

## I. IDENTIFICATION DATA

<b>Thesis title:</b>	<b>The influence of graphene oxide nanosheetson concrete properties on micro level</b>
<b>Author's name:</b>	<b>Anudari Nyamsuren</b>
<b>Type of thesis :</b>	master
<b>Faculty/Institute:</b>	Faculty of Civil Engineering (FCE)
<b>Department:</b>	Department of Concrete and Masonry
<b>Thesis reviewer:</b>	Ing. Jiří Rymeš, Dr. Eng.
<b>Reviewer's department:</b>	Červenka Consulting s.r.o.

## II. EVALUATION OF INDIVIDUAL CRITERIA

<b>Assignment</b>	<b>challenging</b>
<i>How demanding was the assigned project?</i>	
The thesis deals with a specific problem in the field of cement chemistry/material science, which is not explicitly covered in the master's study, therefore, the task is rather challenging.	

<b>Fulfilment of assignment</b>	<b>fulfilled</b>
<i>How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.</i>	
The thesis represents a comprehensive study on the impact of graphene nanosheets on hardened cement paste. Both theoretical and experimental aspects are included.	

<b>Methodology</b>	<b>correct</b>
<i>Comment on the correctness of the approach and/or the solution methods.</i>	
The experimental methodology is adequate, although it might have been more extensive, i.e., more experimental data are needed to support the findings. On the other hand, the level of expertise is adequate to the master's thesis level.	

<b>Technical level</b>	<b>B - very good.</b>
<i>Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?</i>	
The theoretical part presents a comprehensive overview of the state-of-the-art of the problem. It is well written and understandable, which demonstrates that the author of the thesis got sufficient knowledge of the topic. As written above, it would be interesting to see more experimental data. Some inaccuracies are in chapter 4.5.1. <i>GO effects on hydration of cement</i> and 5.5.3 <i>SEM results and discussion</i> . In chapter 4.5.3.2 the impact of GO on flexural strength of hardened cement paste is summarized based on the literature data; however, the water-to-cement ratios are neglected. The impact of the amount of water in the mixture might be more significant than the addition of GO.	

<b>Formal and language level, scope of thesis</b>	<b>A - excellent.</b>
<i>Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?</i>	
The structure of the thesis is good. A few grammar mistakes in the text do not disturb the understanding of the thesis.	

<b>Selection of sources, citation correctness</b>	<b>A - excellent.</b>
<i>Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?</i>	
Yes.	

**Additional commentary and evaluation (optional)**

*Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.*

The overall description is in the next section of this review.

### III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

The thesis deals with a hot topic in the field of cement/concrete material engineering, which is the improvement of the material performance characteristics of the hardened cement paste on the nano/micro level. The scope of the presented work exceeds the common master thesis level.

During the thesis defence, the following topic might be interesting to discuss:

- 1) The addition of graphene oxide nanosheets seems to be a promising approach how improving the material performance of cementitious materials. What might be the most suitable structures for the application of this material?
- 2) Furthermore, what are the drawbacks of this material and why the GO additives are not commonly used today?
- 3) The microstructural analyses were conducted at the age of 21 days while the macroscopic measurements were conducted at the age of 28 days. What is the reason for this discrepancy?
- 4) What might be the reason why the nanoindentation data did not show improvement of mechanical properties upon GO addition (Table 7)? How big was the analysed portion of the samples?
- 5) For the deconvolution of nanoindentation data based on elastic moduli, three peaks are considered: 1) C-S-H + CH, 2) small clinker grains, and 3) large clinker grains. What is the reasoning for assigning the peaks to these phases? Why do C-S-H and CH have a similar modulus of elasticity? Why do small and large clinker grains have different modulus of elasticity? And, most importantly, is the phase proportions consistent with the SEM image analysis?
- 6) The data in Table 6 shows different amounts of unhydrated cement clinker between the GO sample and the reference sample? Is there any reason for this?
- 7) Why the L-D curve in Figure 30 does not start from the load of 0 N?
- 8) Based on the literature review, the dispersion of GO seems to be the critical issue when mixed with cement paste? Was the GO dispersion checked during the preparation of the samples for the experimental campaign?
- 9) In chapter 5.5.1, the author describes the sample preparation for the microstructural analyses. It is written that the samples were dried at 50 °C for 24 hours. Was the dried state checked? How the data might be impacted if the equilibrium drying state was not achieved?

The grade that I award for the thesis is **A - excellent**.

Date: **26.1.2022**

Signature: 