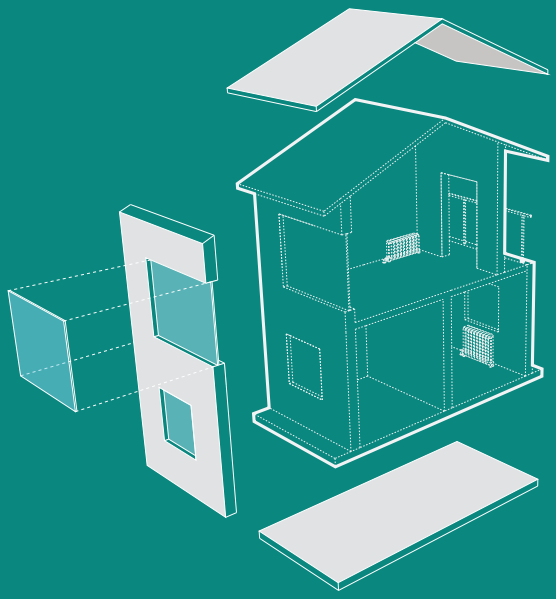
Robustness of Building Envelope

Investigating robust design solutions for energy efficient educational buildings.



Reflection

Sustainable Design Graduation Studio

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Sustainable Design Graduation Studio

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Cover Image: Passive Facade Strategy, Transsolar, Laboratory Building Agora, Lausanne, Switzerland

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1. Introduction

"We shape our buildings thereafter; they shape us" – Winston Churchill.

The famous quote from Winston Churchill, though used in a different setting and political agenda, often drives the designers to introspect and design space considering the adaptive nature of the users. However, this myopic approach needs to be rethought towards the context of the changing environment. Humans from many years have been deteriorating and exploiting the environment we dwell in. It is only from recent years that a severe extent of saving our climate has been into action. Although, the changing climate, to some extent, is controllable but irreversible. In place of this context, the infamous quote from Churchill must be rethought, where "we shaped the climate, therefore the climate will shape us."

The graduation topic with this background of climate change and its effects on the built environment is a part of a much broader societal context where its impact will disrupt the nature of the habitat and the way we design our buildings. There are numerous distinctive and long-term measures taken up to reduce carbon emissions, which is one of the critical reasons for this global phenomenon. Zero energy buildings or energy-efficient buildings are a response to this long-term goal. These high energy-efficient buildings aim at reducing carbon emissions by becoming independent from the use of fossil fuels and use a clean source of energy.

The highly energy-efficient buildings in temperate climate entail highly insulated and airtight building envelope to reduce heating energy in winters, but in summers, it causes the building to overheat. One of the significant indicators of climate change is the increasing outdoor mean temperature, which can cause indoor thermal comfort problems. With current climate projections, the future climate will become hotter, which will increase the overheating problems in energy-efficient buildings in the future. The buildings we design now will stand for the next 50 years and will undoubtedly face the climate change phenomenon. Therefore, it is imperative to investigate the design solutions which are robust for future climate change.

2. Position in Graduation Studio

The Sustainable Design Graduation Studio focuses on the scientifically driven innovative methods or products as a contribution to the sustainable society. In the context of the studio, the graduation research focuses on investigating the robustness of climate adaptive solutions to mitigate the thermal comfort problems in energy-efficient buildings. The building envelope is one of the essential factors in the designing of energy-efficient buildings and systems. Therefore, the thesis focuses on the assessment of overheating risk and proposes future-ready and adaptive solutions for building envelope, where the solution set will focus on passive strategies, thus keeping the energy efficient status intact. It is to be noted that there are researches and techniques in the literature over the integration of passive design strategies. However, the research mainly aims at evaluating these strategies through the robustness check for future scenarios, which enhances the uniqueness of the research.

The research thesis collaborates with the chair of building physics and services, and façade and product innovation. The combination of the two distinctive colors of building technology integrates the relevance of the research topic in the context of the architecture and built environment. Where the challenges in the performance of building envelopes make way for innovative product innovation, this gives the research multi-direction, thus making it relevant on a much larger scale.

3. Graduation Process

3.1 Setting up the context

The graduation research initially focused on the research of climate change and its impact on the built environment. The research helped in painting the bigger picture by understanding the problems and causes of the global phenomenon. Parallelly the research also focused on the existing thermal comfort problems in the energy-efficient buildings. Later it was found to be connected that the thermal comfort problem of overheating in the highly insulated and airtight buildings in a temperate climate is expected to increase with the future climate change. This exercise laid the foundations for defining the problem statement and experimental methodology to provide scientifically relevant answers to the problem statement and objectives.

3.2 Methodology

The research thesis has adopted different approaches and frameworks to provide scientific answers to the raised problem. There are many aspects of the thesis which incorporate uncertainties in the future climate prediction, assessment of overheating, and design of passive strategies for building envelope. According to literature, these uncertainties could be incorporated into the research process by the means scenario study. For example, the effect of future climate change is incorporated by considering the worst-case scenarios of the year 2050 and 2085. However, the scenarios are the worst case; therefore, the strategies or design selections that will entail from this process will be extreme or over-designed.

To be able to understand the topic further, the research conducted a literature review on the various keywords deemed to be necessary for the study. The literature review was done in parallel with different aspects of the research to set up the groundwork for the analysis of design solutions.

The research generally uses research through design methodology where the identified problems and design solutions will be tested on the selected case studies. To further narrow down the aspect of the design solution for building envelope, educational buildings were selected. Literature shows that people spend 90% of their time indoors, and for students, it is even more. Also, there is a high correlation between thermal comfort and productivity in educational buildings. Therefore, two different cases of educational buildings, a university building in TU Delft campus and secondary school in Rotterdam was chosen. The case studies set up under

the bigger umbrella of educational buildings; however, they are quite different in terms of occupancy and activities. Hence, applying the strategies on these buildings would further help the development of design guides which can be scaled for any type of educational buildings.

As mentioned, the research until the literature review was branched out and was lateral in terms of research output. However, the analysis process, which involves the dynamic simulation of the case study buildings, follows vertical research steps, where the thesis proceeds to the next stage based on the results of the previous stage. The drawback of this vertical framework is that the tolerance of unintended consequences like time delay, pandemic situations is low. Any delay in one step causes the delay of the entire research.

3.3 Mentorship and Feedback

To keep the research on track and to avoid it being uni-directional, the research is undertaken the guidance of mentors from the chair of building physics and services, and façade and product innovation. The mentorship is planned with mentors once in four weeks, with a facility of quick discussion arranged through prior communication. To be able to provide a professional perspective for the research, the graduation committee also consists of a representative from building a physics company. The multitude of academic and professional mentors benefits the research by extending it from the academics to the professional field.

A feedback loop is an essential aspect of every research. For effective and constructive feedback, the meetings were planned with specific agendas. Precise questions and presentations were formulated to get the most constructive feedback, providing an overview of the progress, and keeping the meetings short. Every meeting is preceded with minutes of the meeting, which are used for future correspondence and discussions.

4. Societal Relevance

As mentioned earlier that the climate change is rapid, and even with extreme measures, we can only control it but cannot reverse it. Human beings have adapted and become comfortable living in certain climatic conditions. We have evolved our needs, society, and built environment depending upon the immediate context. However, with the advent of changing climate, undoubtedly, there will be an impact on the way we design our buildings. The buildings we design now will stay for the next 50 years; therefore, we must evolve our built environment based on the changing conditions.

4.1 Concept of Robustness

Robustness is not a novel concept. Vitruvius has mentioned in “The Ten Books in Architecture” about the fundamental principles of Architecture, which translate to firmness, utility, and delight. With his first point on an exquisite architecture being “firmitas” or firmness, he meant about

the robustness of the structure. In the present scenario where the development in the building technologies has led to buildings being robust in terms of structural aspects. However, the concept of robustness must be carried forward towards the idea of indoor comfort. Robustness, as a concept, focuses on reducing the uncertainties that occur during the design phase. The most significant uncertainty of future climate change is needed to be incorporated in the building design for providing indoor comfort in the extreme situation possible.

To curb climate change, there are measures based on both mitigation and adaptation. Mitigation refers to reduce the cause of climate change, whereas adaptation entails solutions dealing with the inevitable change occurred due to climate change. Robustness can be considered as a way of achieving both adaptation and mitigation strategies. In the context of building design, a robust design solution can help reduce the carbon emission by reducing energy demand. At the same time, it can be adaptive enough to protect from the changing climatic scenarios. However, the main question one might argue about how robust are the existing solutions are? Which the graduation thesis aims to answer.

5. Personal Reflection

During the research, the organization and planning were deeply affected by the global pandemic occurred. This difficult situation, which brings many uncertainties with itself, forced the author to reflect upon the entire situation. There were few lessons learned which were insightful and are shared below:

Always account for the worst-case scenario.

The lesson was learned after the lockdown due to the pandemic, forcing every person to work from home. The important lesson learned was to incorporate the uncertainties even in the research process. Reflecting on the concept of robustness, it is not just the building; the graduation process needs to robust for such uncertainties.

Consider lockdown as an opportunity rather than a problem!!

As we are forced to work from home, it seems to be a problem for many, where the daily routine of workspace is shattered. However, this is an opportunity to learn something as well. The lockdown brings in some extra time, which was generally consumed into travel and socialising. The extra time was used for developing some soft and hard skills.

Changeover between a monk and a city person.

According to the author, working from the same place as your bed lies is difficult. Therefore, an individual must develop a habitat of being a monk, consistently practicing his ritual (graduation thesis in this case) without being distracted, and to change to a city guy afterward who dwell in these distractions.