Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Aashish Kumar Sadaphal
Student number	5794714

Studio		
Name / Theme	Building Technology/ Sustainable Structures	
Main mentor	Simona Bianchi	Structural Design (Structural Design & Mechanics)
Second mentor	Alessandra Luna Navarro	Façade & Product Design (Design of Constructions)
Argumentation of choice of the studio	For my graduation project, my goal is to develop a digital tool capable of assessing the impact of floods and heatwaves on building facades. In essence, the tool is designed to quantify the resilience of the facade, aiding designers in making informed decisions during the design process.	

Graduation project	
Title of the graduation project	A Digital Design tool for Heatwaves and flood resilient façade system

Goal	
Location:	Kerala, India
The posed problem,	Currently, the world is experiencing severe climate change, leading to numerous devastating hazards. Floods and Heatwaves are among those with most profound impact on infrastructure, human health, and ecosystem. This research identifies several key problems that require attention: **Limited Focus on Facade Resilience**: Various projects are currently ongoing to assess resilience at broader geographic scales i.e. city, district, and region. However, there is still need for a tool or method specifically designed to evaluate resilience and performance at the facade level during extreme events.

	Lack of Multi-Hazard Assessment: The absence of available tools for multi-hazard impact assessment that incorporates both floods and heatwaves make it difficult to understand all the risks and vulnerabilities. **Significant Impact of Small-Scale Flooding:** Even minor flood events can have a huge impact on building facades in terms of economic loss, suggesting a need for a comprehensive assessment that considers the impact of small-scale flooding on the resilience of facades. **Predominance of Qualitative Assessments:** The widespread absence of quantitative assessment tools in the existing literature highlights a notable gap. With most assessments currently being qualitative, there is a need to develop a tool that equips designers with quantitative data for informed decision-making in the design process.
research questions and	**Assessment** **How can a digital design tool be developed to quantify the resilience of the building envelope/façade during the multi-hazard scenario (Heatwaves and Floods) and how it can assist designers and engineers in the decision-making process during the early stage of design?** **Sub questions** • What are the most probable stressors associated with these hazards that should be considered in the tool? • How can the design tool assess different building materials and their performance under the stress of heatwaves and floods, and what materials exhibit the highest resilience in multi-hazard scenarios? **Design** **How can we provide solutions to these hazards (Heatwaves and Floods) while maintaining the thermal comfort and structural stability of the design?** **Sub questions** • How can the structural design of building envelopes be optimized to enhance both thermal resistance during heatwaves and load-bearing capacity during floods, ensuring a holistic approach to resilience in multi-hazard situations? • How can facade sense the changes from the hazards and work accordingly to reduce the impact of these extreme events?

design assignment in which these result.	The aim of this research is to develop a digital tool that assesses the resilience of building facades in case of multi-hazard events, considering floods and heatwaves. The primary goal is to investigate the influence of facade parameters and hazard stressors on the resilience of the facade system. This research will allow the designers by providing insights to take informed decisions in the façade design process ultimately enhancing overall resilience. The outcome of this research will be a digital environment in which façade parameters and hazard intensity data will be input parameters. Within this tool, these inputs will undergo analysis with the help of computational simulation software, generating graphical representations illustrating the relationship between each stressor and performance indicators. The tool will differentiate and evaluate the varying impacts of distinct stressors. The ultimate output of this tool will be a resilience score for the facade, offering a quantitative measure of its ability to withstand and recover from the effects of floods and heatwaves.

Process

Method description

The Study aims to deliver a digital tool for the assessment of the façade resilience in case of multi-hazard events (floods and heatwave). This research is divided into two phases: 1. Quantification assessment of the façade resilience, 2. Provide the best design solution by using this tool. The methodology of the research follows multiple steps as follows:

Assessment phase:

1. **Literature Review:** During this phase, an extensive study is undertaken to identify the problem statement that the tool aims to address. The process initiates with a comprehensive understanding of extreme events, specifically floods and heatwaves. The examination encompasses an exploration of the causes behind these disasters and an analysis of how various types of these events influence the performance of building facades. This research has led to the identification of hazard stressors responsible for the degradation of facades.

2. **Computational Simulation:** Once the stressors are identified in the literature study, they will be used as input parameters alongside façade parameters and a weather file (TMY - Typical Meteorological Year) to simulate the impact of these stressors on the façade. For flood simulation, various computational tools, including Rhino, Grasshopper, SolidWorks (to determine water flow pressure on the façade surface), SAP2000, and ETABS, will be employed. In the case of heatwaves, simulation will be conducted using tools such as Honeybee, EnergyPlus, and Ladybug. (as shown in Figure 1).

3. **Sensitivity analyses:** Following the derivation of results in terms of performance indicators, a comprehensive analysis of stressors will be conducted through sensitivity and correlation analyses. During this phase, multiple graphs will be generated to visually depict the extent of impact that each stressor exerts on individual performance indicators.

4. **Fragility analysis:** Upon obtaining the weightage factors for each stressor through sensitivity analysis, fragility curves will be constructed to illustrate the probability of failure.

5. **Resilience metrics:** This set of metrics will encompass various criteria against which the façade will be evaluated, assigning scores accordingly. The cumulative scores will then be totaled to determine the overall resilience score of the façade.

6. **Frontend development**- During this phase, the front-end interface will be created to streamline the entire process for designers and decision-makers, ensuring ease of use.

Design phase:

During this phase, the optimal design will be crafted using digital tools to verify the accuracy and effectiveness of the chosen methodology.

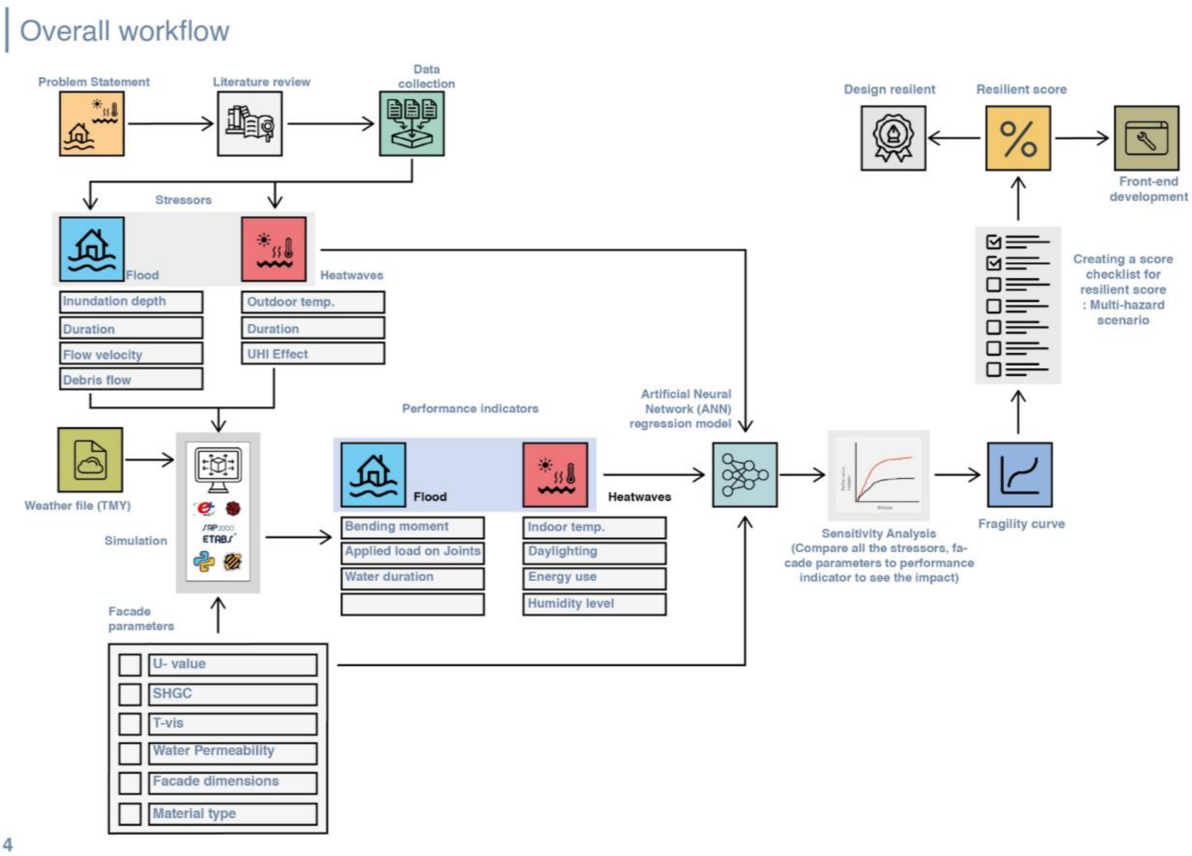

Figure 1:Overall Workflow

Literature and general practical references

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Reflection

1. **What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?**

   My graduation topic is "A digital design tool for floods and heatwaves resilient façade system" which is a subset of the Studio topic "Digital design tool for climate resilient structures". This research specifically focuses on the quantification of façade resilience in a multi-hazard scenario, taking into account both floods and heatwaves.

   This thesis is categorized under the Building Technology track, specifically under the chairs of Structural Design and Façade & Product Design. The project requires a multidisciplinary approach, necessitating the gathering of knowledge from structural design, façade design, building physics, and the risk management methodology derived from natural hazard engineering. The outcome of this project is expected to provide valuable insights for designers, architects, and decision-makers involved in the design of building envelopes. Ultimately, it aims to enhance overall resilience in the face of environmental challenges.

2. **What is the relevance of your graduation work in the larger social, professional, and scientific framework.**

   Currently, the world is experiencing severe climate change, leading to numerous devastating hazards. Floods and Heatwaves are among those with most profound impact on infrastructure, human health, and ecosystem. Various projects are currently ongoing to assess resilience at broader geographic scales i.e. city, district, and region. However, there is still need for a tool or method specifically designed to evaluate resilience and performance at the facade level during extreme events.
   My graduation work, focused on developing a digital design tool for a façade system resilient to floods and heatwaves, holds profound relevance in broader social, professional, and scientific contexts. On a social level, it directly contributes to community resilience by ensuring buildings can withstand multiple hazards, enhancing public safety during extreme weather events. Professionally, architects, engineers, and decision-makers benefit from the integrated methodologies, advancing design practices and supporting informed decision-making in urban planning and construction. Scientifically, the multidisciplinary approach of the project, incorporating structural design, façade design, and risk management, contributes to the understanding of creating climate-resilient structures, with potential implications for further studies in the field. In essence, my work addresses pressing societal needs, improves professional practices, and contributes valuable knowledge to the scientific community.