ČVUT
ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	**HE CURRENT STATE OF SELECTED CHURCHESOF THE BROUMOV GROUP NUMERICAL ANALYSIS OF WALL FAILURES**
Author's name:	**Charalampos Paschopoulos**
Type of thesis :	master
Faculty/Institute:	Faculty of Civil Engineering (FCE)
Department:	Department of Mechanics
Thesis reviewer:	Radek Zigler
Reviewer's department:	Department of Building Structures

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

How demanding was the assigned project?

The thesis is focused on numerical analysis of load bearing capacity of historic masonry of two small baroque churches in Broumov region using a non linear finite element method. The assignment can be assessed as challenging, since it required, apart from sound theoretical background, also mastering the used finite element software (ATENA by Cervenka Consulting).

Fulfilment of assignment **fulfilled**

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.

The submitted master thesis is done according to the assignment.

Methodology **correct**

Comment on the correctness of the approach and/or the solution methods.

The methods used by the author in her work are correct and in accordance with the usual practice for the historic structures' damage and residual safety assessment.

Technical level **C - good.**

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?

The technical level of the submitted bachelor thesis is good. The proposed solutions demonstrate that the author can apply the knowledge gained by study. However, some conclusions and statements should have been more elaborated or supported by further analysis (for example "According of the obtained results, I can conclude that the investigated churches (St. Anna and St. Barbara), at the time of investigation are not in danger of serious structural failure" etc.).

Formal and language level, scope of thesis **C - good.**

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?

From formal point of view, the thesis level can be assessed as good. The thesis is organized in a logical way. However, the used system of numbering of chapters (multiple sub-chapters 1, 2, 3…), figures/pictures and tables (multiple Figs. 1, 2, 3… etc.) makes the orientation and understanding of the text more demanding.
The level of English is satisfactory and the language is understandable. Some minor grammar mistakes and typing errors (for example "…where have not been before a church…", "They are several types of NDT…", "…In our cse we used from the methods of NDT…", "Sandstone destructive testing in the Broumov region it was reached the peak strength value around 40 MPa…"), as well as some mistakes in terminology do not reduce the overall quality of presented thesis.

Selection of sources, citation correctness **C - good.**

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?

The citation ethics has not been breached and all the sources are more or less correctly cited. However, the citation form is quite strange, as some resources are cited in text by (*number*) and are listed in the References section, some are cited in the text/figure caption by full citation (for example "*KUKLÍK, Pavel, Martin VÁLEK, Pratik GAJJAR a Jacopo SCACCO. The Basic Tasks in Evaluation of Ancient Structures Sustainability and in Estimation of Enclosure Walls Bearing Capacity. International Journal of Structural and Civil Engineering Research. 2019, 8(4)*") and some are cited only by (*Name, year* – for example Gupta, 2018 or Bozulic, 2018) and no further info is available. Nor are both of these citation's types listed in the References.
Some of the essential codes for assessment of existing structures (ISO 2394:2015 "General principles on reliability for structures" and ISO 13822:2010 "Bases for design of structures - Assessment of existing structures") together with other used codes (EC, ASTM) should have been listed (and cited in text) in References.

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 primary goals of the thesis were achieved. Moreover, the presented thesis contains some parts that should be noted as very interesting – the FEM results of homogenized masonry properties (compressive, tensile and sheer stresses as well as modulus of elasticity, post-peak behaviour of modelled masonry etc.) could be useful for future studies of historic structures.
On the other hand, some parts of the thesis could have been more elaborated. Namely:

- description of studied churches is limited, mostly based on Wikipedia entries etc.,
- in-situ evaluation of the selected churches is quite brief. There are very few details, no overall description/drawings of the damage inspection (there are no crack patterns, moisture zones and surface degradation and other important factors that could have made the presented thesis even more valuable). Also, the analysis of the main causes of the structural and material damage could have been more thorough. But this would probably exceed the thesis assignment,
- borehole testing of churches is mentioned, however it is not clear whether these were done on the structure for evaluation of masonry or on soil (probably the second, as the source mentioned is the Geology department, CTU, but no reference is cited),
- FEM analysis description in general – no info about material properties (probably already mentioned before, but for clarity it could have been stated again, or at least referenced), no info about masonry units-mortar contact properties (fixed or other?),
- FEM analysis description – tensile test – contact problem between masonry units and mortar (fixed or other?),
- FEM analysis – modulus of elasticity in compression based on arbitrary "two points" on L-D diagram?,
- Compressive/tensile tests – according to what standard? Shear tests were done according to ASTM,
- Tensile/Shear stress – no discussion on the difference between the obtained L-D diagrams,
- Strength vs. Stress analysis – no detailed info about numerical models – geometry, loads, material properties (although mentioned in text, more precise description allowing reproduction of analysis would be beneficial), no info how numerical results (structural damage) corresponds to real damage of the structure – support for conclusions etc.

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

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

Overall, the presented thesis is in accordance with the assignment. For the theses defence discussion, I suggest these questions/topics:

1. Destructive Testing is cheap, fast and easier to interpret (than Non Destructive Testing). Please explain why.

2. Please explain this statement used in thesis (focus on bold part) - "In case of micromodeling **masonry units are enlarged** and represented by continuous elements, masonry mortar joints are represented by discontinuous elements. The joints are represented by mortar and two interfaces (from both sides of the mortar is one interface of unit-mortar)". What did you mean by "masonry units are enlarged"?

3. Please describe compressed masonry failure mode (based on your statement "Masonry structures are generally speaking weak in tension. The reason of their weakness is that they are composed of different materials and between them there is mortar. The mortar serves as a bond between the different materials but it is the weaker component of a masonry wall. As a result, historic masonry structures are able to effectively resist compressive forces but they are not expected to resist the tensile stresses").

4. Does selection of representative volume of modelled masonry structure have impact on the obtained results (see Fig. VIII/4)? How was this volume chosen in your analysis for both structures?

5. Are there any other methods to obtain homogenized properties of masonry (apart from FEM analysis used in thesis)?

The grade that I award for the thesis is **C - good.**

Date: **29.1.2020** Signature: