

I. IDENTIFICATION DATA

Thesis name:	Numerical Analysis of Climatic Conditions Influence on the Current State of the St. Ann Church
Author's name:	Brenda Natalie Podio
Type of thesis:	master
Faculty/Institute:	Faculty of Civil Engineering (FCE)
Department:	Department of Mechanics
Thesis reviewer:	Ing. Jan Kočí, Ph.D.
Reviewer's department:	Department of Materials Engineering and Chemistry

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	challenging
<i>Evaluation of thesis difficulty of assignment.</i>	
<p>The objective of the thesis is a simulation of thermal and mechanical behavior of the St. Ann Church exposed to real climatic conditions. To analyze the thermo-mechanical response of the church, several challenging tasks had to be done, namely:</p> <ul style="list-style-type: none"> • a detailed condition assessment to understand the structure and current damage state; • in-situ measurement and climatic data gathering; • geometrical model formulation and adjustment; • thermal and mechanical model formulation; • mesh generation (discretization) and assigning properties to the elements, definition of boundaries; • performing the large set of thermal and mechanical simulations; outputs processing and analyzing of simulation results. <p>All these tasks are very time-consuming and require expert and technical skills to obtain serious and realistic results. Combination of those two factors must be reflected in the solution of the above described problem. For that reason, I evaluate the thesis difficulty as "challenging".</p>	

Satisfaction of assignment	fulfilled
<i>Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.</i>	
<p>The thesis meets the assignment which is formulated in the title of thesis and raised in the in the Introduction section. However, for a practical reason I would recommend to introduce a separate chapter with the description of the individual tasks and sub-tasks of the thesis, which will bring together the theoretical data and practical (expected) results. This would definitely contribute to better readability and make the assessment of the obtained results and conclusions easier. However, as the main objective of the thesis was to simulate the influence of climatic conditions on the current state of the St. Ann Church, I have to conclude the thesis assignment was fulfilled.</p>	

Method of conception	correct
<i>Assess that student has chosen correct approach or solution methods.</i>	
<p>First of all, I have to claim that the student has chosen very demanding task that include multiple simulations performed in the form of two-step solution. The solution of such a task include several procedural steps that have to be processed correctly and responsibly to obtain reliable results. As those procedural steps are very time-consuming and require expert skills and knowledge, some simplified assumptions had to be made in order to obtain the appropriate results (in reasonable time and with limited resources) as well as not to exceed the scope of master thesis. Though some simplification may increase the level of uncertainty of both input parameters and simulation outputs (e.g. neglecting moisture transport, neglecting soil settlements, homogenization principles), I am evaluating the applied methods as correct. The presented outputs are sufficient towards understanding the thermo-mechanical response of the building loaded by climatic conditions.</p>	

Technical level	A - excellent.
<i>Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.</i>	
The technical level of the thesis meets the requirements for the master thesis. The student used appropriate number of references (36), which were used as source of data and information. The description of church's history, overview of the region as well as structural survey was partially adopted from scientific literature and previous works. Other data on structural survey came from student's own research. Similarly, some input parameters for numerical simulations were adopted from the scientific literature. The parts of the thesis, where student presents her own work are clear and easy to follow. All symbols are explained in the text, captions or legends. The nomenclature is appropriate and consistent throughout the entire thesis.	
Formal and language level, scope of thesis	A - excellent.
<i>Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.</i>	
I have no comments or objections to the usage of formal notation. The typographical and language arrangement of the thesis is on the excellent level.	
Selection of sources, citation correctness	A - excellent.
<i>Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.</i>	
I have no objections against again selection of sources, citation correctness and overall work with the references. The number of sources is appropriate, sources are relevant and all cited data are correctly distinguished in the text from own results and thoughts. Citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards	
Additional commentary and evaluation	
<i>Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.</i>	
Please insert your commentary (voluntary evaluation).	

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The presented thesis brings a new insight on the assessment of whole-building performance from the point of view of thermo-mechanical loading. The approach is far beyond common methods of the assessment and combine computational engineering approach with structural survey and in-situ observations.

The thesis is divided in several sections aimed at history of St. Ann Church in the context of the history of Broumov region and whole Europe. This section is followed by a structural survey and preliminary investigation providing the reader with detail information on buildings geometry, material composition, current damage state, analysis of local climate and presentation of the results of in-situ measurements. This section is followed by technical sections aimed at two different modelling approaches.

First, the heat transfer is solved independently using thermal model and then, the outputs of thermal model are used as a load for the mechanical analysis. In the mechanical analysis both elastic and fracture-plastic material models are used to obtain complex view on the structure behavior and obtaining stress and strain fields including crack identification.

In my opinion, some drawbacks can be seen in introduction of several simplifications in both heat transfer and mechanical analysis. Those simplification included neglecting of moisture transport, homogenization of material

properties and neglecting of some soil parameters. On the other hand, I can easily understand that making those simplified assumptions was absolutely necessary due to large scope of the project and I really appreciate that every simplification in thoroughly discussed and justified in the text. From this point of view, if the moisture transport is neglected in the modelling, I would suggest not to provide any Recommendation (section 7.1) on moisture-related damage and rehabilitation measures as this is not scientifically supported in the thesis.

From an overall point of view, the chosen scientific approach to the project solution is excellent. The thesis is very well written, organized and easy to follow. I also appreciate the graphical part of the work.

Please see below my questions (or maybe more suggestions than questions) to the master candidate:

- 1) Section 5.3 Boundary conditions: Could you please explain your motivation for using Dirichlet boundary condition on the interior side of the structure?
- 2) Section 5.3 Boundary conditions: I am missing the input data for the surface emissivity used in Eq. 7. This value mostly depends on surface color and for real objects ranges between 0 and 1 (1 for ideal black body, 0 for perfect reflector). As the surface is not uniform over the church walls, have you also homogenized this parameter?
- 3) Section 5.5 Results: I was wondering whether the identification of summer and winter temperature fields is sufficient from one set of monitoring points (Fig. 5.5). Especially if those points are in the southern façade and all of them exposed to sun radiation. Maybe selection of several more profiles would be more accurate for the identification of the hottest and coldest state of the structure.
- 4) Section 4.3.1 Thermal material properties, Fig. 4.4: You have used 1 x 1 m² square for homogenization of material properties of entire building. As the building walls are differing from each other, it would be maybe more suitable to homogenize each wall separately. Moreover, some of the walls contain substantial amount of bricks, which are not included in the homogenization (Table 4.1). My question is: is it possible to define those walls separately in the Antena studio? Would this help to increase the model accuracy?

Thank you for your response.

I evaluate handed thesis with classification grade **A - excellent**.

Date: **19.7.2019**

Signature: