

## Opponent's review of the Doctoral Thesis

Candidate Christoph Pohl

Title of the doctoral thesis Numerical Modelling of Moisture Transport in Concrete under High Temperatures

Study Programme Civil Engineering - Physical and Material Engineering

Tutor doc. Ing. Vít Šmilauer, Ph.D., DSc.

Opponent doc. Ing. Václav Kočí, Ph.D.

e-mail vaclav.koci@fsv.cvut.cz

### Topicality of the doctoral thesis theme

Commentary: Concrete belongs among the most frequently used building materials worldwide due to its generally known favorable properties. On the other hand, there is an attitude labeling it as an environmentally "hostile" material which must be substituted by more friendly alternatives in the future. Unfortunately, such alternatives that would exhibit a comparable combination of excellent mechanical properties, durability, shape variability etc., are not yet available. Any research aiming at an improvement of concrete properties, durability or better understanding of its performance (which is the objective of this thesis) is therefore very topical as it contributes to eliminate the concrete's weak points, to mitigate its negative environmental impacts and therefore to build a stronger argumentation against the critical opinions.

excellent     above average     average     below average     poor

### Fulfilment of the doctoral thesis objectives

Commentary: Six main objectives of the doctoral thesis are clearly formulated by the candidate at the end of the Introduction section (on page 4). All of them have been fully addressed mainly in Sections 5 and 6, but partially in Sections 2 and 3 as well.

excellent     above average     average     below average     poor

### Research methods and procedures

Commentary: Several research methods are used throughout the thesis which can be considered as a prove of the candidate's versatility and overview and also his capability to combine various techniques and approaches.

In the first part of the paper, a review on heat and moisture transport mechanisms is given, being completed by an overview and discussion aimed at mathematical models for description of such phenomena.

It is also expected, that the candidate has an awareness of experimental techniques that are exploited to determine selected material parameters required by the models as the input data.

Last but not the least, the computational modelling technique is used (including the mathematical model formulation and its implementation) to estimate the hygrothermal performance of concrete under specific conditions.

<input type="checkbox"/> excellent	<input checked="" type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
------------------------------------	---	----------------------------------	--	-------------------------------

**Results of the doctoral thesis – dissertant’s concrete achievements**

Commentary: As the main results of the doctoral thesis, the numerical model is presented that has been developed to describe the hygric performance and water vapor pressure in concrete at high temperatures which represent the most important phenomena from the point of view of spalling prediction. The numerical findings related to maximal pressure of water vapor and its position in the sample were also supported by the results of experimental monitoring of the moisture distribution. The sensitivity analysis of the model expressed based on the variability of input data showed an acceptable consistency of the results.

The specific achievements of the candidate can be seen mainly in the part of the thesis that is aimed at the computational modelling. The candidate in a certain way adjusted the approaches being used so far by means of tailoring the phenomena studied and by means of selecting specific material properties entering the model which, according to the discussion, play the most important role in the spalling phenomenon. In the end, the results of the thesis indicate, this way of spalling investigation might deserve further attention.

<input type="checkbox"/> excellent	<input checked="" type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
------------------------------------	---	----------------------------------	--	-------------------------------

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

Commentary: Spalling is a very complex phenomenon, being the objective of many studies published so far. There are several approaches which differ by the accuracy or demands on input data, material parameters in particular. The work can be therefore understood as one of the many offering new point of view on the complex problem by means of selection of specific parameters, mathematical models or adopting specific simplifications on the expense of the results accuracy which is always a compromise. It is therefore very valuable, that the work is intended to be easily replicable by means of the principles described in Section 7. This enables a correction of the potential mistakes and errors or a development the proposed method even more.

<input checked="" type="checkbox"/> excellent	<input checked="" type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
---	---	----------------------------------	--	-------------------------------

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

Commentary: The thesis is written in English. It is well structured and logically organized which makes it comprehensible for readers. On 96 pages, there are adequate numbers of figures (48) and tables (10). The work refers to 80 publications. In general, the formal layout of the thesis complies with high standards of the reaserch publications and there is nothing to be reporached. There are only minor typos and mistakes (e.g. units in Fig. 3.2) which does not devalue the overall quality of the thesis.

<input checked="" type="checkbox"/> excellent	<input type="checkbox"/> above average	<input type="checkbox"/> average	<input type="checkbox"/> below average	<input type="checkbox"/> poor
---	--	----------------------------------	--	-------------------------------

**Evaluation of author’s plagiarism**

Based on the plagiarism check and subsequent report provided by prof. Jirasek, there are no signs of publication ethics violation.

**Remarks**

I have several comments that should be addressed within the defense of the doctoral thesis:

1.) The model developed in the thesis operates with the gas pressure as the indicator to the chance of spalling. In what way is the model applicable for specific types of concrete samples? The gas pressure threshold is not constant and value may vary depending on a concrete type. What about the other parameters? Are they supposed to be measured individually for specific samples investigated or is the variance covered only by the sensitivity analysis performed?

2.) The composition of concrete is often modified to increase its resistance against spalling (e.g. by addition of polypropylene fibers, etc.). Is it possible to use the model also for an assessment of efficiency of such measures?

3.) Could you outline the possibilities how the model could be further developed and extended to be more precise or less demanding on time and input data (and the time needed for their determination). Do you plan to make some of these modification whitihin your future research activities?

### Final assessment of the doctoral thesis

As described within the particular sections of this review, the doctoral thesis meets all the requirements on the quality research and academic publications, which only proves the candidate to deserve the Ph.D. degree after a successful defense.

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

yes  no

Date: 30.05.2022

Opponent's signature: .....  .....