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## Opponent's review of the Doctoral Thesis

Candidate Mgr. Yuliia Khmurovska

Title of the doctoral thesis Influence of Neutron and Gamma Irradiation on Concrete Properties and Structural Performance

Branch of study Konstrukce a dopravní stavby (Structural and Transportation Engineering)

Tutor prof. Ing. Petr Štemberk, Ph.D., D.Eng.

Opponent Prof. Ippei Maruyama

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### Topicality of the doctoral thesis theme

Commentary: Good. The topics dealt in the manuscript is highly concerned by the field of nuclear engineering, especially for long-term operation of nuclear power plants.

excellent     above average     average     below average     poor

### Fulfilment of the doctoral thesis objectives

Commentary: The achievement is good. Author covers numerical calculation and experimental works. These trial showed her good potential as a researcher or an engineer.

excellent     above average     average     below average     poor

### Research methods and procedures

Commentary: Numerical calculation shown in chapter 3 followed the advanced knowledge of the related field and she understood and interpreted them for her objective. The PIE shown in chapter 4 and 5 represents good results within the limitation of applicable technology and handle the data appropriately. But referring relevant papers and further investigation might be desired to make the data more reliable and scientific in future.

excellent     above average     average     below average     poor

### Results of the doctoral thesis – dissertant's concrete achievements

Commentary: Author covered wide range of relevant fields.

excellent     above average     average     below average     poor

### Importance for practice and for development within a branch of science

Commentary: The obtained data is fundamental, but very insightful for engineering objectives. The model proposed in chapter 3 might be used for more realistic calculation, or can be used for sensitive analysis for constitutive laws. This is quite important for regulatory bodies. From a view point of science, the direct data are significant and very precious, but for additional interpretation and measurement might enforce the obtained results.

excellent     above average     average     below average     poor

### Formal layout of the doctoral thesis and the level of language used

Commentary: Very good.

excellent     above average     average     below average     poor

### Remarks

Chapter 2, p.34, regarding the carbonation under gamma-ray irradiation, the reference by Maruyama et al is wrongly used. Please check the detail.

Chapter 3, p.52, 3.2.5, Impact of heating of physical properties should be mentioned quantitatively. not "slight". And humidity and temperature are always relevant. If the sample temperature is elevated under the wet condition, many things change rather than the sample exposing to general environment and easy to dry.

Chapter 3, please specify the numbers used for the calculation. Some are guessed by the figures, but you should mention all the properties and numbers for the calculation for reproducibility.

Eq. (3.15) and (3.16), is it true that all the damage due to different reasons can be multiplied, rather than accumulation. If the damage is small, it might be possible, because it can be rough estimate. but damage due to metamictization is quite large, and reviewer can not believe that this can be multiplied. In addition, irradiation experiment summarized by Field et al, did not distinguish the impact the temperature on the radiation expansion, therefore, the data itself shows both impacts of temperature and RIVE. I guess you should mention about the limitation or assumptions for this model.

P.59, For the calculation of creep, what kind of consideration is applied for FEM? you should mention how to implement the creep behavior onto FEM calculation. Step by step? or others?

P.63, author mentioned that the creep has a large impact on damage and damage pattern. But author should mention / clarify which creep is significant in this calculation, compressive or tensile? Because after the damage of concrete, the behavior is completely different in tension or compression.

Chapter 4, p.69, porosity change mechanism can be explained by the hydration or drying (temperature + drying). This is recently understood clearly in the cement chemistry field. Please check the relevant papers. And probably in this case this can be explained by the difference of hydration due to temperature change. This is probably proven by the full-XRD/Rietveld analysis with adding the corundum to identify the full phase composition of the samples, including amorphous phases.

p.73, regarding MIP experiments, number of samples (because this is mortar sample and easy to scatter) and pre-treatment, especially about carbonation under elevated temperature, should be clarified.

Fig. 4.15 and Fig. 4.16, there are several papers about impact of drying on physical properties of cement paste, mortar, and concrete and check the impact of colloidal nature of C-S-H on the physical properties. The conclusion might be enhanced by citing relevant recent papers.

Chapter 5, p. 88, regarding nano-indentation, probably, 64 points can not be enough to obtain the table 5.2. Please show the readers about distribution or frequency distribution of obtained results.

The BSE image can not be appropriate to distinguish between OP and IP or HD C-S-H and LD C-S-H, because the gray value is affected by the magnification. It is also questionable of Fig. 5.4, if there is no plausible explanation of Irln.  
Table 5.4, it is pity that the author did not conduct the XRD with addition of internal standard. For the analysis of XRD on cement based materials, it is necessary procedure to do so because the major hydrates C-(A)-S-H is semi-crystal or X-ray amorphous. Or author quantify the CH amount by using TG measurement, and then expand the data to the samples.

### Final assessment of the doctoral thesis

Reviewer admit that the author covered numerical technique and wide range of experimental techniques for the purpose of understanding the phenomena of cement-based materials and its structural member under irradiation conditions. And their results are engineering meaningful and showed highly appreciated results. Therefore, the thesis is worth Ph.D degree.

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

yes  no

Date: 23<sup>rd</sup> Aug. 2019

Opponent's signature: 丸山一平