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	**Pavan Kumar Satyamurthy**
Student number	5700833

Studio		
Name / Theme	Building Technology-Graduation/ SDM, FPD	
Main mentor	Marcel Bilow	FPD
Second mentor	Mauro Overend	SDM
Argumentation of choice of the studio	The main premise of the Building Technology program is to bridge the gap between architecture and engineering. In my case, this study has encouraged me to think across disciplines and pursue gaps in research and innovation. Among many concerns, there is a pressing need to revisit and rethink the way we approach construction. My inclination towards structural mechanics and construction, combined with my previous hands-on experience in the fields of architecture, construction, fabrication, and machine design has led me to this choice of studio. I hope to contribute through innovative design ideas and the subsequent research and development in the engineering of efficient structures that can also be sensitive, within the extent that I comprehend the vast and complex topic of (contextual) sustainability.	

Graduation project	
Title of the graduation project	A Novel Production and Fabrication Technology for the Construction of Bio-Based Trusses
Goal	
Location:	No specific location

The posed problem,	We want efficient structures (structurally speaking). Lattice structures (trusses, space frames etc) are efficient and versatile. However, the fabrication and construction of lattices have challenges and drawbacks, specifically- Logistical, instrumentation/fabrication, spatial/geometrical, and End Of Life scenarios. Can we do something about this? It would be worth improving these, for future applicability and potential of such structures.
research questions and	Can a Filament Winding Technique be developed to fabricate Lattice Frames using bio-based fibres and resins? What product and fabrication method would that be?
design assignment in which these result.	A. Develop a novel cordage textile that is used for the fabrication of this lattice structure, by discovering i. an effective 'recipe' of materials, ii. The 'architecture' of the textile structure, and iii. The appropriate processing method and sequence. B. Develop the appropriate fabrication method for the lattice structure, including the winding of the cordage. C. IF possible, characterize the structural performance and its relation to fabrication parameters.

(My thesis project is an attempt to explore the way we build a specific class of efficient structures- the truss system, but address the aspects of its constructability and its limitations by investigating the use of alternate materials- specifically bio-based ones, and develop a novel way to fabricate these structures that may potentially be more versatile and low-tech than the existing methods- and ideally, address the traditional drawbacks and challenges relating to geometrical complexity, ease of fabrication, and end of life prognosis.)

Process

Method description

There is a clear distinction of the research work into the earlier mentioned design assignments:

A. **Cordage development:** Broadly speaking, this will entail research by prototyping trials that explore two aspects of the cordage which must be researched in parallel.
   Materiality: The quest to find the appropriate bio resin and fiber among the various candidates. This is established by destructive load testing of the various prepared iterations and comparing against meaningful benchmarks- Caarbon Fiber Reinforced Polymer Tubes, and steel sections (often used in lattice structures).
   Textile Architecture: Exploring what methods create the best cordage (from structural capacity and fabrication point of view)- twining, braiding, knitting etc,… as well as the specific design of the cordage's cross section, the number of layers, and their sequence.
   These are developed keeping one eye on being able to work with the cordage and wind it, fabricate with in concveniently in part B.

B. **Fabrication of the Truss structure:** Here, I will develop the exact workflow options for how this 'cordage' can be wound into a lattice structure. The geometries of lattice structures will be explored, starting with a simple planar truss.
   Curing: Part A is developed with some foresight into how the polymer matrix shall be cured or activated, which is a part of the fabrication process.
   The Jig: The 'in-situ' fabrication is investigated in more detail, with consideration about the jig, mandrel, or scaffold that is required to physically wind this bespoke rope into a truss. This is a crucial part of the workflow and affects the overall feasibility of the proposal.
   Engineering of the joints: It is know that the failure of lattice structures often happen in the nodes (joints) between struts, ties and chords. Hence, special care must be take to discover the best way to wind the rope joints. Clues exist in the examples from carbon fiber products, and this will be further explored through iterative destructive load testing of a variety of joint 'tying' methods in a specially prepared loading jig.

C. **Performance Characterization:** If parts A and B are completed in good time, a very useful study would be to explore the relations between lattice geometries, fabrication parameters, and structural performance. This way, a set of ‘Recommendations’ regarding the lattice geometry, member sizing etc, can be proposed to ensure the bet structural performance. This can be explored through load testing of controlled variations, and possibly supported through computational analysis.

Literature and general practical references

[The literature (theories or research data) and general practical experience/precedent you intend to consult.]

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 graduation topic evidently combines the disciplines of Structural Mechanics and Product Development and Innovation, with some aspects of material science and possibly End Of Life (EOL) considerations. These all align with the disciplines and spirit of the Building Technology Program in the MSc AUBS. My education in Sustainable Archtiectural Materials and Structures (SAMS), the Technoledge Structural design, Product design and engineering in the Buckylab, and spirit of Circular Product Design played key roles in my choice of this topic, in addition to my previous interests and experience in fabrication, architecture, and machine design.

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

In the domain of structural mechanics there has always been a search to find efficient structures. This refers to structures that have a strength to weight efficiency, but also ones that are technically, financially, and environmentally feasible to construct. Lattice structures were already a landmark development in efficient structures. This thesis is inspired from some of its few limitations.

The ecological ‘friendliness’ of the proposed scheme is also encouraging. Although the project is not finished yet, if the hypothesis and visions are realized, we will be able to develop constructions of the most efficient sort, but also using some of the most ubiquitous and nominally produced/priced materials in the world- materials like jute and flax, and resins like PLA which are produced world over and are bio degradable. It is a tempting thought to be able to build once again, structures that can be safely ruined, composted, landfilled or perhaps even recovered at the end of the buildings life.

Finally, there is a spirit to make this fabrication technology as accessible as possible. We are trying not to go in the relatively high tech directions of 3d printing and robotic manufacture, in the hopes that it will be a viable technology to use in remote locations in the world, or in less privileged settlements and societies.

All of this remains to be seen, though, and it depends on the outcomes of the project. The above thoughts do remain the governing spirit of this thesis, however, and research directions will be chosen accordingly.

If proven promising, there will certainly be more potential to further develop and refine the product and technology, while also finding ‘locally appropriate’ solutions for various contexts around the world. ‘Human labour’ remains the main universal resource required for this technology. In contexts where this is unfeasible, robots may be used, or other conventional constructions may be used.