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REVIEW

of the PhD dissertation by Mr. Iman Abbasi Nattaj Omrani, M.Sc.
entitled „*Developments in Investigating the Durability of Porous Building Materials Under the Chemical & Physical Modes of External Sulfate Attack*"

1. Basis for the preparation of the review

The formal basis for this review is a letter dated May 23, 2025, addressed to me by the Dean of the Faculty of Civil Engineering, Architecture and Environmental Engineering at Lodz University of Technology, Artur Wirowski, PhD, DSc, associate professor, informing me of my appointment, pursuant to Resolution No. 1.14/12/2025 of May 15, 2025, of the Civil Engineering, Geodesy and Transport Discipline Council at Lodz University of Technology, as a reviewer of the doctoral dissertation by Mr. Iman Abbasi Nattaj Omrani, M.Sc., entitled "*Developments in Investigating the Durability of Porous Building Materials Under the Chemical & Physical Modes of External Sulfate Attack*". The letter was accompanied by a copy of the doctoral dissertation and the relevant documents. The dissertation supervisor is Prof. Marcin Koniorczyk, PhD, D.Sc., and the auxiliary supervisor is Dr. Piotr Konca, PhD.

This review of the doctoral dissertation has been prepared taking into account Article 187 of the Act of July 20, 2018, "*Law on Higher Education and Science*" as amended.

2. Subject matter and content of the dissertation

The dissertation consists of 142 pages and is structured as follows: a table of contents, 6 chapters (including the introduction, summary, and bibliography), and a summary. Both the dissertation and the summary are written in English. The dissertation does not contain any appendices, nor does it include a consolidated list of figures or tables. While the latter is not formally required in doctoral dissertations, it is often included as it facilitates navigation through the content. The dissertation contains a total of 62 numbered figures, 26 tables, 48 formulas, and 202 bibliographic references.

In the introduction (Chapter 1, pp. 6–9), the Author concisely outlines the objectives of the work, the research hypotheses, and the scope of the dissertation. It is stated that the work concerns the assessment of the durability of selected porous building materials subjected to external sulfate attack. The Author notes at the outset that external sulfate attack should be considered in two distinct categories, i.e., chemical sulfate attack (CSA) and physical sulfate attack (PSA), due to their differing mechanisms of damage. In the subsequent chapters, the results obtained are discussed and analyzed while maintaining this division. It is highlighted that while the impact of CSA on building materials is already well understood, in the case of PSA there remain many uncertainties and unanswered questions. The Author identifies methodological gaps and a lack of standardization in the assessment of the durability of porous building materials against PSA as a key problem. The aim of the dissertation is to conduct original research to expand the current state of knowledge in this area by: (i) identifying the optimal method for extracting the pore solution of sulfated cementitious samples prior to microstructural analysis; (ii) developing a new method for simulating accelerated PSA in cementitious materials and introducing a new criterion for studying its progress; (iii) designing a novel non-destructive method for assessing salt content in porous building materials under PSA; (iv) analyzing changes in the permeability of cementitious materials under PSA and developing an improved hierarchical capillary bundle model for simulating this parameter.

Chapter 2 (pp. 10–47) constitutes a literature review. The reader is introduced to the current state of knowledge regarding the issues addressed in the dissertation. The focus is placed on porous building materials, particularly their permeability and air pore structure. The Author rightly states that these are among the most critical properties determining the resistance of porous materials to PSA. The literature approaches to modeling the relationship between air pore structure and permeability are discussed, with particular emphasis on the random hierarchical capillary bundle (RHCB) model. The Author also discusses the properties of the materials later used in the original research, i.e., cementitious composites based on Ordinary Portland Cement (OPC), composites based on limestone calcined clay cement (LC^3), red clay brick, and sandstone. Subsequently, CSA in OPC-based cementitious composites and the mechanism of PSA in porous building materials are examined. As a result, the Author identifies several research gaps, including the lack of standardization and consensus regarding the extraction of pore solution from CSA-exposed OPC-based materials; the absence of standard methods for simulating and assessing PSA in cementitious composites; the lack of non-destructive testing methods for assessing salt content in porous building materials under PSA; and limitations in the RHCB model.

Chapter 3 (pp. 48–84) begins with a description of the research procedures applied, including X-ray diffraction (XRD), thermogravimetry (TG), mercury intrusion porosimetry (MIP), and the CEMBUREAU gas permeability test. The theoretical assumptions of the improved RHCB model are then presented, with particular emphasis on analyzing the effect of various probability density functions (PDFs) in Equation (31). For the first time, an attempt is made to determine the impact of different PDFs on the standard deviation and the PDF of the final simulation results. To this end, the evaluation of the effects of a uniform distribution and normal distributions with an expected value of 0.5 and standard deviations of 0.33 and 0.66 is proposed. The chapter proceeds with a description of the materials used in the research, i.e., OPC- and LC^3-based paste and mortar, red clay brick, and sandstone. For the first two, a detailed characterization is provided, including chemical composition; the development of hydration in pastes as a function of curing time analyzed using XRD and TG techniques; the development of the air pore structure; and, finally, the determination of the compressive strength of mortars. Additionally, for LC^3-based composites, the cement production procedure is presented. Unfortunately, the scope of characterization for clay brick and sandstone is rather limited, as it is confined to presenting, fortunately, the most relevant property from the perspective of the dissertation topic—namely, the air pore structure characterization.

Of particular importance in terms of originality is Section 3.4, where the Author provides a very detailed description of the sample preparation procedure and the investigations plans, highlighting the novel aspects related to the four objectives defined in Chapter 1. It is worth noting that, in addition to describing the procedures and plans, the Author also presents them in the form of graphical diagrams, which facilitates a deeper understanding of this part of the dissertation for the reader.

Chapter 4 (pp. 85–118) constitutes the most important part of the dissertation. It provides a detailed discussion of the Author's experimental results and their analysis. The chapter is divided into four subsections, each corresponding to a specific research objective. This division makes this part of the work very clear and facilitates the reviewer's assessment of whether the individual objectives have been achieved.

In the first part (Section 4.1), the focus is on studies aimed at determining the optimal method for pore solution extraction. The Author analyzed six methods: oven drying at 40 °C (Oven), vacuum drying at 30 °C (Vacuum), and four solvent exchange methods, namely via isopropanol at 25 °C (ISP 25 °C), via isopropanol at 5 °C (ISP 5 °C), via ethanol at 25 °C (ETH 25 °C), and via ethanol at 5 °C (ETH 5 °C). The Author did not analyze methods requiring thermal treatment at higher temperatures due to their destructive effect on PSA products in cement paste. Of all the methods analyzed, compared to the control sample, ISP 5 °C exhibited the highest intensities in the XRD test, the lowest transmission intensities for characteristic wavenumbers in the FTIR test, and the closest mass loss in the TG measurement. These findings led the Author to conclude that the solvent exchange method via isopropanol at 5 °C is the optimal method in this context.

Next (Section 4.2), strain measurements were analyzed as a novel criterion for investigating the progress of PSA in cement mortar. It was observed that PSA caused 0.66% and 0.48% strain in OPC mortars with w/c ratios of 0.5 and 0.4, respectively. In contrast, CSA-induced strain was less than 0.05% in both cases. The Author pointed out that internal expansion was the reason for the deformations caused by PSA, resulting in the destruction of samples with w/c ratios of 0.5 and 0.4. It was also noted that this finding stands in contrast to conclusions drawn from literature, where PSA is often considered to be limited to mere surface scaling.

Subsequently (Section 4.3), the possibility of using UPV as a non-destructive method for assessing in-pore salt content was analyzed. These studies were conducted on red clay brick and sandstone. The Author designed a temperature program for initiating mirabilite crystallization/dissolution in the above-mentioned materials. The program consisted of two stages: an auxiliary cycle and a main cycle. It was first demonstrated that the auxiliary cycle was necessary and effective in providing a template for sole crystallization of mirabilite at temperatures above 0.5 °C. Two main conclusions were formulated in this part of the work: first, the salt-induced UPV rise depends on the orientation of the pore relative to the direction of compressional wave propagation; and second, the greater the volume of in-pore mirabilite, the higher the solid density of the material, which accordingly increases the UPV. As a practical outcome, simple linear equations were proposed to determine the average volume of in-pore mirabilite as a function of either the average UPV or the average UPV change for both materials tested.

The final part (Section 4.4) presented considerations regarding the simulation of gas permeability in PSA-exposed OPC mortar using the improved RHCB model. As previously stated, the main innovation in this area was the evaluation of the influence of different PDFs of random input data on the PDF of the simulated K_{int} parameter. It was shown that the closest match between the average simulated and experimental K_{int} was achieved when the random input data followed a normal distribution with a standard deviation of 0.33. In this case, K_{int} fell within 0.1 magnitude of the experimental value, which constituted the highest precision of the model among all analyzed cases.

Chapter 5 (pp. 119–125) provides a summary of the work, formulates final conclusions, and indicates possible directions for future research. Chapter 6 (pp. 126–140) contains the bibliography, comprising 202 references.

In conclusion, the layout of the dissertation is appropriate. It is worth highlighting the way the Author approached the analysis and interpretation of results, namely by dividing Chapter 4 into four subsections, each corresponding to a separate research objective. This approach positively influenced the organization of the dissertation content. In the reviewer's opinion, an exception to this otherwise logical structure are the single subsections in Section 2.2 and Chapter 5, which each contain only one subsection (2.2.1 and 5.1, respectively). The use of subsections is meaningful when there are at least two or more; in this case, incorporating these single subsections directly into the main chapters would have been more appropriate. Overall, the graphical elements of the dissertation are carefully prepared, and the issues addressed are presented in a clear and comprehensible manner.

The content of the dissertation leads the reviewer to conclude that the Candidate possesses general theoretical knowledge required at the PhD level in the discipline of Civil Engineering, Geodesy, and Transport. Moreover, the way the research program was established demonstrates that the PhD Candidate has acquired the skills necessary to conduct independent scientific research.

3. Evaluation of the dissertation

The main challenges currently faced in the field of cementitious materials engineering include the increasing operational loads on existing infrastructure, stricter requirements related to climate neutrality, and the necessity to reduce costly repairs resulting from premature deterioration. Already in Chapter 1 of the dissertation, the Author appropriately identifies physical sulfate attack (PSA) and salt crystallization in pores as among the most destructive degradation processes affecting concrete in variable climates, particularly in regions with significant temperature fluctuations and high environmental salinity. The choice of topic—comprehensive investigation of the microstructural effects of PSA and the proposal of an improved hierarchical capillary bundle model for predicting gas permeability increase—directly addresses these challenges. Thus, I evaluate the selection of the PhD dissertation topic positively, considering it both current and highly relevant.

Based on a review of the literature, the Author formulated four research objectives:

- identification of the optimal method for extracting the pore solution of sulfated cementitious samples prior to microstructural analysis;
- development of a new method for simulating accelerated PSA in cementitious materials and introducing a new criterion for studying its progress;
- design of a novel non-destructive method for assessing salt content in porous building materials under PSA;

- analysis of changes in the permeability of cementitious materials under PSA and development of an improved RHCB model for simulating this index.

In the context of the chosen topic, the formulated objectives required the Author to master numerous theoretical issues, advanced laboratory techniques, and to plan an entire series of labor-intensive experiments. It is worth emphasizing that the Author rightly selected Na_2SO_4 as the salt to prepare the sulfate solution, as this salt, according to available literature data, causes the most severe damage in terms of sulfate corrosion in both cementitious materials, red clay brick, and sandstone. The Author approached the problem in a multi-faceted manner, combining a carefully selected set of experimental methods (XRD, TG/DSC, FTIR, MIP, UPV, gas permeability testing) with an original adaptation of the RHCB model. This research strategy allowed not only for elucidating the mechanisms of damage and pore development during cyclic mirabilite crystallization/dissolution but also for providing a practical engineering tool for assessing the durability of elements exposed to PSA. The research hypotheses presented in Section 1.2 correspond directly to the above objectives and are verifiable within the context of the methods employed. In analyzing the results, the Author compared them with findings from the literature and drew appropriate conclusions. The dissertation is firmly grounded in the current state of knowledge: 78 out of 202 references are publications from the last 10 years. This reflects the novelty of the topics concerning PSA, LC^3, and hierarchical models, combined with older works discussing the fundamentals of building materials chemistry and methodologies (e.g., MIP or UPV).

In summary, the objectives of the work are ambitious yet realistic, and their hierarchy reflects a logical progression from measurement to modeling. The hypotheses have been formulated in a clear and verifiable manner. Thus, the experimental research presented in the dissertation has enabled the Author to achieve original solutions to scientific problems, fully meeting statutory requirements. The work aligns with the current trend of extending the service life of structures and reducing the environmental footprint of the construction sector, as each additional year of structural use effectively postpones CO_2 emissions associated with the production of new building materials and renovation works.

4. Comments

4.1. Substantive comments

1) The Author employs different materials to achieve the individual research objectives. For the first, OPC paste was used; for the second – OPC and LC^3 mortars; for the third – red clay brick and sandstone; and for the fourth – OPC mortar. What were the criteria for selecting porous materials for accomplishing each of the dissertation objectives?
2) Section 1.1 – The Author defines the first objective as the identification of the "*optimal*" pore solution extraction method. There is a need for a clear and explicit definition of what is meant by "*optimal*" i.e., which method would be considered optimal and which would not.
3) Section 1.2 – The first research hypothesis concerning the pore solution extraction method is formulated in a rather obvious way: "*...sensitivity decreases the precision of the microstructural analysis of the sulfated samples.*" In the reviewer's opinion, such a formulation is rather self-evident to a person scientifically involved in concrete technology, even without conducting a literature review.

4) Section 2.1.1 – The Author refers to the classification of pores (micro-, meso-, macro-) based on the International Union of Pure and Applied Chemistry (IUPAC). This division applies to general materials science; however, in cement practice, these boundaries are typically shifted upward to reflect dominant transport phenomena: D_{eff} of micro-pores < 100 nm (C-S-H gel pores and fine capillary pores), meso-pores – 0.1 µm to 10 µm (medium and large capillary pores), macro-pores > 10 µm (air voids, cracks). Example reference: Gong, F., Zhang, D., Sicat, E., & Ueda, T. (2014). *Empirical estimation of pore size distribution in cement, mortar, and concrete*. Journal of Materials in Civil Engineering, 26(7), 04014023.
5) Section 3.1.1 – The Author provided XRD measurement parameters: diffraction angles of 5–80° 2θ, step 0.017°, exposure 200 s/per step. At these values, this results in approximately 4410 steps; multiplying by the time per step gives more than 240 hours of continuous testing per single sample, which is unrealistic. Is the stated 200 s/per step correct? How long did a single measurement actually take?
6) Section 3.1.4 – There is no information regarding the samples amount for the MIP test. How many samples were examined per measurement?
7) Section 3.1.7 consists of only one sentence. It would be desirable for the PhD Candidate to expand this section with at least such information as sample size, sample count, loading rates for both compressive and tensile strength tests, etc.
8) Section 3.1.8 – In the methodological description of the UPV test, information about the size of the tested samples is missing. Such information only appears later in the results section (Chapter 4).
9) Section 3.1.9 – Please clarify the exact pressures at which gas permeability was tested. The text mentions only "*at least three built-up pressures higher than atmospheric pressure*".
10) Section 3.1.9 – Why was O_2 chosen as the working gas? In cementitious composites, gas permeability is often tested using N_2 as a working gas, which is more inert with respect to the cement matrix.
11) Tables 11 and 12 – It is unclear whether the chemical composition was determined independently or if these are manufacturer-provided data. If determined by the Author, the methodology should be specified. Additionally, for OPC, important parameters such as SO_3 content, alkali content, and loss on ignition (LOI) are missing.
12) Figures 18 and 23 – It is unclear how the vertical axis values were constructed. It appears the data were presented with an offset, in which case the Y-axis values are not actual for the individual OPC samples depending on their age.
13) Figure 20 – It is puzzling why the peak value of differential pore volume for 28-day OPC paste is noticeably smaller compared to that of 2-, 7-, and 56-day OPC paste. The Candidate does not discuss this observation in the text; please provide a possible explanation.
14) Section 3.3.1 – The Author indicated that mortar samples were "*mechanically compacted*". Please clarify how exactly the samples were compacted, i.e., whether a vibration table or standard jolting apparatus was used. What were the compaction parameters? This process and its regime are crucial for the repeatability and reliability of the results obtained.
15) Section 3.3.1 – The Author stated that "*the mortar samples were sealed and stored at room temperature until the designed test age*". This statement does not clearly indicate the curing

conditions. The curing regime should be provided with temperature and relative humidity values, as well as any deviations during the curing period.

16) Section 3.3.2 – Why was kaolin calcination conducted at 600 °C? It is generally considered that the optimal range for this process is 700–850 °C to fully dehydrate kaolin (as the Author himself noted in the literature review). Was the quality and reactivity of the resulting metakaolin assessed in any way?
17) Section 3.3.2 – Was the Blaine surface area of the obtained LC^3 cement tested? Please provide the chemical composition of the finished LC^3 cement. The dissertation only presents the chemical composition of the components used to produce LC^3.
18) Section 3.4, Objective 1 – The Author reported sample dimensions of 100 mm × 100 mm × 2 mm. However, based on the samples shown in Figure 29, they appear to be 10 mm × 10 mm × 2 mm. Additionally, how were the samples cut? Potential vibrations during cutting of such small samples could cause secondary microcracking, which may have affected the results.
19) Table 16 – It is unclear how the Candidate designed the DSC temperature program for initiating mirabilite crystallization/dissolution in brick and sandstone. Is this program based on literature analysis or the result of the Author's own trials and procedure calibration?
20) Section 4.1 – The Candidate evaluates the changes in the quantity of certain phases (ettringite, gypsum) in OPC pastes after different pore solution extraction methods based on XRD peak intensity, which is not appropriate. The reasoning presented here is therefore questionable. Besides phase content, peak intensity is influenced by many factors such as crystallographic properties, average crystallite size, or preferred orientation. The most reliable approach would be to calculate the phase proportions using Rietveld refinement. Fortunately, it appears that the Author is aware of this and mentions plans to adopt such an approach in future studies (Section 5.1).
21) Section 4.1 – The Author noted that in the TG test, the ETH 25 °C group could not be investigated because of a technical malfunction. Please elaborate on this; it is unclear what issue occurred.
22) Section 4.1 – The Candidate assumed that leaching aimed to remove residual Na_2SO_4 salts from the pore structure. However, the water used during leaching (cyclic immersion in distilled water and drying at room conditions) may also partially dissolve ettringite or gypsum, potentially artificially increasing porosity. Was this phenomenon monitored in any way?
23) Section 4.1 – In the last paragraph, the Author states, "*...this difference was not significant (i.e., less than 5% in terms of porosity)*". On what basis was it determined that a porosity difference of about 5% is insignificant? What type of significance is meant—statistical?
24) Section 4.1 – In the last paragraph, the Author stated that in the MIP test no notable difference between the pore structure of the different solvent-treated samples was observed. This is not entirely true because, in the case of ETH 25 °C, a new small peak appeared at a pore diameter of about 100 nm, which was not present in other samples. Please provide a probable explanation for this observation and assess its significance in the context of the objective analyzed in this section.

25) Section 4.2 – Did the Author calculate the solid phase density of OPC- and LC^3-based mortars from the MIP data? Aside from the pure air pore structure, this would be valuable complementary information regarding the internal structure of mortars, especially since different cements were used.
26) Figure 47 – The procedure described in Section 3.4 indicates that strain measurements were performed every four days. The trend is clearly visible; however, for completeness, a data point after 20 days of exposure is missing.
27) Section 4.2 – The Author concludes that CSA- and PSA-exposed samples had practically the same ettringite and gypsum content. This conclusion was based on a comparison of XRD diffractograms of the two samples, which, as mentioned earlier, is not entirely appropriate. Nevertheless, please explain why, despite the different mechanisms of action, the content of these two compounds in the samples is very similar.
28) Figure 54 – In some cases, there are relatively large data dispersions (error bars). It might be preferable to present mass variation on a percentage scale relative to the dry or water-saturated sample.
29) Section 4.3 – The Author observed that "*the lower the initial dry UPV of the brick (direction III), the higher the UPV rise after mirabilite crystallization*". Please provide probable causes for this phenomenon.
30) Table 22 – The R^2 values indicate a very good fit of the linear equations to the empirical data. However, R^2 alone does not provide information about the prediction error. It would be valuable to also include an error metric such as MAE (mean absolute error) or RMSE (root mean squared error).
31) Section 4.3 – The Author attributes the increase in UPV to mirabilite crystallization. However, there is no indication that the effect of temperature change on UPV was considered. Literature data (e.g., Hariri, R., Chaix, J. F., Shokouhi, P., Garnier, V., Saïdi-Muret, C., Durand, O., & Abraham, O. (2024). *Quantification of the Uncertainty in Ultrasonic Wave Speed in Concrete: Application to Temperature Monitoring with Embedded Transducers*. Sensors, 24(17), 5588) suggest that a temperature drop of about 40 °C (as in these tests, from 40 °C to 0.5 °C) can result in an UPV increase of approximately 50–100 m/s or more (depending on the material's structure). Thus, the measured UPV values likely represent a combination of the effects of mirabilite crystallization and temperature change.
32) In a work of this nature, microstructural analysis using scanning electron microscopy (SEM) is highly recommended. It is reassuring that the Author also recognizes this need and mentions the plan to perform such analyses in future research.

4.2. Editorial comments

1) The lack of a list of abbreviations and symbols at the beginning of the dissertation makes it difficult to quickly find the meaning of the acronyms and units used in the equations. Including such a list would significantly improve the readability of the work.
2) Language errors and typos identified during the review::
    - p. 6, last paragraph, third line: written "*...century, A number...*", should be "*...century, a number...*";

- p. 49, second paragraph: written "*...prsented...*", should be "*...presented...*";
- p. 49, second paragraph: written "*...operate...*", should be "*...operator...*";
- p. 50, first paragraph: written "*...characteristics...*", should be "*...characteristic...*";
- p. 50, first paragraph: written "*...bons...*", should be "*...bonds...*";
- p. 57, caption of Fig. 15: written "*...capillay's...*", should be "*...capillary's...*";
- p. 57, caption of Fig. 15: written "*...netwrok...*", should be "*...network...*";
- p. 65, third paragraph: written "*...Blain...*", should be "*...Blaine...*";
- p. 81, last paragraph: written "*...thought...*", should be "*...through...*";
- p. 83, second paragraph: written "*...leching...*", should be "*...leaching...*";
- p. 119, second paragraph: written "*...closet...*", should be "*...closest...*".

3) p. 20 – The sentence reads: "*Compared with belite which reacts 30% during the first 28 days of hydration, belite possesses a higher reaction rate...*". It seems that in the second part of the sentence the Author actually meant alite?
4) Fig. 11 – The figure caption lacks a definition of what parts A and B of the figure represent.
5) Different bullet point styles are used in the work, e.g., p. 41 (dots) and p. 47 (dashes). This should be unified for consistency.
6) It is recommended that small tables or figures, along with their captions, be placed entirely on a single page, e.g., Table 12, Fig. 28.
7) Fig. 28 – The graph is not very clear. To improve clarity, it would be better to present two graphs side by side, one for clay brick and the other for sandstone.
8) Fig. 30 – It is recommended to add information to the diagram about the control group used in the XRD and TG tests.
9) The dissertation is formatted such that each new paragraph begins without the characteristic indentation. It is recommended to include a first-line indent in new paragraphs, as this improves the readability of the dissertation.

5. Final conclusions

In his doctoral dissertation, Mr. Iman Abbasi Nattaj Omrani, M.Sc., presented the results of research on the effects of different modes of external sulfate attack (CSA and PSA) on the microstructure, permeability, and durability of cement pastes and mortars, red clay brick, and sandstone. At the same time, he proposed an improved version of the RHCB model. This comprehensive approach—combining advanced laboratory diagnostics (XRD, TG/DSC, FTIR, MIP, UPV, gas permeability testing) with modeling—enabled the PhD Candidate to achieve the objectives of the dissertation and verify the research hypotheses. A significant achievement is the development of a practical procedure for pore solution extraction, which minimizes distortions in MIP results and phase analyses, as well as the introduction of a new criterion for assessing the progress of PSA based on a combination of UPV and DSC measurements. It should be emphasized that the findings are comprehensive—they do not focus on a single parameter but encompass correlations between phase composition, pore distribution, transport properties, and linear deformations. This required the acquisition of extensive skills in conducting labor-intensive experiments and processing large datasets. These conclusions represent a valuable contribution to the field of durability engineering of cementitious composites and provide predictive tools useful for designing structures exposed to sulfate corrosion.

Based on the analysis of the dissertation submitted for review, I conclude that it fully meets the statutory requirements. In the course of his research, the Author achieved original solutions to scientific problems, demonstrated general knowledge in the discipline of Civil Engineering, Geodesy, and Transport, and exhibited the ability to independently plan and conduct scientific research.

The comments presented in this review do not diminish the Author's achievements; they are of an organizational nature or intended to stimulate scientific discussion.

In conclusion, I state that the reviewed PhD dissertation by Mr. Iman Abbasi Nattaj Omrani, M.Sc., meets the requirements specified in the Act of July 20, 2018 – *Law on Higher Education and Science*, and I recommend that the dissertation be admitted to public defense.