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	Juan Carlos Prazmowski Baczyk
Student number	5557771

Studio		
Name / Theme	Building Technology / Climate-Responsive Architecture	
Main mentor	Serdar Asut	Design Informatics
Second mentor	Martin Tenpierik	Climate Design
Argumentation of choice of the studio	I believe our built environment should respond to the climate it inhabits, being part of the system rather than combative. Design Informatics bridges our understanding between complex climate conditions and our built environment, empowering decision making processes. Climate Design guides the choices made towards a more sustainable future whilst Design Informatics serves as the methodology to achieve this goal.	

Graduation project	
Title of the graduation project	Early Stage Optimization Workflow Towards a Climate Responsive Design
Goal	
Location:	There is no specific project location, the workflow will be tested against different climate types around the world.
The posed problem,	This research stems from two main issues found consistently throughout the literature study; the focus on energy consumption as a baseline for building sustainability and the implementation of optimization strategies for an already existing project, developing strategies for its improvement. After the adoption of the Paris Agreement in 2015, aiming to curb global temperature rise below 2°C, there is a need for buildings to reduce energy consumption, becoming near zero energy buildings by 2050. Although energy simulations offer valuable data towards building adaptation to reduce energy consumption, they visualize the problem from purely an

	energy perspective, disregarding other factors influencing interior comfort. Such optimizations assist towards improving building operations by implementing energy reduction strategies such as volume and window geometry (Laouadi et al., 2002), material selection optimization (Vighnesh et al., 2021) or window area (Persson et al., 2006). When running energy simulations, the setting is often an existing building. The simulations are run for the current (base) design and are compared to a series of optimization results based on a parametric model (improved design). Possible improvement strategies are then presented to reduce energy consumption based on multiple trial and error simulations. Implementing the best performing simulated scenario will benefit the building operation and reduce energy consumption. However, major renovations such as changing window sizes, rotating a building or modifying walls are not always plausible or cost efficient. Since the implementation of computer aided design optimization it has been possible to improve structural elements (Van Thai et al., 2022), façade design and paneling (Hinkle et al., 2022), orientation (Hakim et al., 2021), window characteristics (Persson et al., 2006), material selection (Vighnesh et al., 2021) and geometry (Granadeiro et al., 2013), amongst others. Despite the varied range in optimization possibilities towards an efficient building, the implementation of such a workflow does not reflect as effective when looking at new constructions. A workflow considering various improvement parameters (multi-objective) towards interior comfort, which can be implemented at early design stages, will greatly reduce the need for renovations and future building adaptations whilst reducing energy consumption.
research questions and	**The main research question is:** How can a multi-objective optimization workflow assist in early design stages towards a climate responsive design? The sub-questions are separated per field of research as: **Climate Design**

	• What are the passive design strategies used per climate type? • Which design principles support each other and what are the possible conflicts? **Design Informatics** • How does a multi-objective optimization workflow empower design development? • How can simulation data be integrated into current & future workflows? • What are the available tools used for optimization simulations?
design assignment in which these result.	The final outcome of this research will consist of a two-step approach. The first being a workflow proposal for a multi-objective optimization problem where user inputs will influence design decisions qualitatively while computational simulations provide a set of options, guiding the design through quantitative data. The workflow will be tested and adjusted to determine best overall results, gathering data from iterative analysis whilst modifying approximation possibilities. The second section will focus on testing the workflow based on two criteria. The first will focus on the results provided by the workflow itself with regards to building operation metrics such as solar heat gains, night-sky cooling, natural air cooling, energy performance and solar accessibility, comparing this output with an already existing structure. When considering workflow efficacy, it's necessary to verify the workflow's ease of use, knowledge requirements and time to output procedure. Testing will therefore be quantitative and qualitative, culminating in a novel approach towards implementing data driven passive strategies into a climate-responsive design.

Process

Method description

The research develops over three phases where each phase's conclusions sequentially informs the next.

Phase 1: Research (Climate & Passive Strategies)
This phase focuses on gathering information on climate and its classifications. Research will focus on types of climate data available, their gathering method and climate classification from a data driven perspective.

In parallel, research into various types of passive design strategies will be conducted, pairing the strategies to each climate type based on their operating principles. The aim is to gather knowledge as to what passive principles operate the best under specific climatic conditions and determine when these climatic conditions are met by using the climate data obtained in the first research phase.

Coupling data with passive strategies will guide the decision making process throughout the workflow design phase by integrating the strategies based on conditional criterion.

Phase 2: Design (Workflow Development & Parametric Optimization)
This is the main section within this research project, addressing a proposed workflow to aid in the early design phase decision making process. The use of computers towards full design optimization is optimistic and unrealistic which is why, within this workflow, a user and computer interaction process will be presented; having both qualitative and quantitative data as design inputs. The workflow will be developed based on previously tested workflows discovered during the literature research; adapting the process for an early design stage focusing on three main passive strategy components: Surface to volume ratio, ventilation and skin materiality and their integration towards a climate-responsive design.

The second workflow aspect will be analyzing climate data through methods explored during Phase 1 and offering passive design strategy options based on climate data analysis. As a whole, the process aims at offering key parameters during the initial design stages to create an efficient building based con climatic needs whilst providing a list of further design strategies which can be implemented.

Phase 3: Validation
The final phase focuses on testing the proposed workflow. Using a small building as a control to verify workflow design and analysis output. The building will be modelled and analyzed for energy requirements, illuminance and thermal comfort; the results being compared with the results obtained through the proposed workflow outlined in Phase 2. Data from the process will be compared to show the benefits and limitations of the proposed workflow.

The validation process does not only function as the final output, it becomes an integral part of the validation workflow, occurring at various stages through the workflow development for parameter adjustment and process modifications.

Literature and general practical preference

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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)?**

The research 'Early Stage Optimization Towards a Climate Responsive Design' merges two fields of study within the Building Technology track. Climate Design serves as the research and analysis pillar. Assessment of design strategies, simulation result analysis and their relationship to climate types falls under a Climate Design umbrella. Design Informatics serves as the methodology towards data generation, developing a workflow to assist in a data driven decision process. Both chairs are required when developing a design methodology. Climate parameters analysed under a multi-objective optimization criteria require translation into a parametric, instruction based process.

The topic relates to the Building Technology track as it aims to compile information from the Climate Design and Design Informatics fields, entwining them into an intuitive workflow proposal towards the development of climate-responsive designs. Combining both fields addresses the need to develop energy conscious buildings through climate-responsive design strategies making the built environment more sustainable and less energy intensive.

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

Global population is on the rise and a need for new housing will inevitably cause an increase in new constructions, within and beyond city limits. New constructions will lead to a higher energy demand, potentially causing a strain on local grids if we continue to have the same energy levels. The development for a workflow towards creating climate-responsive designs aims at curbing such global needs, offering data driven information towards design possibilities.

The workflow, by no means, aims at substituting architectural or design oriented tasks, it aims to collaborate with decision makers. Through presenting various possibilities where each decision taken is a conscious one, stakeholders will know the trade-offs they have, giving up one option from another.

If scaled, such a workflow can be widely implemented for different design briefs within various climate types, improving the knowledge pool through data generation from a performance based approach. This can eventually lead to the development of a tool with machine learning potential, where passive design strategies become an integral part of our design needs.

The data used for this process is widely accessible through climate datasets which means a workflow proposal can spark new ideas in the future which can be replicated using the same information and focusing on similar design and process criteria.