

# OPONENT REVIEW

on PhD thesis

*MSc. Magnus Wessberg: „Design and analysis of energy efficient indoor climate control methods for historic building“*

The dissertation thesis is written in English language, it has 96 pages that are sectorized to seven parts.

This thesis explores the link between technical implementation and target ranges for indoor climate, including control strategies and algorithms that take into account cost effectiveness, energy efficiency, and sustainability. The first addressed method is intermittent heating of massive historic buildings. To control the change rate of relative humidity at a heat-up event, a simplified model is presented for heat and moisture transfer during the heat-up period. In addition, a method is presented and validated to derive the hygrothermal parameters and the time constant of the building from measurements measured at a step response test. Finally, the study considers a feedforward control algorithm that uses the model to predict and control the change rate of relative humidity during the heat-up procedure. The method has been validated on measurements and models of three churches on the island of Gotland, Sweden.

Next author described adaptive ventilation. Its using is very important for unheated historic buildings where often face problem with high humidity levels that can lead to increased risk of mould growth. Adaptive ventilation is one of the energy efficient methods that can decrease the mould growth risk. Adaptive ventilation was designed to be a low energy and low impact option, but needs validation and further development.

Introduction chapter describes generally problem of climate control. Second chapter is focused on problem statement, third to thesis objectives. The chapters 4 to 6 make the heart of thesis. 4<sup>th</sup> chapter describes math models of intermittent heating of massive historic buildings and simplified hygric model for intermittent heating of massive buildings. This chapter is closed by discussion. 5<sup>th</sup> chapter describes validation and analysis of adaptive ventilation method and 6<sup>th</sup> chapter is focused on comparison of control methods with the emphasis on mould growth. In conclusion is discussion to all using methods.

All used models are original works of author.

Current theme is very actual from aspect efficient indoor climate control of historic building and protection of this building from mould. By this problematics deal renowned workplace in world but any this problem unresolved satisfactorily. Then this theme is wholly in harmony with actual state of this scientific branch. Results of this thesis are possible using in area next research projects and technical praxis.

The author set these targets:

1. Propose and validate a methodology for shaping the heating power for intermittent heating in massive historic buildings with regard to heat-up time and change rate of RH.
2. Perform validation and analysis of adaptive ventilation method for relative humidity control in historic buildings
3. Propose and validate improvements of indoor climate control methods in historic interiors with the focus of mould growth prevention.

This thesis fully fulfils these determined targets.

Selected methods of processing corresponded with the targets of this dissertation thesis. Full thesis is written very transparent and intelligible form which indicates about authors high knowledge of this branch. This thesis is by graphic level on excellent level, too.

The results of this thesis explores the link between technical implementation and target ranges for indoor climate, including control strategies and algorithms that take into account cost effectiveness, energy efficiency, and sustainability. Next result is adaptive ventilation. Its using is very important for unheated historic buildings where often face problem with high humidity levels that can lead to increased risk of mould growth. All methods are successfully verify on three massive historic buildings – churches: Fide church, Hangvar church and Tingstäde church. Adaptive ventilation were verify on buildings: farmhouse, Hangvar church and Skokloster castle. The all describes methods are originally works of author and were published in scientific journal and conferences. The results are very good used in practise.

Signification for social praxis is in design and analysis of energy efficient indoorclimate control methods for historic buildings.

I have these questions to author of this thesis:

1. How were used thermometers?
2. How was period of measurement samples?
3. How were differentiate climatic conditions by measurement of churches?
4. Is trimming outside air (temperature, RH) before blowing to indoor of building by adaptive ventilation?
5. Missed symbol list.
6. Fig. 5.10 – missed legend of colours.
7. Fig. 4.3 – 4.5 and 4.10 – 4.12 – on time axes is scale  $\sqrt{t}$  ( $s^{\frac{1}{2}}$ ), why?
8. Pg. 27 – is Table 1, right Table 4.1

## **Conclusion:**

This dissertation thesis is focused on design and analysis of energy efficient indoorclimate control methods for historic buildings. All methods are successfully verified on three massive historic buildings – churches: Fide church, Hangvar church and Tingstäde church. Adaptive ventilation was verified on buildings: farmhouse, Hangvar church and Skokloster castle. The all described methods are original works of author and were published in scientific journal and conferences. The results are very good used in practise.

The published works is full sufficient and corresponded with theme of thesis.

I can state that this dissertation thesis of MSc. Magnus Wessberg has high scientific and technical level and satisfies requests of creative scientific work by §47 par 4 of Rule 111/1998 digest and statutory instrument for control to defence of dissertations and that is why I

**r e c o m m e n d**

it for defence and after its successful defence give to the author degree Ph.D..

Prof. Ing. Jaromír Volf, DrSc.  
Faculty of Engineering, CULS Prague  
Kamýcká 129  
165 21 Prague 6

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