Sustainable design graduation studio – AR3B025
Building technology track
Faculty of Architecture and Built Environment

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Research Topic:

Investigation in a hybrid building construction technique, that could be encoded in a digital tool, by maximizing the use of local building materials such as timber in seismic zone 5 of Meghalaya, India.

REFLECTION

The research is a part of the graduation requirement for the master track of building technology, at the Faculty of Architecture and built environment at the Technical University of Delft. The methodology and experiments were formulated on the basis of academic guidelines. The technical concepts and scientific aspects learnt in the field of structures and design informatics during the period of the master track were of vital importance in the development of this research. The mentors played an important role in development of a clear methodology during the period of the research. Given my architectural background, the mentors helped in efficient formulation of the technical scope and limits of this thesis. The step-by-step procedures were guided by the mentors with the progress on determination and validation of the results. Since, the research was conducted under the faculty of architecture, technical aid was also sought from the civil engineering department and the laboratories for mechanical testing were used in the mechanical, maritime and materials engineering department. Important insights, which determined the practical applicability of this research, were also gained from the discussions with the experienced professionals from ARUP. It should also be mentioned that data shared by the Government of Meghalaya, India, was important for the background research and deeper understanding of the context.

Research approach

On being driven by these architectural aspects, the scientific aim of the research was to investigate on the possibilities of construction using local natural timber for the given seismic region. The traditional use of timber in the local construction system called the ‘Assam type’ was an important case study for this research. Conclusions drawn from studies on the Japanese art of timber construction, seismic design principles and the modern technological advancements were vital for design process. The research has been realized by a process which was governed by technical parameters, choices made on the understanding of background research and design development made on inferences drawn from laboratory experiments. However, a balance had to be drawn from what could be borrowed and investigated from this vast pool of knowledge, while what could be left for future development. Also, as the research is design based, certain decisions were outweighed by subjective choices rather than scientific basis. However, these choices were veiled by the technical calculations and FEA simulations which were performed for the
global structural validations during the process. Further the experiments were limited by the availability of resources and technical support in terms of availability of test facilities in the academic framework. Also, the personal technical skills in the field of structures and computational design influenced the research by design process. However, arguments and alternatives for the limitations have been clearly defined in this research.

**Practical applicability of this research**

This research process proves that a construction technology using the locally available natural timber (particular species – Shorea robusta and Pinus kesiya) is possible to create a multi-storey building that satisfies the need of the housing shortage in the urban context as well as responds to the seismic risk. This thesis has opened up possibilities for further research for the given issue. To reach out this idea to the local designers, the design logic of this research has been encoded in a digital tool, specifically a grasshopper definition, which can aid the designers locally to implement this proposed ‘hybrid timber construction technology’ at an early design phase. For the greater benefit of the society, this practical availability of the digital tool gets it out of the academic archives and into the real market for actual use.

However, the setup of the timber industry in the region cannot be ignored for practical implementation of such a proposal. It is learnt from the background research that the current situation of timber construction industry is struggling in the legalization of such techniques in international platform. It is understood that it would take time for such kind of design solutions to find a place in the local building regulations. A high amount of research and practical examples have to be made to gain the confidence of the locals and prove the validity of such innovations.

Also, the market needs to adapt to provide the resources and setup a chain of manufacturing process. This takes into account various stakeholders like the commercial timber farmers, the authorities, the retailers, investors, the designers and engineers and the consumers. Thus, the success practical applicability of such innovation needs a persistent dedication from various stakeholders.

**Challenges during the research**

While, the context of this research was Meghalaya-India, the actual study was made in the university in Delft, The Netherlands. This was a major factor that influenced the whole research. Though background information was collected during the field visit, a lot of study was dependent upon online resources. There was a lack of relevant data which specially deals with the given context. This also affected the planned time-line of research methodology, as what could be easily determined on site had to be achieved via a third-party process. A lot of assumptions were made, and inferences were drawn from similar studies during the process of the research to bridge this gap. Also, the experiments were dependent upon the local available timber in the academic setup instead of the original proposed species. The next major constraint was the limited skill for the technicalities and scientific validation throughout the process. Given the fact that this research demanded technical input from various subjects like structures, material science, FEA and even programming. Major role was played by the mentors for this technical guidance, getting me in touch with the concerned and setting limits for this research. Thus, help was taken from external sources to meet these demands.

**Architectural significance**

Given the purpose of this master track, this research is a median between the technical possibilities of natural timber as construction material given the architectural parameters for functioning of a space. Also, the intangible architectural aspects like the aspirations of the people, cultural aspects of the traditional building methods and the image of the urban context were unconsciously active in the design process. The research outputs a 3D grid which can be used by the architects for spatial composition, a play of the void and the built to enhance the spatial quality in the built fabric of the urban region, whilst technically answering the seismic and sustainable concerns. This structural 3D grid was the result of a scientific design process, however the parameters of this design like the grid-size and visual uniformity were taken into account for the psychological comfort of the users, given their present lifestyle and habit. As mentioned in beginning of this research, for acceptability of the design, it should be such that in can easily slip into
the existing system without affecting the lifestyle and habits of the locals. This has been achieved in this research, as the proposed design promises a similar spatial quality.

**Scientific and societal significance**

The research is vital for both societal advancement and scientific innovation. While the world is advancing with taller structures using engineered wood, little importance is being given to natural wood, which is abundantly available in most regions of the world. The lack technological research of using this material in its natural state has caused a drawback in its usage. Also, the dependence on engineered wood for modern construction has only increased the transportation of such materials from the developed regions or ‘technologically advanced’ regions of the world to the developing areas, increasing the carbon footprint. The grassroot idea of this research was to design under the constraints of local possibilities and craftsmanship in terms of resources like— materials, money, human resource, space and technical data in the local region and also making the developed design idea available for the local people.

This research transcends beyond the current innovations in the field of timber construction. On using natural timber for construction, a complete manufacturing line of the engineered wood is eliminated thus, further reducing the environmental impact. It should be mentioned that the strengths of the natural timber and the structural efficiency cannot be matched to that of engineered timber, just like engineered timber cannot be compared to steel. However, the global concerns of environmental impact have forced us to rethink the way we build by questioning the existing systems and ideate innovation.