P37: *(...) connections had a great influence on meeting the performance of the building.* This sentence is incorrect.

(DC#36) P39: Lack of consistency in using acronyms: FVDs, rather than *VDs*

(DC#37) P40: *not possibly efficient*?

(DC#38) P41: The explanation of the $x = y$ relationship is missing.

(DC#39) P42: It should be clearly stated that Cases A–D relate to the four analysed buildings. Because the author failed to provide explanation of these buildings, the results presented at this point are meaningless.

(DC#40) P44: Conclusions stated in Section 5 should be explicitly linked to the ten papers presented as the scientific achievement.

(DC#41) *Therefore, probabilistic assessment of steel structures including IMWs and SSI were considered, focusing on proper modeling approach and their influence on seismic assessments.* What is the subject of the sentence? Should singular or plural form be used? What is a *proper modeling approach*? The way the terms *probabilistic assessment* and *seismic assessments* are used in the sentence makes the message unclear.

(DC#42) P44: *(...) a combination of their effects was investigated and both effects were simultaneously modeled.* There is redundant information in this sentence.

(DC#43) P47: Engineering Structures, not *structures*

(DC#44) Paper VI, P16: *(...) both SMAs and VDs significantly increased the seismic collapse probability (...)* Is this statement correct?

4 Conclusions

Art. 187 of the UPSWiN states that the doctoral thesis (own translation):

(i) *presents the candidate's general theoretical knowledge in the discipline or disciplines and the ability to conduct independent scientific or artistic work*;

(ii) *can take the form of a written work, (..) including a collection of published and thematically related scientific articles*;

(iii) *should include a summary in English (...).*

While the requirements stated in (i) & and (ii) are clear, the requirement stated in (iii) is open to interpretation. This is because the Polish word *streszczenie* does not have a direct equivalent in English. To make matters worse, neither UPSWiN nor the Council for Scientific Excellence, which oversees Polish bodies awarding doctoral degrees, provides any guidance in this respect. It seems the closest English word is *summary* rather than *abstract*. There is a significant difference between these two terms. An abstract is a brief note, typically less than one page and presented as a single paragraph, providing a concise overview of the thesis. A summary, by contrast, is more substantial – it is a stand-alone description of the work presented as a scientific achievement. Such a summary should explain the motivations for the work, identify existing knowledge gaps based on a literature review, define the specific research questions and objectives, present the adopted research methodology and report the results obtained within the doctoral project. It should also provide conclusions evaluating the extent to which the conducted work answers the research questions and meets the stated objectives. Although the doctoral thesis contains most, but not all, of these elements, their presentation is muddled and does not fully enable the reader to understand the thesis contributions. In that sense, **the reviewed work is an example of a very successful doctoral project, but not an equally successful doctoral thesis**.

Despite these shortcomings, the following conclusions can be drawn from this review:

- **The author of this doctoral thesis possesses general theoretical knowledge in the scientific discipline *Civil Engineering, Geodesy, and Transport*.** This is evidenced through the presentation of concepts related to mechanics of structures, and more specifically to earthquake engineering and structural dynamics, use of terminology specific to this discipline, and the descriptions of various relevant technologies and engineering practices. The ability to situate the results of the study within a broader scientific context further demonstrates subject-matter knowledge. The inclusion of a bespoke experimental campaign within the work programme, in addition to analytical and numerical modelling, also supports this conclusion.

- **The author of this doctoral thesis has developed the ability to conduct independent research.** This is supported by the scope of the original research carried out, including both modelling and empirical studies. The contributions of the doctoral candidate to the presented work are clearly indicated in several published papers presented as a scientific achievement, including papers II–VI, IX & X. The results presented in the thesis are critically evaluated, and the author's interpretations are appropriately balanced and discussed in the context of current knowledge in the field.

- **The results presented in the doctoral thesis constitute evidence of an original solution to the studied research problems**, namely seismic retrofitting of buildings and novel approaches to the seismic design and assessment. All ten papers presented as a scientific achievement were published in reputable peer-reviewed journals and have already attracted considerable attention in the scientific community.

The arguments presented demonstrate that the doctoral thesis by Farzin Kazemi entitled *Seismic retrofitting strategies for buildings using innovative approaches* meets all three conditions required for a doctoral thesis to be considered compliant with the relevant requirements as specified in (as per original document title) art. 187 ustawy z dnia 20 lipca 2018 r. *Prawo o szkolnictwie wyższym i nauce* (Dz. U. 2023 r. poz. 742, z póź. zm.). In view of the above, I recommend that the thesis be admitted for public defense.