Structural Timber Fabric :
Applying Textile Principles on Building Scale

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Auteurs Markus Hudert, Masoud Sistaninia

Encadrement Prof. Yves Weinand[1]

[1] Timber Constructions Laboratory, IBOIS

Fig. 1'

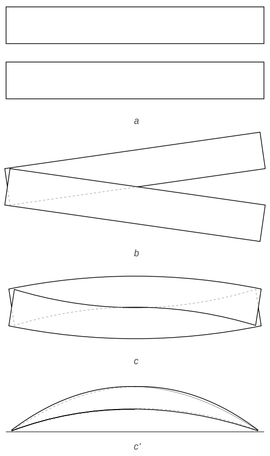

Fig. 1: *Assembly process of the* Textile Module.

Textiles are interesting from both a structural and an architectural point of view. Their patterns and textures, created by the interworking of yarn elements, are not only highly appealing on an aesthetical level, they also possess load bearing qualities. The research project *Structural Timber Fabric: Applying Textile Principles on Building Scale* sets out to investigate this potential and proposes to develop a new family of timber constructions based on the logic and principles of textile techniques. In this context, and within the scope of several case studies, one of the core objectives is to create an innovative structural system with concise aesthetic, spatial and structural qualities. Thus, the proposal addresses important challenges at the frontiers of the fields of architecture and civil engineering. The here presented poster outlines selected parts of this research.

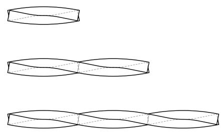

***Fig. 2**: Connecting several modules in a linear way leads to arch-like elements.*

Fig. 1''

Fig. 1'''

Fig. 2'

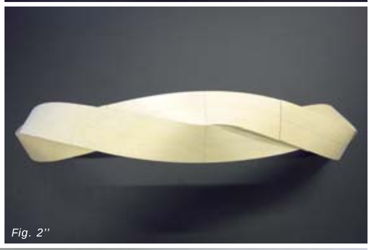

Fig. 2''

During the process of analyzing textile techniques regarding their suitability for large scale application, it became clear that, apart from the commonly known techniques such as felting, knitting, braiding and weaving, an immense amount of variants exists. This insight triggered an adjustment in the direction of investigation. Instead of aiming at a comprehensive overview of existing techniques, the quest for a least common denominator of textiles was launched. This quest resulted in the finding that practically all textile structures can be reduced to one in principle identical unit cell. This unit cell acts as a kind of basic module and consists of two intercrossing threads.

In a following step, the principle of this unit cell was brought to large scale by interbraiding two strands of glue laminated timber. By doing so, the research's first promising outcome, the so-called *Textile Module*, was produced **(Fig. 1)**. It shows how the use of a particular textile technique of assembly, together with the properties of a specific material, can lead towards a particular and structurally efficient construct, whose geometry is automatically generated by the process of assembly. Additionally, it commands of exceptional behaviour when put under pressure: the structure becomes longer and flatter but in the same time, the sectional triangle in the middle of the module narrows, becomes higher and therefore stiffens the structure.

One of the structural advantages of textiles is the already described system effect: they are made up of many basic elements that are interconnected and work together as a whole. Therefore the failure of one or several of the basic elements doesn't lead to the failure of the whole structure. In order to achieve a similar effect on building scale, it is likewise necessary to create a structure that is composed of a multitude of elements. At present, the research work focuses on how this can be accomplished by using the *Textile Module* as a basic element, or, in other words, as unit cell of such a structure. The most obvious method of doing so is to combine several modules in a linear way **(Fig. 2)**, which creates an arch like structure. A sequence of several of those arches can then be combined again to form a structure similar to a vault **(Fig. 3)**. The disadvantage of this approach is that the arch elements stay independent from each other. There's no continuity in the cross direction. A possible reaction to that is the addition of elements perpendicular to the arches which also improve the overall structural capacities by large amounts **(Fig. 5)**. A second possibility is to create a fabric that is continuous in both directions. This becomes possible by shifting the basic modules and increasing the distance between them **(Fig. 6)**. However, this can also lead to geometrical complications in the total of the structure. All the same this is a promising direction for future examinations and further development.

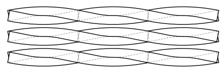

***Fig. 3**: The accumulation of those arch-like elements creates a spatial structure.*

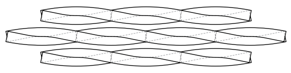

***Fig. 4:** Displacement of the stripes allows for aligning structurally weaker with structurally stronger zones.*

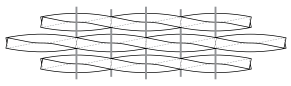

***Fig. 5:** Additional elements in perpendicular direction create a coherent structure with enhanced properties.*

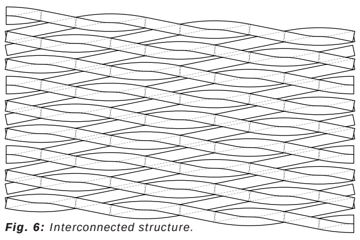

***Fig. 6:** Interconnected structure.*

Fig. 3'

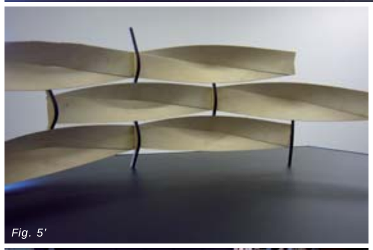

Fig. 5'

Fig. 5''

Fig. 6'

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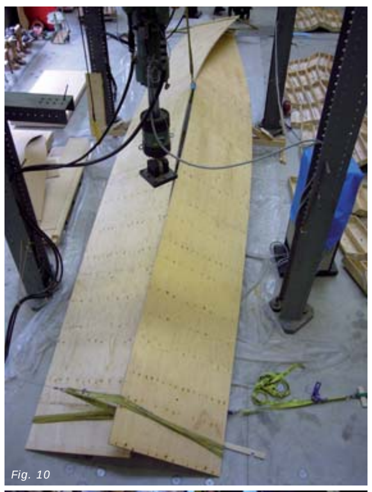

Fig. 10

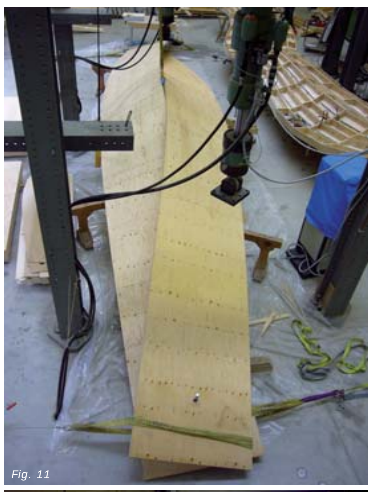

Fig. 11

Fig. 12

Fig. 13

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Fig. 16

Fig. 17

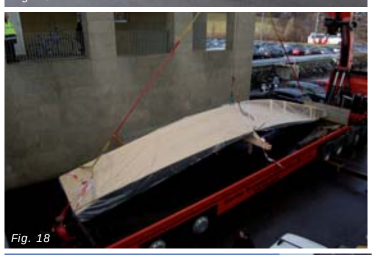


Fig. 18

Fig. 19

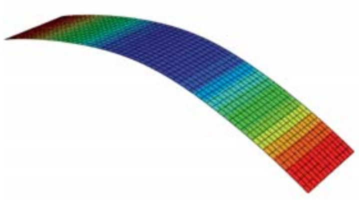
Fig. 20

***Fig. 7:** Joint panels.*

A large scale prototype of the *Textile Module* was developed in the context of the exhibition *Timber Project*, which was on display from February 25th to May 31st at the Archizoom exhibition space **(Figs. 10 to 20)**. In the forefront of this, the assembly of the structure was simulated with the FEM software Abaqus **(Fig. 9)**. By doing so, the initial stress, caused by the bending of the panels, could be identified. Furthermore, the structural behaviour of the joint panels **(Fig. 7)** was examined. Resulting from this study, the dimensions and proportions of the timber panels were determined.

In a following step, the structural performance of the *Textile Module* was compared to an arch composed of the same quantitiy of material **(Fig. 8)**. In this test, the performance of the *Textile Module* was considerably better than the one of the arch.

For the continuation of this research, the work with FEM software will be very important. It presents a promising approach to draw near a geometrical description of the *Textile Module* and the computation of its structural properties. Apart of the singular *Textile Module*, other configurations will be simulated and calculated in the near future.



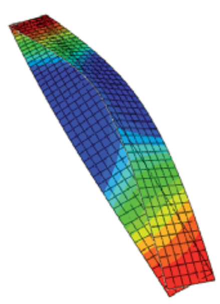


***Fig. 8:** The structural perfomance of the Textile Module in comparison to an arch.*

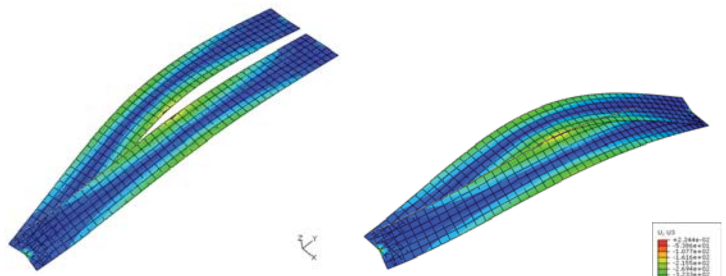


***Fig. 9:** Simulation of assembly and form generating process with FEM software Abaqus.*

Fig. 21