Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences
**Graduation Plan: All tracks**

<table>
<thead>
<tr>
<th><strong>Personal information</strong></th>
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<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Subhranshu Panda</td>
</tr>
<tr>
<td><strong>Student number</strong></td>
<td>4727606</td>
</tr>
<tr>
<td><strong>Telephone number</strong></td>
<td>+31-644307195</td>
</tr>
<tr>
<td><strong>Private e-mail address</strong></td>
<td><a href="mailto:spandaindia@gmail.com">spandaindia@gmail.com</a></td>
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<table>
<thead>
<tr>
<th><strong>Studio</strong></th>
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<tbody>
<tr>
<td><strong>Name / Theme</strong></td>
<td>Building Technology Sustainable Design Graduation Studio</td>
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<tr>
<td><strong>Teachers / tutors</strong></td>
<td>Dr. Michela Turrin, Prof.de.ing Ulrich Knaack, Dr.ir Jeroen Coenders</td>
</tr>
<tr>
<td><strong>Argumentation of choice of the studio</strong></td>
<td>n/a</td>
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<tr>
<th><strong>Graduation project</strong></th>
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<tbody>
<tr>
<td><strong>Title of the graduation project</strong></td>
<td>OCF - Optimised Concrete Façade. Optimisation with Ornamentation for a Prefabricated Concrete Façade.</td>
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<table>
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<tr>
<th><strong>Goal</strong></th>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>Mumbai, India</td>
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<tr>
<td><strong>The posed problem,</strong></td>
<td>Building infrastructures do consume materials from different available sources, either extracting minerals or biologically grown. The minimum possible use of these materials that can perform the same job could be an alternate sustainable measure for the construction industry.</td>
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Non-optimised exploitation of available materials to satisfy the demands of the architectural industry is the prime contributor towards the unsustainability. Most of the biologically grown materials like wood etc., are processed with chemicals to make them a viable building material replacement that does loose the sustainable aspect of the contents while being argued as one of the feasible alternatives.

This project deals and establishes the predicament with the fabrication of an ornamented concrete facade panel derived from optimisation for minimum use of the material.
<table>
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<tr>
<th>research questions and design assignment in which these result.</th>
<th>Main research question</th>
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<tr>
<td></td>
<td>How can a concrete facade panel be ornamented and fabricated based on optimization for minimum possible use of material?</td>
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**Sub research questions**

- Why is concrete a viable material choice for facade in today’s scenario?
- Which parameters and constraints need to be addressed considering the application typology of an office or mixed-use building?
- How does the constraint of the manufacturing process affect the optimization method?
- How do the digital tools and manufacturing process boast their purpose in facades and ornamentation?

Design of a topologically optimized non-load bearing concrete façade panel intended to reduce the volume of material consumed and enhanced ornamentation with high aesthetic values. This project will also result in designing moulds for the production of these concrete panels.

**Process**

**Method description**

This project will adopt a design through research methodology with formulated tools and design boundaries guiding the research. The constraints researched and production feasibility may guide for change in design considerations.
Literature study: This project will deal with three primary aspects of research and designing,
1. Concrete as a material for facade panels
2. The process of optimisation minimise volume with fabrication constraints
3. To fabricate the designed facade panel
The aspect of ornamentation will scrutinise along all the above elements.

Design Framework: The boundary conditions and focus area for the research of the optimisation method and design of the facade panel and fabrication method will be made. Different algorithms and software with different design and fabrication considerations will be explored and analysed to establish the tools to be used.

Design and Optimisation: Within the brackets of tools and methods analysed previously, the final design element and the optimised geometry will be determined. The method of fabrication and the material configuration selected along with their related constraints will be outlined and a continuous method to update the optimisation algorithm will be established.

Prototyping: With the final design and considerations the prototyping of the design element and the method of fabrication will be done. The mixture of concrete to be used for the final design will be identified and the needed modifications to the design will then be considered learning from the experience.

Production: The optimal design will be fabricated and analysed on a feasible scale depending on the fabrication method and available resources. The analysis of the volume reduction in and performance of the facade panel will be carried out.

Validation and Detailing: The validation of the designed element will be carried out in comparison to a conventional concrete facade panel in replicating the application over an existing building and conclusions will be established and discussed. The detailing and visualisation of components within the panel and its fixture will be carried out.

The above mentioned method description has been graphically represented with the help of a flowchart below.
Literature Study

Research Framework

Design Framework

Design and Optimisation

Prototyping

Material composition testing

Production method testing

Casting mould

Casting panel

Post production

Validation and Detailing

Replicating application over an existing building

Comparative study of volume and material reduction

Detailing and visualisation

START

Facade

Material

Optimisation

Fabrication

Facade design and detail

Sizing

Components

Fixing

Pre-cast concrete facade panels

Ultra High Performance Fibre Reinforced Concrete

Loading and fixtures

Mechanical properties

Optimisation Softwares

Mould production and material

Ornamentation

Topology optimised geometry

Fabrication and casting method

Climate zone and location

Office and mixed-use typology

UHP-GFRC facade panel

Topology Optimisation

Fabrication and casting method

Casting mould

Casting panel

Post production

Determine supply and mixture

3D printing prototype and casting mould

Production

Validation and Detailing

Purpose of digital tools and manufacturing process in facade and ornamentation

Climate zone and location

Office and mixed-use typology

UHP-GFRC facade panel

Topology Optimisation

Fabrication and casting method

Casting mould

Casting panel

Post production

Determine supply and mixture

3D printing prototype and casting mould

Parameter and constraints

Parameters and constraints

Parameters and constraints

Manufacturing constraints affecting method of optimisation

START

QUESTIONS ANSWERED
Literature and general practical preference


DN-32 Connections for Architectural Precast Concrete. (n.d.). Precast/ Prestressed Concrete Institute.


Millipede. (2014). Retrieved from sawapan.eu:


Reflection

Relevance

Societal relevance

Construction demands material consumption and with the current trend of rapid development and diminishing natural resources, the optimal use of the material is at utmost priority for a sustainable economy and future. Concrete is one of the most consumed material in the world seeks higher attention for its possible application. This research will promote optimal use of concrete in rapidly developing countries like India while preserving the benefits, service life and economical aspect of the material. This research will also try to establish communication between the derived geometry between the user and the admirer by using the optimisation tool, modern fabrication methods and concrete as a material.

Scientific relevance

Rapidly developing modern technologies implemented into the construction industry and the exploiting the ability of these tools to develop building elements by optimising and reducing the volume of material consumed without alteration in its purpose of service, could tend to establish a sustainable measure. The use of modern tools could be used to express a language in architecture, and its ability could be stated and explored as a method of ornamentation. This research will examine and challenge the possibilities of designing and fabricating a highly complex concrete façade panel with reduced volume in comparison to an elementary concrete façade panel.
### Time planning

#### Presentations Interval

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<tr>
<th>WEEKS</th>
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<td>9</td>
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<td>27th May</td>
<td>3rd Jun</td>
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#### Proposal
- Idea validation
- Research and design framework
- Feasibility study

#### Literature Study
- Literature study: Precast façade panel
- Literature study: Concrete as material
- Literature study: Topology Optimisation
- Literature study: Fabrication Methods

#### Research Framework
- Formulate research questions and problem statement
- Formulate Methodology
- Formulate focus of project

#### Design Framework
- Study for project location and typology
- Study for feasibility and considerations for façade panel
- Study for constraints and application of topology optimisation

#### Design and Optimisation
- Design alternatives for façade panel
- Design façade components and fixing detail
- Design alternatives of topology optimisation
- Sampling of optimisation algorithm

#### Prototyping
- Digital modelling of final design element
- 3D printing of design element
- Mockup for small scale casting mould
- Trial for concrete mixture
- Mockup for small scale production method
- Alteration of design and optimisation algorithm

#### Production
- Casting mould
- Casting concrete
- Post production

#### Validation and Detailing
- Replicating application on existing building
- Study for volume and material reduction
- Panel performance testing (Optional)
- Detailing and visualisations

#### Documentation
- Presentations

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**Note:** The table represents a project timeline with specific dates and tasks assigned to each week and phase.