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	Georgia Kougioumoutzi
Student number	5843588

Studio		
Name / Theme	[Resilient Façade Design: Innovation Amidst Earthquakes]	
Main mentor	[Simona Bianchi]	[Seismic design, Glass structures]
Second mentor	[Fred Veer]	[Material Science]
Argumentation of choice of the studio	In formulating the focus for my thesis, I strategically integrated the knowledge acquired during my inaugural master's degree, my tenure at TU Delft and my part time position as a façade advisor at Gevel Advies. This includes automation of structural analysis, façade design with a focus on durability, resilience, dissemblance, environmental sustainability, and aesthetics building physics, detailing. My objective is firstly to create and develop a computational tool that is accurate in computing the stresses that the façade system and its connections must withstand during extreme events like earthquakes. Afterwards, using the outputs of the tool to design a transparent glass bracket. The key aspects of this tool will be based on a synthesis of my learnings from the CORE project's automation of computations and use of evolutionary algorithms. To ensure the rigorous academic quality of my research, I rely on relevant literature, theoretical frameworks, and state of the art approaches. Furthermore, the proposed bracket system seeks not only for technical efficacy but also for low embodied carbon, leading to a more sustainable constructed environment. I hope that my thesis will make a valuable and novel addition to the subject of façade systems by recognising and resolving existing alternatives and gaps in the present literature.	

Graduation project	
Title of the graduation project	[Resilient Façade Design: Innovation Amidst Earthquakes]

Goal	
Location:	[Groningen, Netherlands]
The posed problem,	How can the integration of automation technologies in engineering processes, coupled with finite element analysis, facilitate the development of transparent and sustainable brackets to fortify the building's suspended façade(stick system) against extreme environmental conditions like earthquakes?
research questions and	How can the structural analysis of a façade become less challenging for architects, civil engineers', façade advisors. How brackets withstand extreme conditions such as, earthquakes? How can the structural system of suspended facades become more aesthetically pleasing? How can the efficiency of researching new materials for a façade system in extreme conditions be improved. Can we use structural glass as a bracket system and withstand seismic and wind forces?
design assignment in which this result.	Design and create a tool capable of calculating the forces that a bracket must withstand under earthquakes. Simultaneously, conceive a bracket system using Finite Element Methods using structural glass.

Process
Method description

This thesis employs a mixed-methods approach to address research inquiries and accomplish primary objectives. The methodology comprises three distinct phases that serve as the framework for the research process: exploration, creation, and assessment.

Exploration

During the preliminary exploration phase, an exhaustive review of relevant literature is undertaken to acquire a nuanced understanding of the current research landscape. Key concepts, theories, and methodologies central to the research inquiries are carefully identified and scrutinized. The literature review employs a diverse set of search, screening, and selection methods to gather publications pertaining to the specified topics, encompassing suspended facades in extreme conditions, automation, structural analysis, and bracket design. Six keywords are judiciously selected: Suspended facades, glass structures, earthquakes, façade bracket,automation and algorithm process. These keywords guide queries within reputable databases such as Scopus, Google Scholar, Academia, Research Gate, Science Direct, and Web of Science. Simultaneously, scheduled consultations with Façade Advisors and Structural Engineers from Gevel Advies contribute practical insights, ensuring alignment with industry requirements and the eventual applicability of the research. The screening process involves a meticulous evaluation of titles and abstracts to pinpoint relevant papers for subsequent in-depth review.

The literature review in this thesis is systematically organized into six distinct sections, each designed to address the sub-questions delineated in Chapter 1.2.2. The first section serves to establish a comprehensive understanding of suspended facades under extreme environmental conditions, notably earthquakes. Subsequently, the second section critically evaluates structural analyses conducted under multi-hazard conditions, referencing both Eurocode guidelines and American standards. The third section delves into Finite Element Analysis (FEA) and the material composition of elements within a wooden/aluminium curtain wall stic system façade, and glass structures with a particular emphasis on the meticulous construction of a dataset requisite for deploying FEA models.

Sequentially, the fourth section scrutinizes site selection considerations and proposes architectural strategies tailored for wooden and aluminium façades. Moving forward, the fifth section centres on the development of an intelligent 3D model using Grasshopper, affording users the flexibility to customize dimensions for each façade fragment. The ensuing step involves the automation of structural calculations using Python, yielding the forces borne by brackets within each system across diverse building dimensions, heights, and floor numbers.

Concluding the literature review, the sixth section undertakes an in-depth exploration of bracket design. Employing inputs derived from the preceding sections and Finite Element Method Models, this section presents a range of design options aimed at optimizing the structural integrity of the brackets. Through this multifaceted approach, the literature review seeks to contribute a nuanced and comprehensive understanding of the intricacies surrounding suspended façades, fostering advancements in both theoretical knowledge and practical applications within the realm of architectural engineering.

Creation phase

During the development phase, the research study implemented, a framework is developed on how to calculate the forces taken by each façade fragment in the extreme conditions (earthquakes) which will lead to a computational tool. The application will calculate the forces the façade fragment must withstand in different building dimensions, height, and weight of the fragment itself. The tool will also calculate the deflection off the part it is "hanged" from, the minimum shear force that the bracket must withstand and stay in the plastic region and not fail, according to the Eurocode standards. After the data is collected, the research continues with the finite element analysis of the semi-transparent glass bracket.

Assessment phase

After a series of test with the dimensions of the design, the outputs are discussed, and a final model will be presented. The condition for the selection is mass of the material, the CO2 emissions of the element, the cost and finally the time of assembling. The outcomes of the evaluation are meticulously reviewed and consolidated within a comprehensive report. This culminates in an in-depth discussion and conclusive findings addressing the primary research inquiry. Subsequently, the constraints of the research are deliberated upon, followed by the formulation of prospective avenues for future research proposals.

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)?

In the course of the Master's program in Architecture, Urbanism, and Building Sciences, with a specialization in Building Technologies, I have obtained a diverse knowledge base that has laid the foundation for my research thesis. More specifically this program has equipped me with a comprehensive understanding of contemporary construction systems and methodologies essential for approaching new projects. Within the Master's track of Building Technologies, the curriculum has provided me with a robust foundation in creating sustainable structures. This encompasses considerations such as embodied carbon in proposed designs, harmonizing with the climate, the existing architecture, the demountability, and leveraging pre-existing elements in design solutions. These aspects align seamlessly with the overarching goal of advancing architectural design and building sciences.

The relevance of my graduation topic, focused on integrating automation technologies and finite element analysis to develop cost-effective and sustainable brackets for fortifying building suspended facades against extreme environmental conditions, aligns cohesively with the ethos of the Master's program. Specifically, within the Architectural Design and Building Sciences section, there exists a profound emphasis on fostering a more sustainable and aesthetically refined architectural landscape. Moreover, the intersection of architectural design and civil engineering, as emphasized in my thesis, represents a pivotal point in bridging disciplinary gaps. By establishing a symbiotic connection between these domains, the result is anticipated to be the realization of structures that are not only more sustainable and economical but also aesthetically pleasing.

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

Earthquakes fall into the category of rapid-onset disasters and stand as some of the most catastrophic natural occurrences affecting human civilization. Globally, over a million earthquakes strike each year, translating to an average of roughly two earthquakes per minute. Between 1998 and 2017, earthquakes accounted for over 750,000 fatalities worldwide, constituting more than half of all-natural catastrophe-related deaths. During this period, earthquakes affected over 125 million individuals, leading to injuries, displacement, homelessness, and emergency evacuations.

This study explores the potential of curtain-wall systems, particularly in the modular construction approach, as a means to enhance structural resilience in the face of such natural disasters. In this way of construction, factory-made volumetric units are delivered, assembled, and connected on-site to create functional structures. With up to 70–95% of the work taking place in factory conditions [4] , modular construction offers several advantages, including faster construction, superior quality control, better work safety, it can enhance the natural lighting, the economies of scale, and lower environmental impacts[1,5]. The use of the modular technique in an efficient factory setting can significantly reduce the environmental impact of construction. In addition, modular buildings also provide the flexibility to relocate, expand, or renovate as the needs change. [4,6,7].

In the face of severe natural occurrences, such as earthquakes, the structural performance of curtain-wall systems must be rigorously examined and built to meet structural criteria. While considerable research has been dedicated to examining the structural aspects of buildings under extreme conditions, particularly seismic events, there remains a significant dearth in scholarly investigations focused on suspended façade systems within this domain. . The core objective revolves around assessing the susceptibility of the building's exterior to damage and financial consequences when subjected to extreme horizontal and vertical earthquake forces. More specifically The core objective revolves around assessing the susceptibility of the building's exterior to damage and financial consequences when subjected to extreme horizontal and vertical earthquake forces. Aspects of curtain walls with series of metrics to quantify potential envelope damages, associated the failure of the non-structural and structural elements as well as the probability of water and air ingress. [8]