Timberfabric: Applying Textile Principles on a Building Scale

Yves Weinand and Markus Hudert

IBOIS Laboratory for Timber Constructions

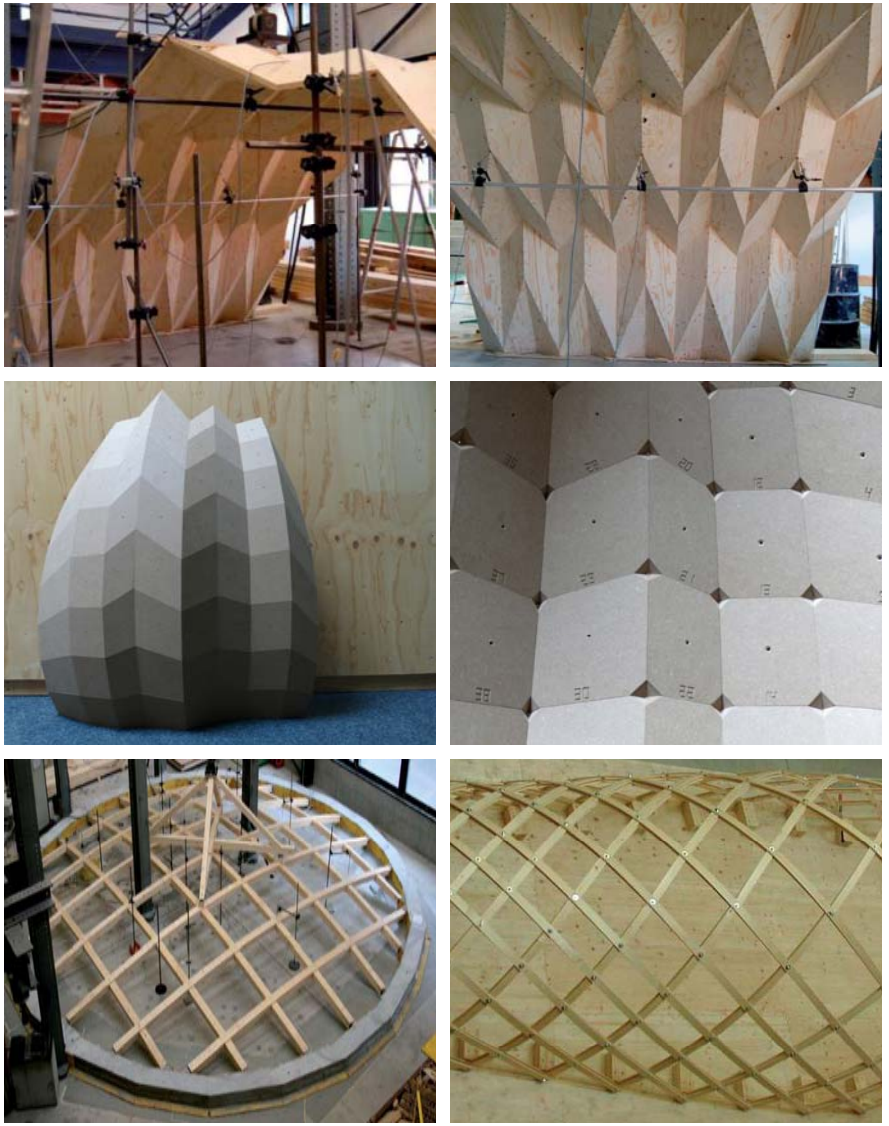
An Interdisciplinary Research Team

- Yves Weinand, architect and civil engineer
- Hani Buri, architect
- François Demoures, mathematician
- Benjamin Hahn, civil engineer
- Markus Hudert, architect
- Laurent Humbert, mechanical engineer
- Sina Nabaei, civil engineer
- Masoud Sistaninia, mechanical engineer
- Bernhard Stamm, civil engineer
- Ivo Stotz, architect

IBOIS Laboratory for Timber Constructions

Some Research Topics

- Origami
- Fractal Geometry
- Timber Gridshell Structures
- Timberfabric Structures



INTRODUCTION

Structural Timber Fabric: Applying Textile Principles on Building Scale

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- Developing a new family of timber constructions based on textile principles

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- Harnessing textile qualities - especially the system effect - on building scale

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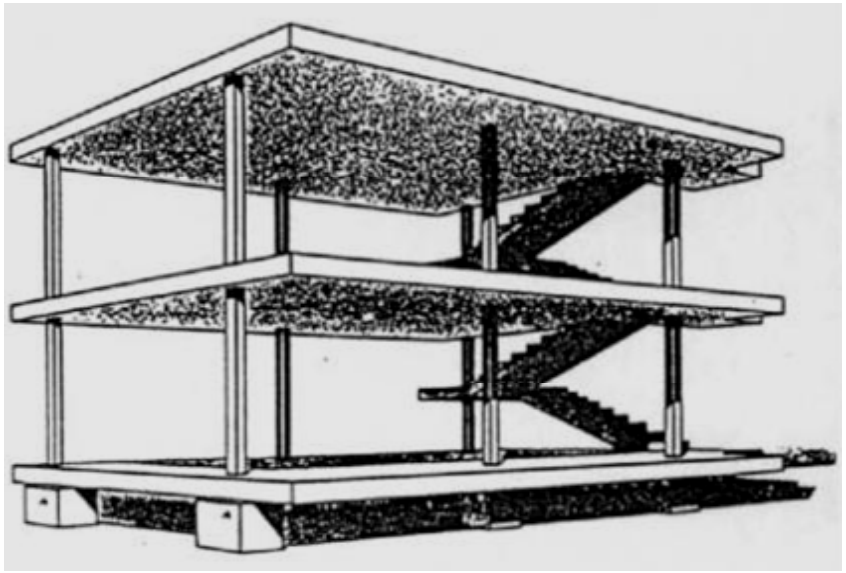
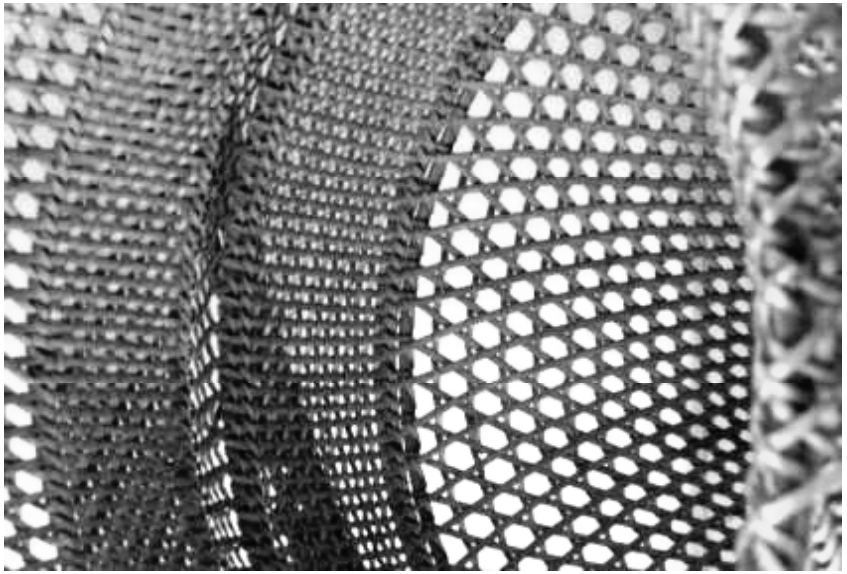
- Developing a new family of timber constructions based on textile principles
- Harnessing textile qualities - especially the system effect - on building scale
- System effect in textiles: a multitude of elements work together as one coherent structure



Le Corbusier, Domino House, 1914 - 1915



Basket structure, many elements working together as one structure.

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- Harnessing textile qualities - especially the system effect - on building scale
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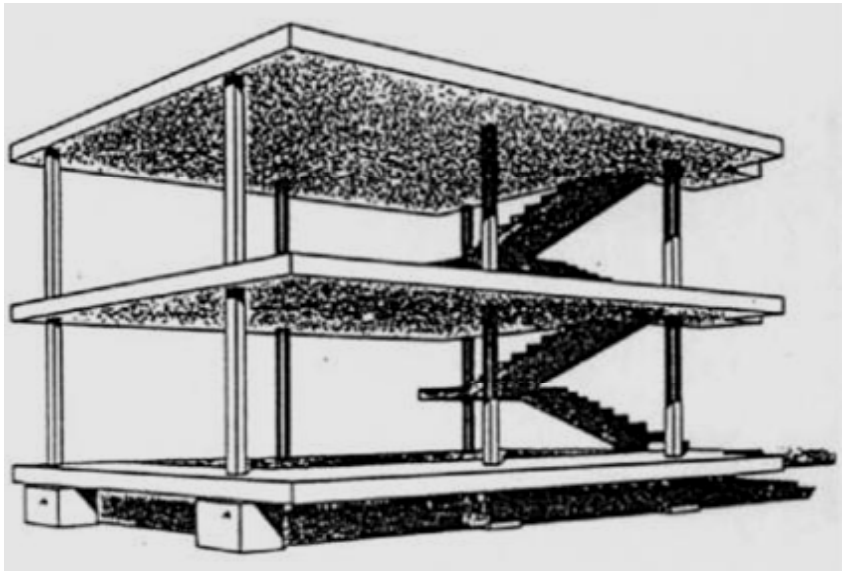

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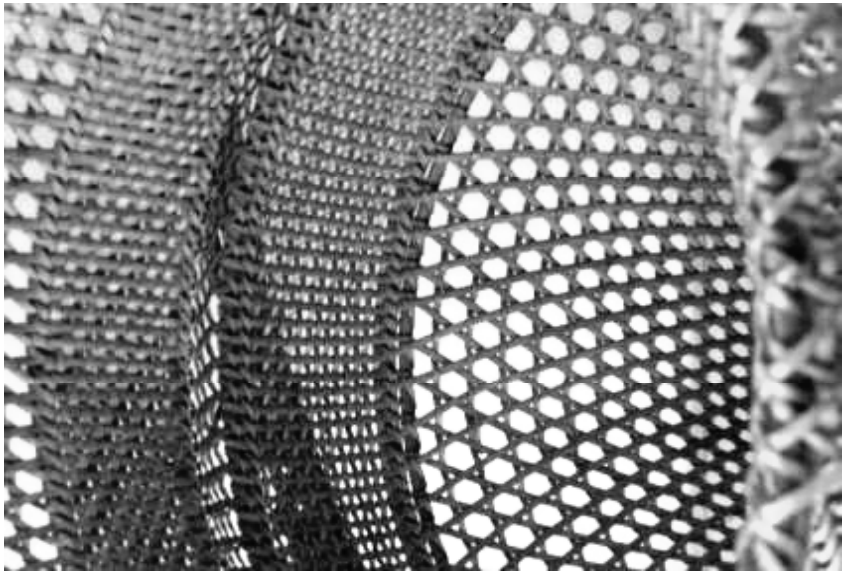
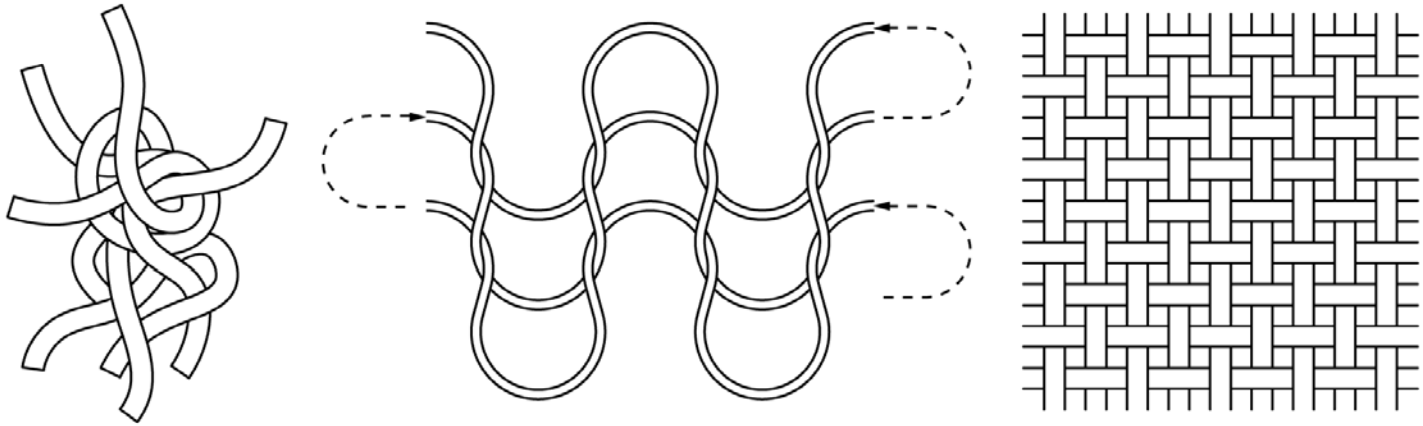


Basket structure, many elements working together as one structure.

- An innovative structural system with exceeding aesthetical and structural qualities

BUILDING WITH TEXTILES

General Remarks on Textiles

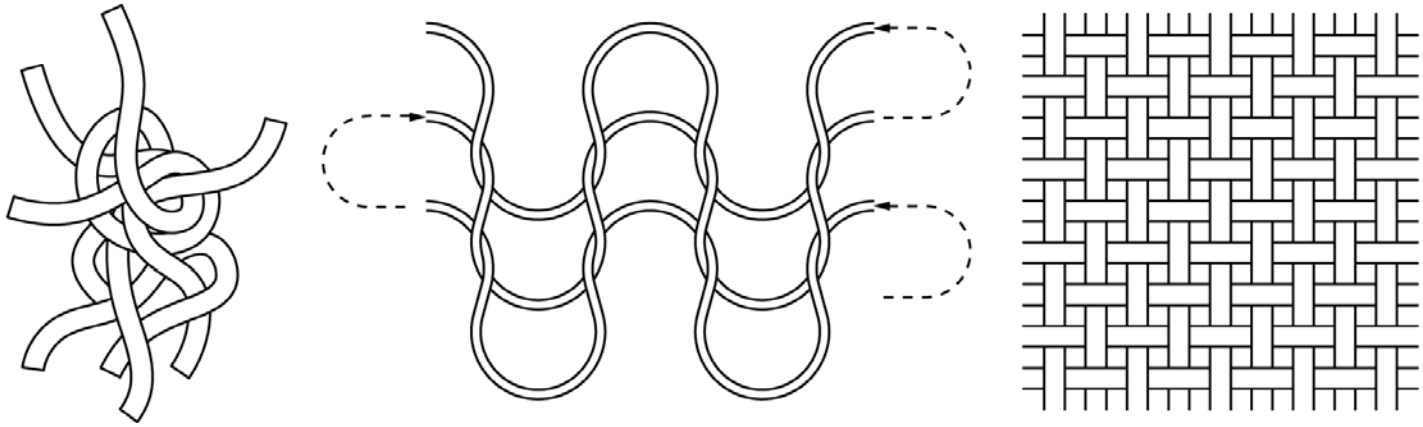


Entangled fibres in felt, yarn structures of knitted and woven fabric.

BUILDING WITH TEXTILES

General Remarks on Textiles

- Textiles are omnipresent in our everyday life: apparel, carpets, curtains and many more



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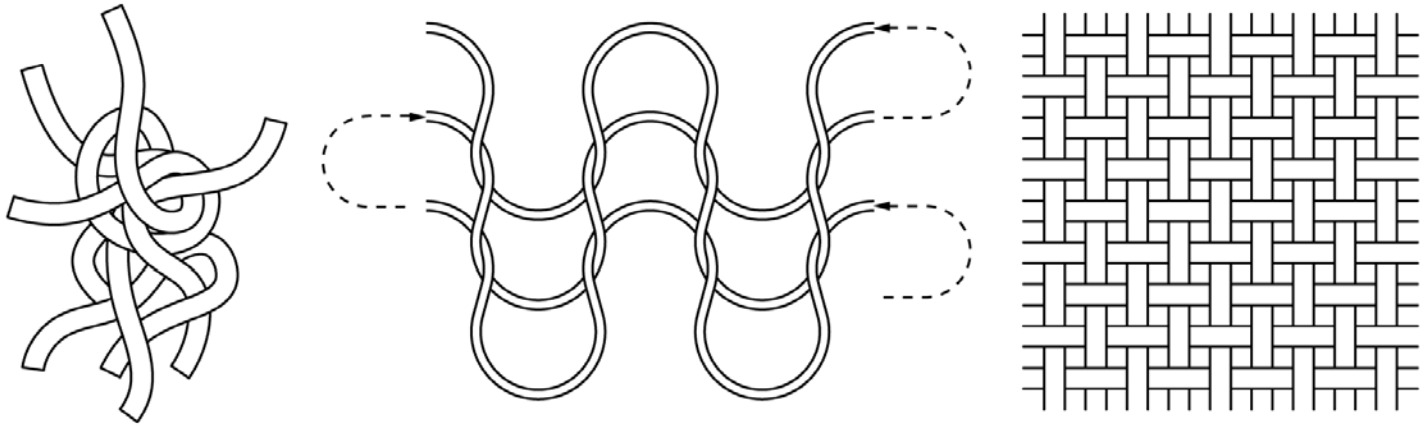

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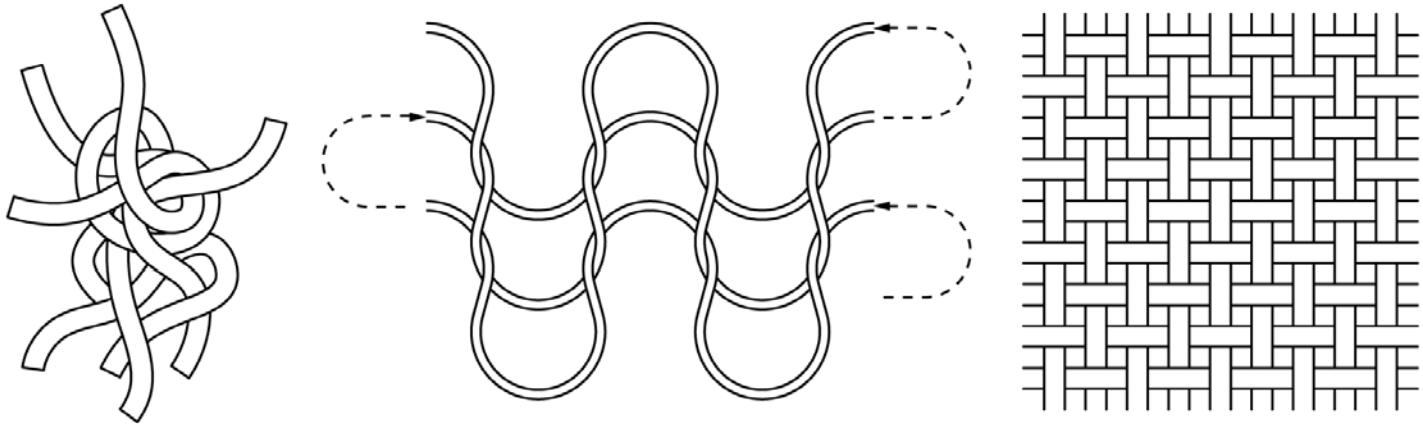
BUILDING WITH TEXTILES

General Remarks on Textiles

- Textiles are omnipresent in our everyday life: apparel, carpets, curtains and many more
- The production of textiles is one of the oldest crafts known to mankind
- It's very likely that textile techniques were employed for early man-made shelter



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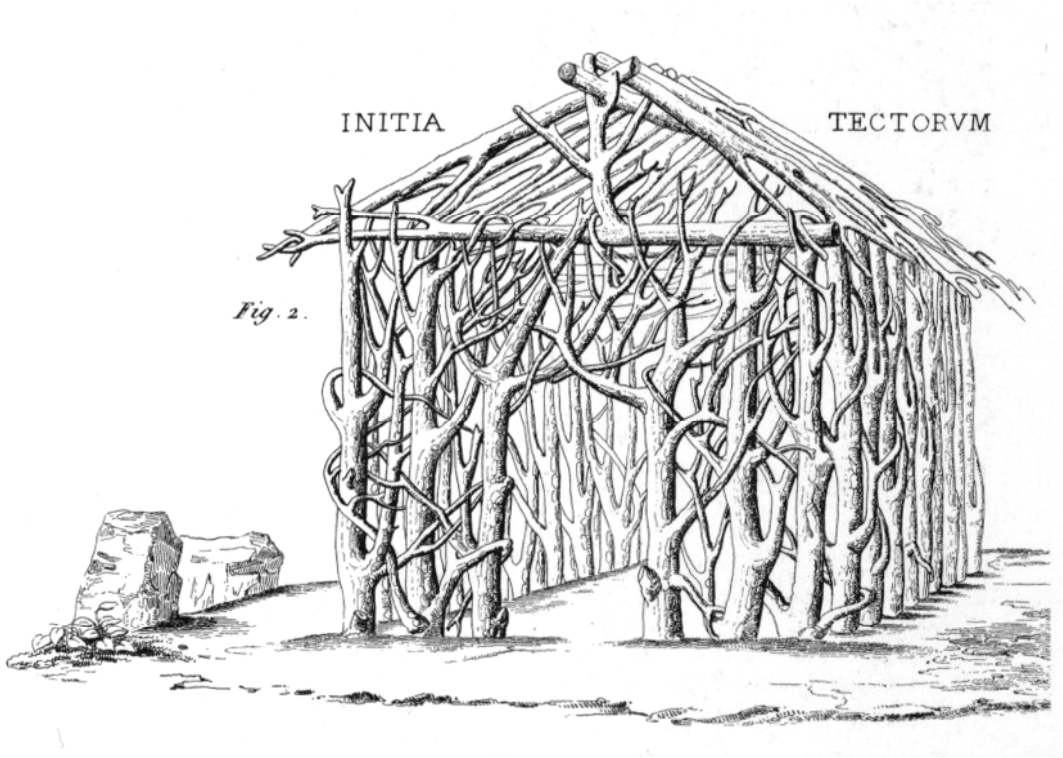
BUILDING WITH TEXTILES

Textile Structures in Early Man-made Shelter



The Primitive Hut
Primitive Hut made of interwoven branches

(Jean-Baptiste Rondelet 1743 - 1829)

BUILDING WITH TEXTILES

Textile Structures in Early Man-made Shelter

The Primitive Hut
Primitive Hut made of interwoven branches

(Viollet le Duc 1814-1879)

BUILDING WITH TEXTILES

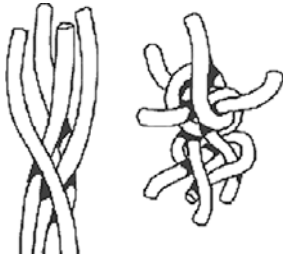
Huts made of woven bamboo stripes, Ethiopia

Woven bamboo hut in Ethiopia; Source: Grow Your Own House

Woven bamboo fence in Ethiopia; Source: Grow Your Own House

CLASSIFICATION OF TEXTILES

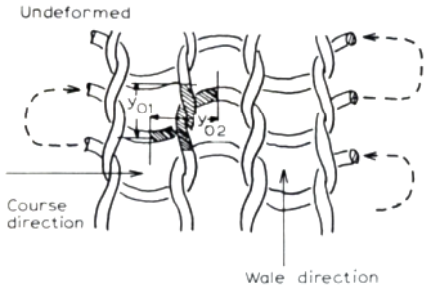
Felted Fibers *(simple fibre assembly)*



Example
.Felt
.Paper

Interworked Elements *(advanced fibre assemblies)*

Primary Textile Techniques

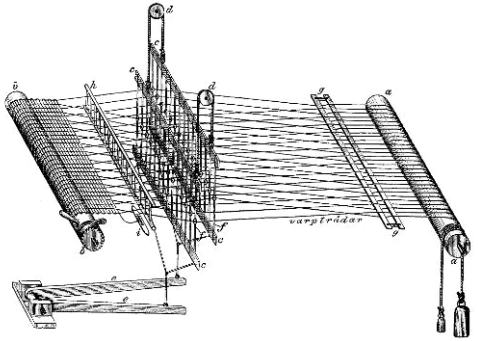


Example
.Mesh Fabrics
.Knitting, crocheting

Transitional Techniques

Example
.Braiding
.Plaiting (with active systems)

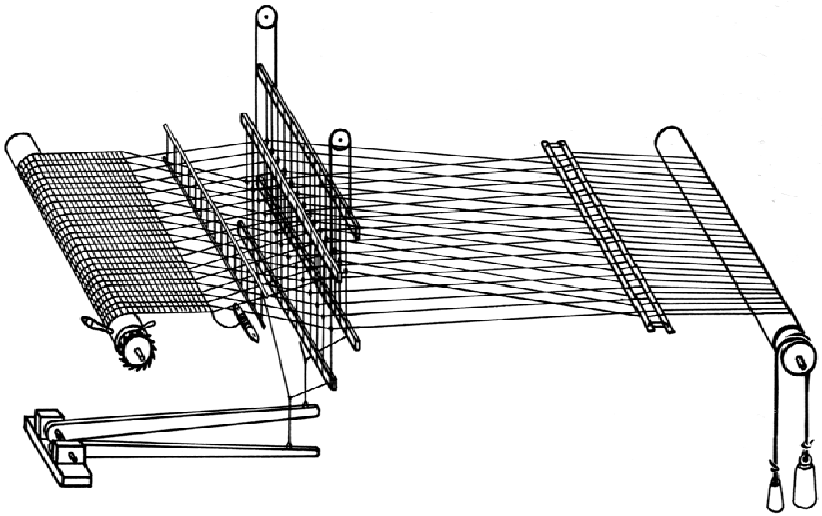
Advanced Textile Techniques



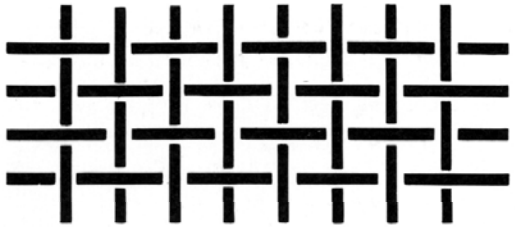
Example
.Weaving

BUILDING WITH TEXTILES

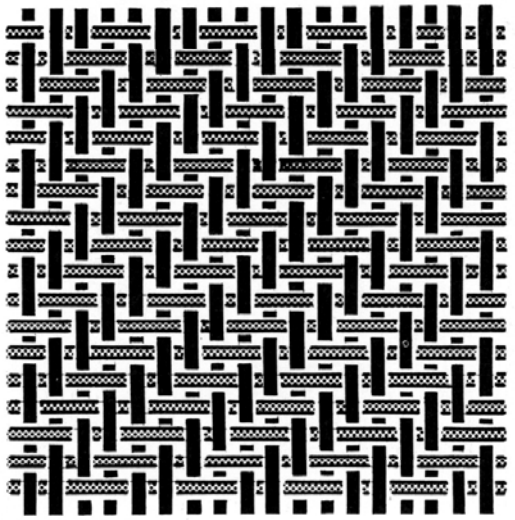
Characteristics of Woven Fabrics – Application as Structure



Weaving Loom; Source: Seiler-Baldinger 1994



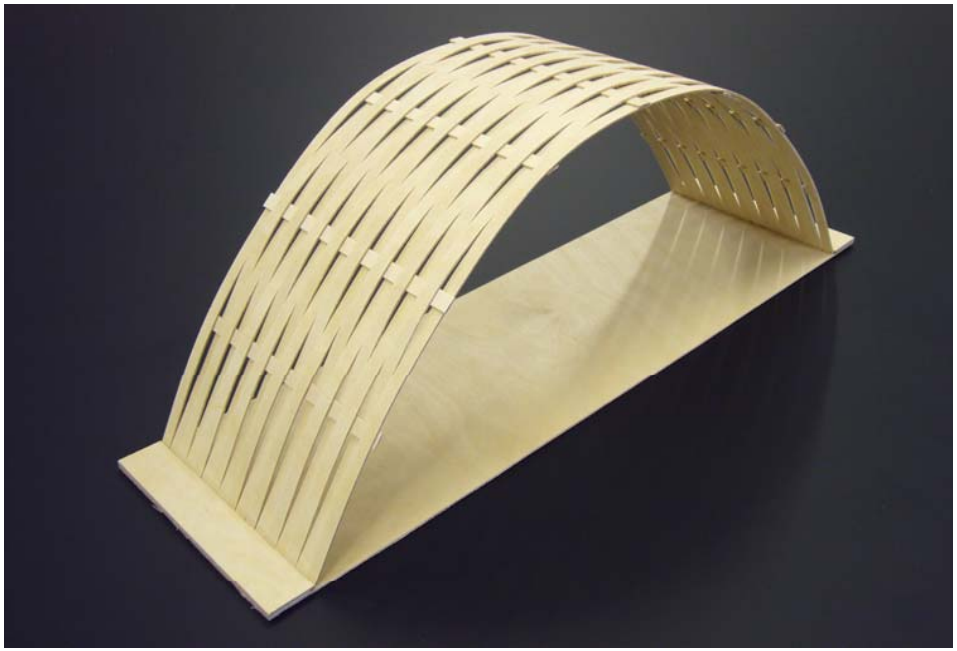
Plain weave pattern; Source: Seiler-Baldinger 1994



Twill weave pattern; Source: Seiler-Baldinger 1994

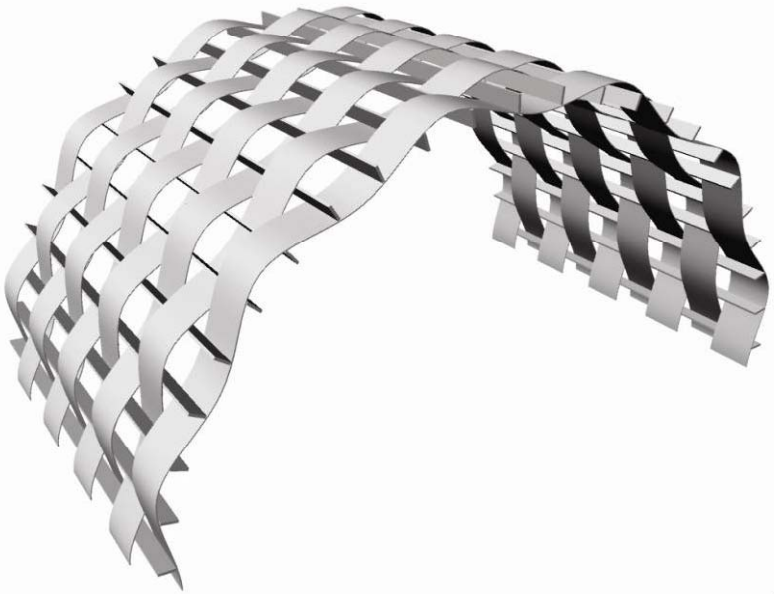
BUILDING WITH TEXTILES

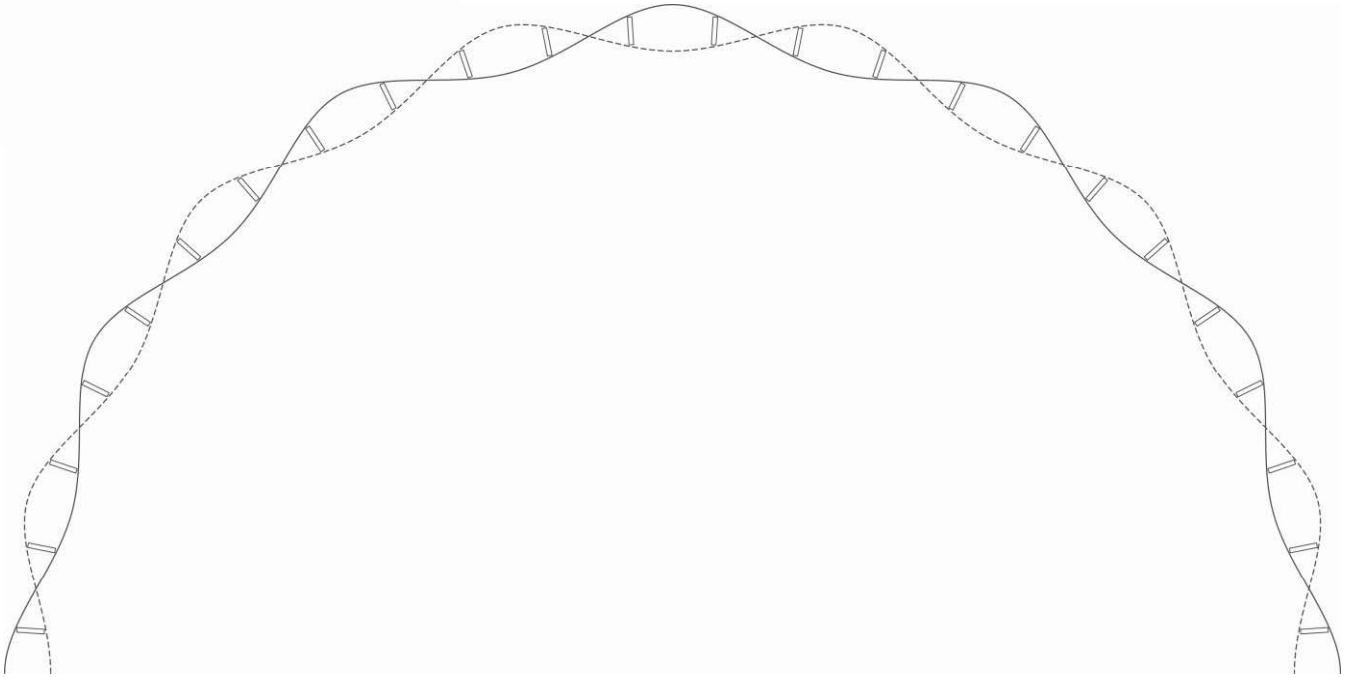
Plain Weave Pattern - Application as Structural Shell

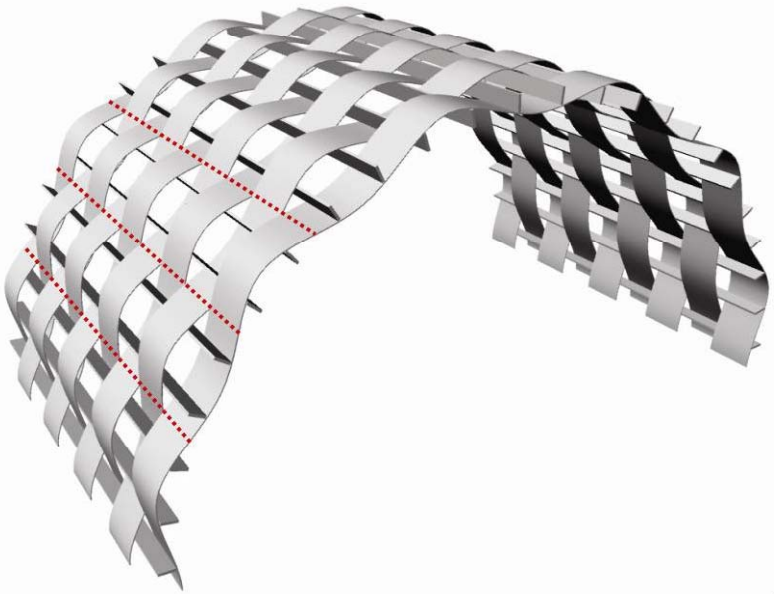


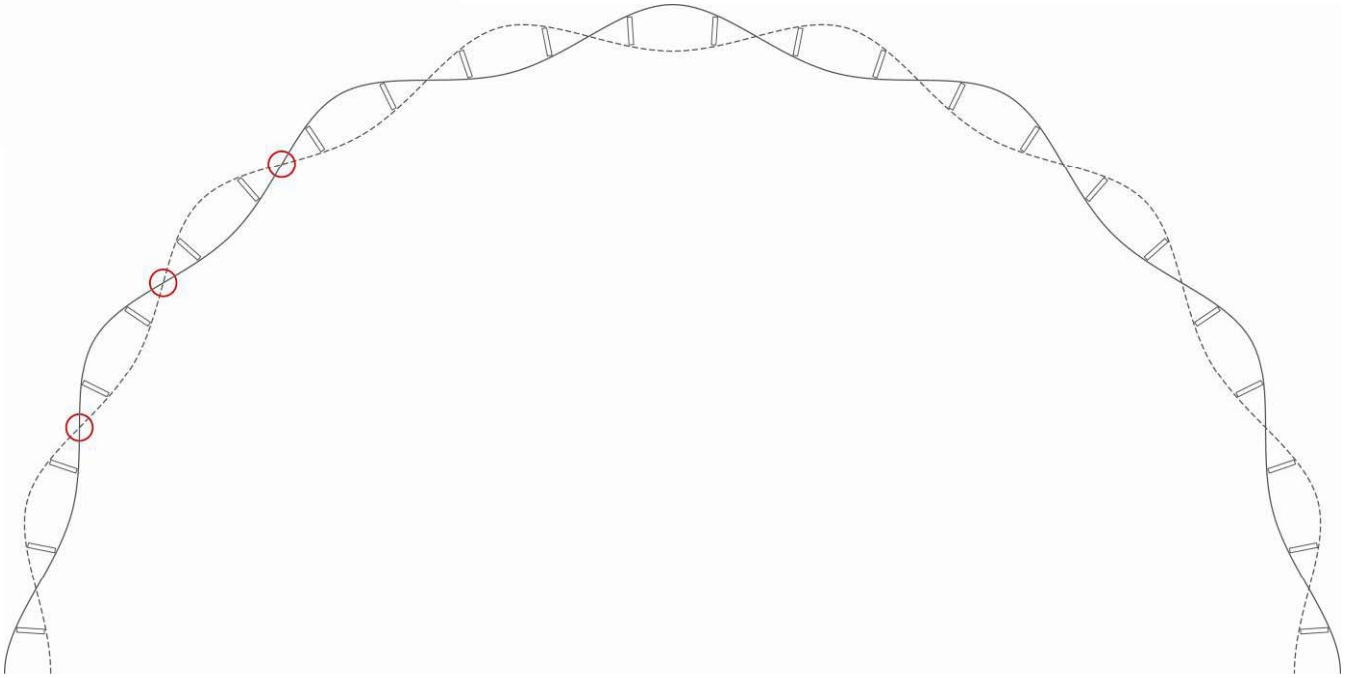
Model of a woven roof structure, exterior view .

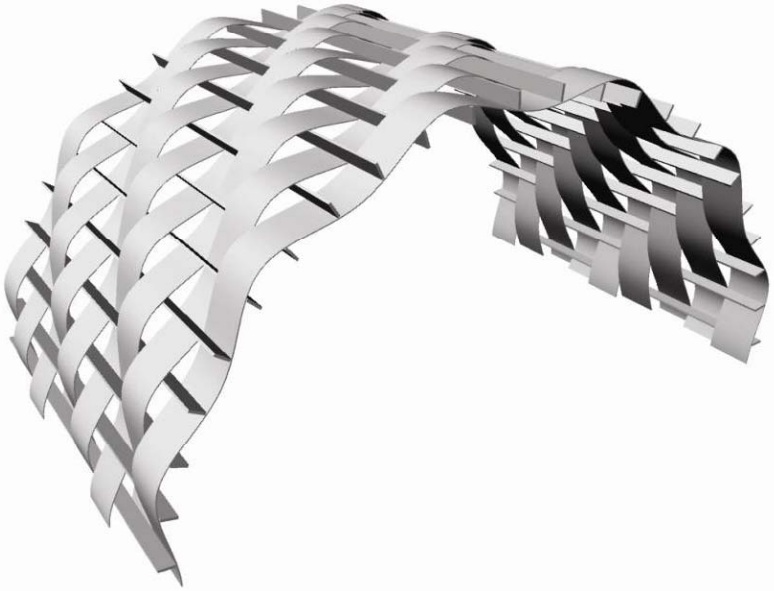
Model of a woven roof structure, side view.

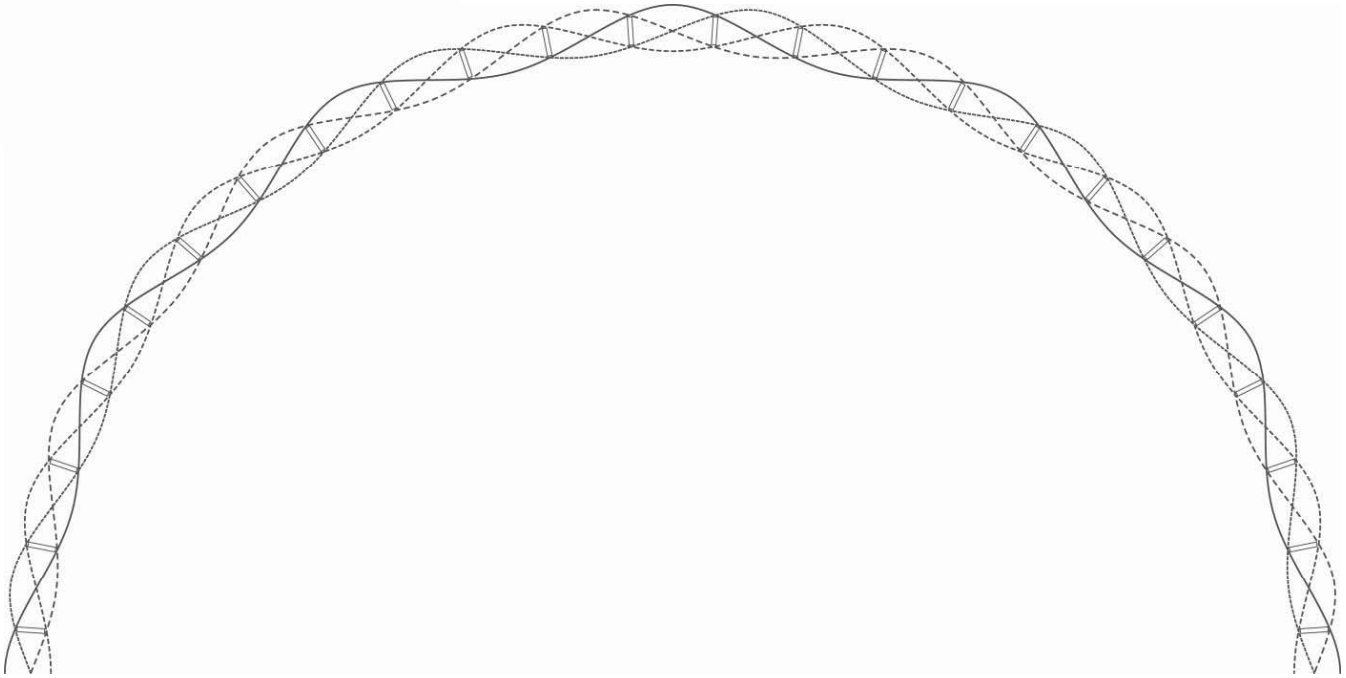












BUILDING WITH TEXTILES

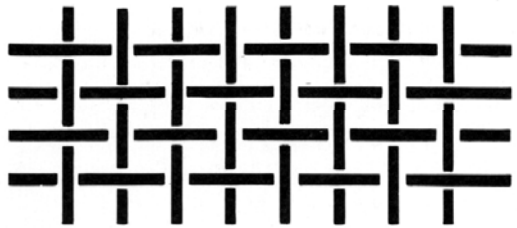
Model of Twill Pattern Structure

Model of a woven roof structure, twill pattern, exterior view.

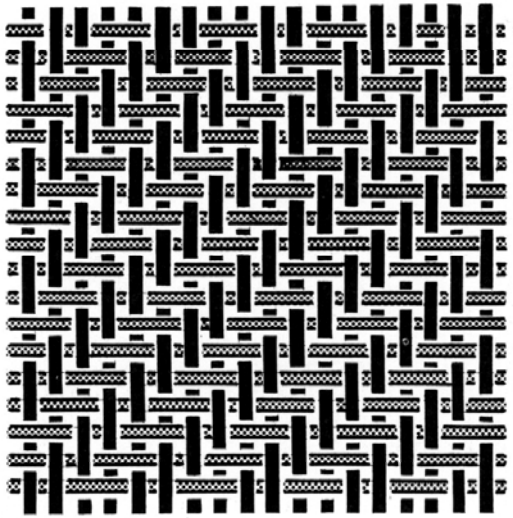
Model of a woven roof structure, twill pattern, Interior view.

BUILDING WITH TEXTILES

Comparison Plain Weave and Twill Weave Pattern

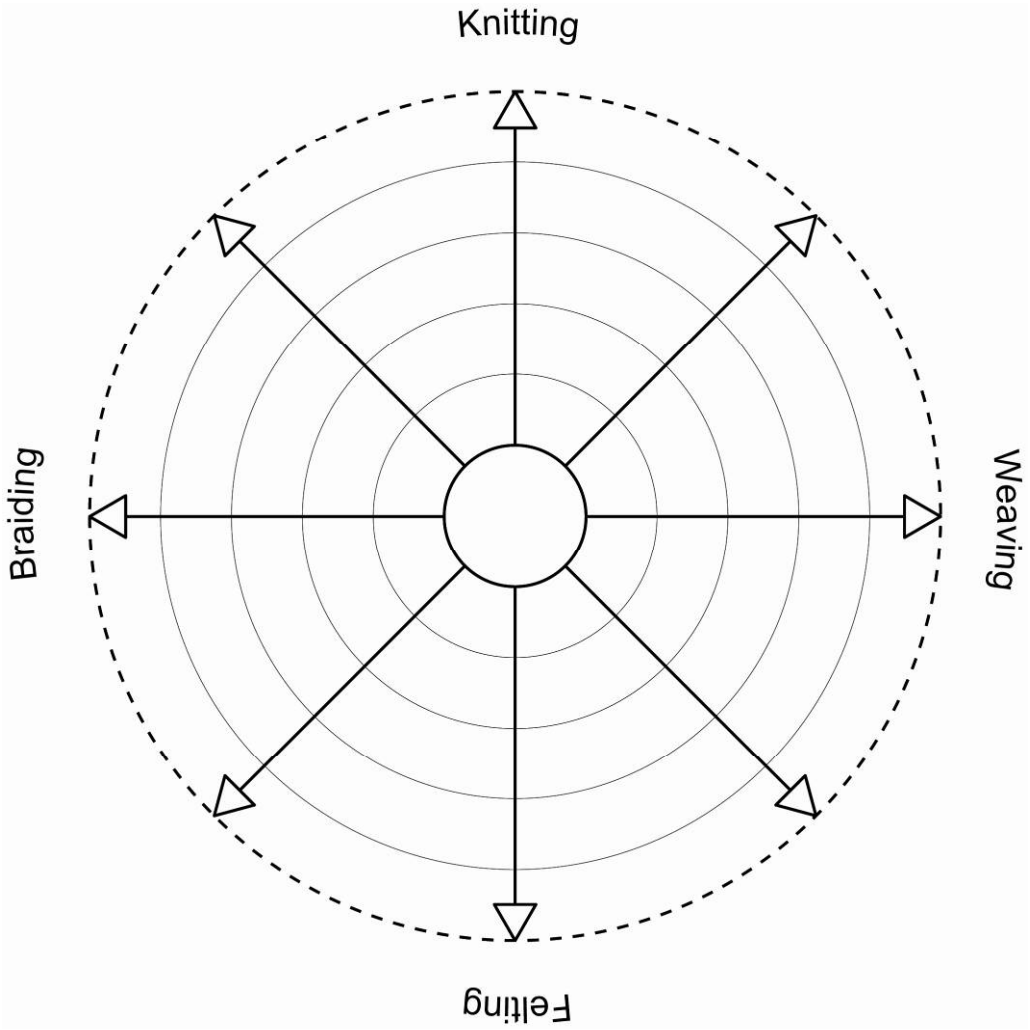


Plain weave pattern; Source: Seiler-Baldinger 1994



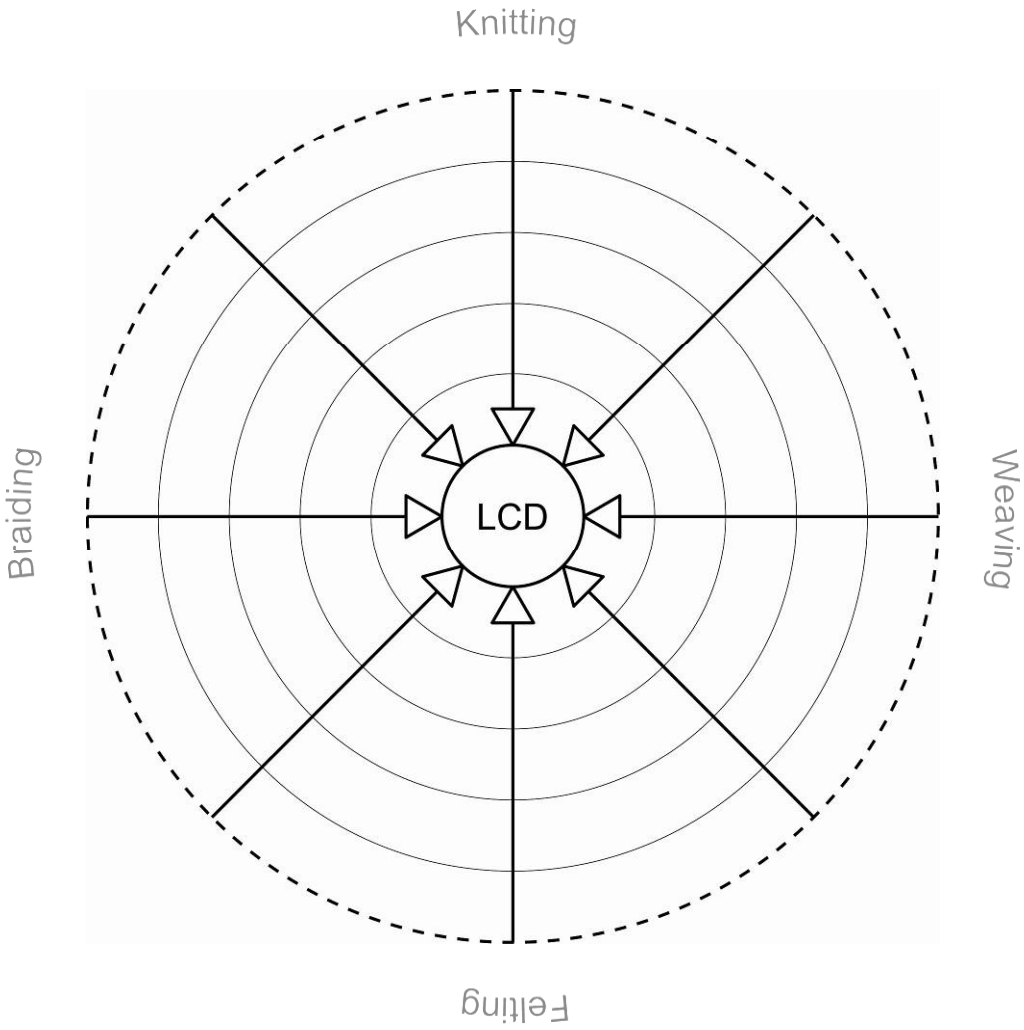
Twill weave pattern; Source: Seiler-Baldinger 1994

IDENTIFYING A LEAST COMMON DENOMINATOR



Exploring the variety and diversity of textile fabrics - expansive approach.

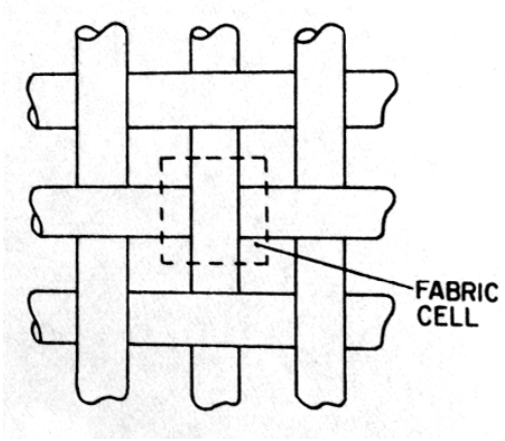
IDENTIFYING A LEAST COMMON DENOMINATOR

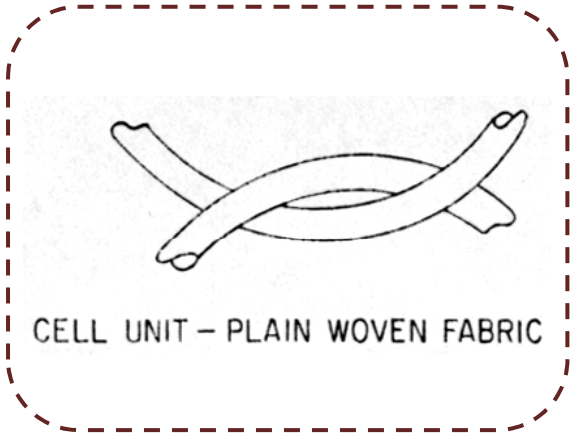


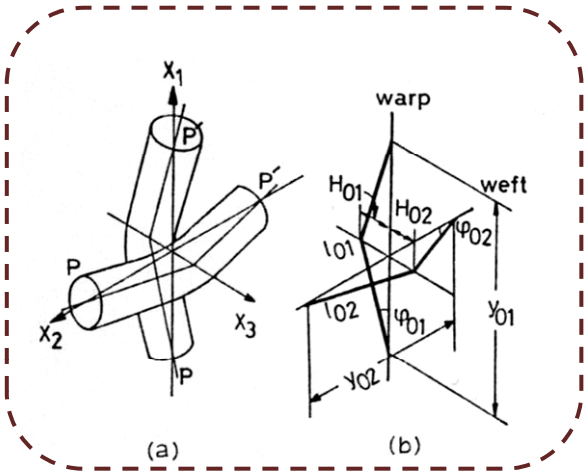
*Defining the **L**east **C**ommon **D**enominator.*

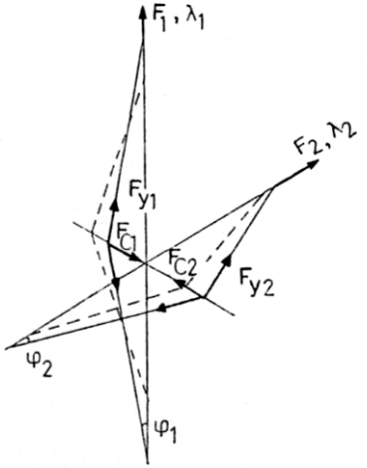
IDENTIFYING A LEAST COMMON DENOMINATOR

Unit Cell in Woven Fabrics





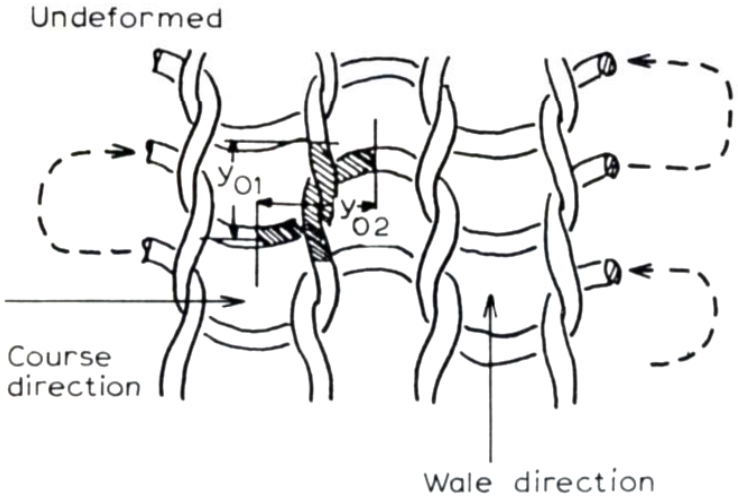


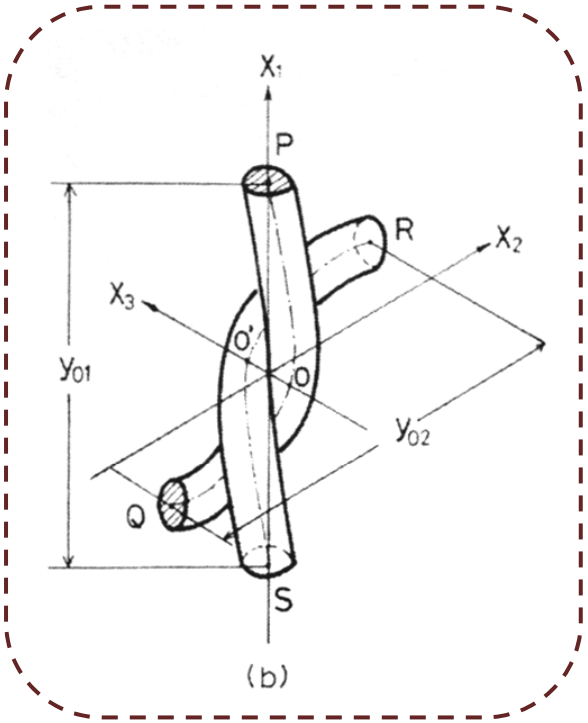


Source: Textile Structural Composites, T.-W. Chou and F. K. Ko, 1989

IDENTIFYING A LEAST COMMON DENOMINATOR

Unit Cell in Knitted Fabrics





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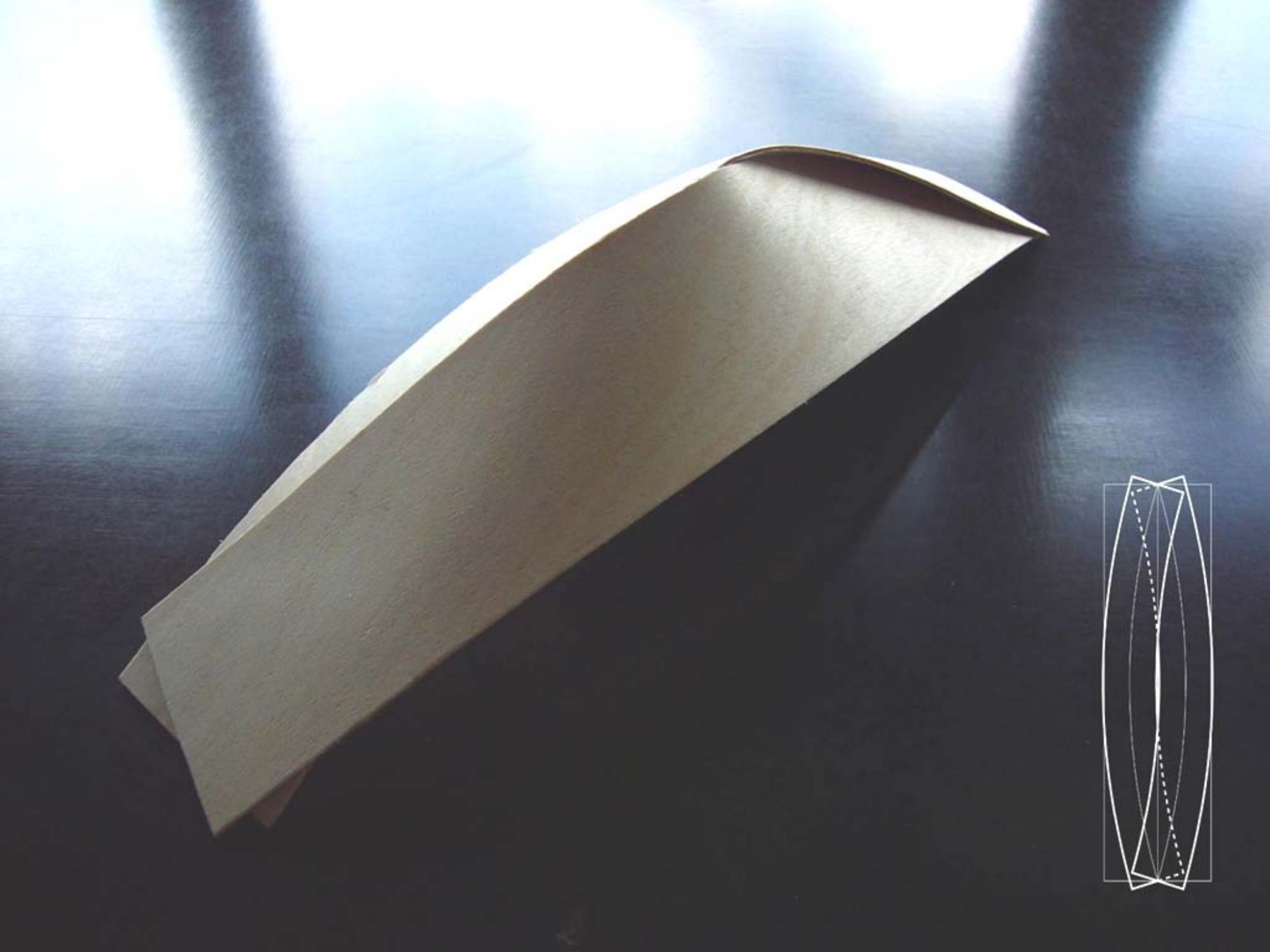
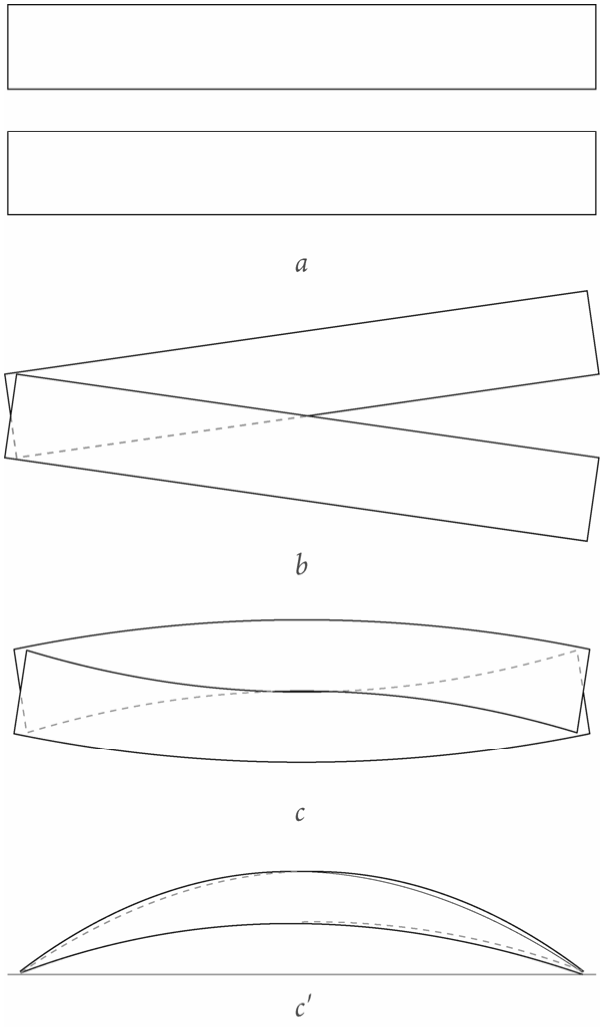


THE TEXTILE MODULE

Assembly Process



THE TEXTILE MODULE

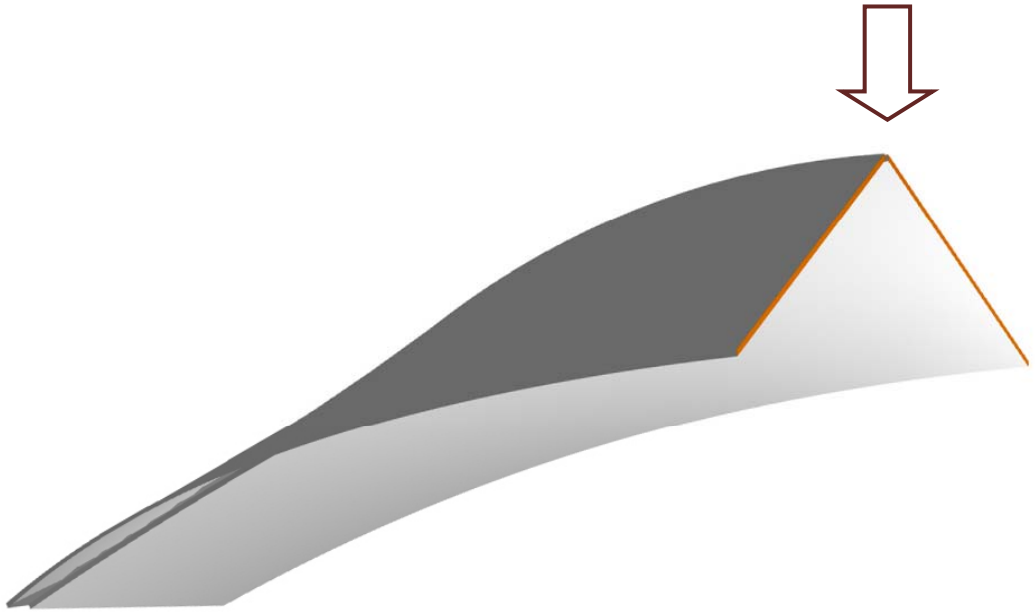
Self-generating Form

Model of the Textile module, top view.

Model of the Textile module, perspective view.

THE TEXTILE MODULE

Behaviour Under Load



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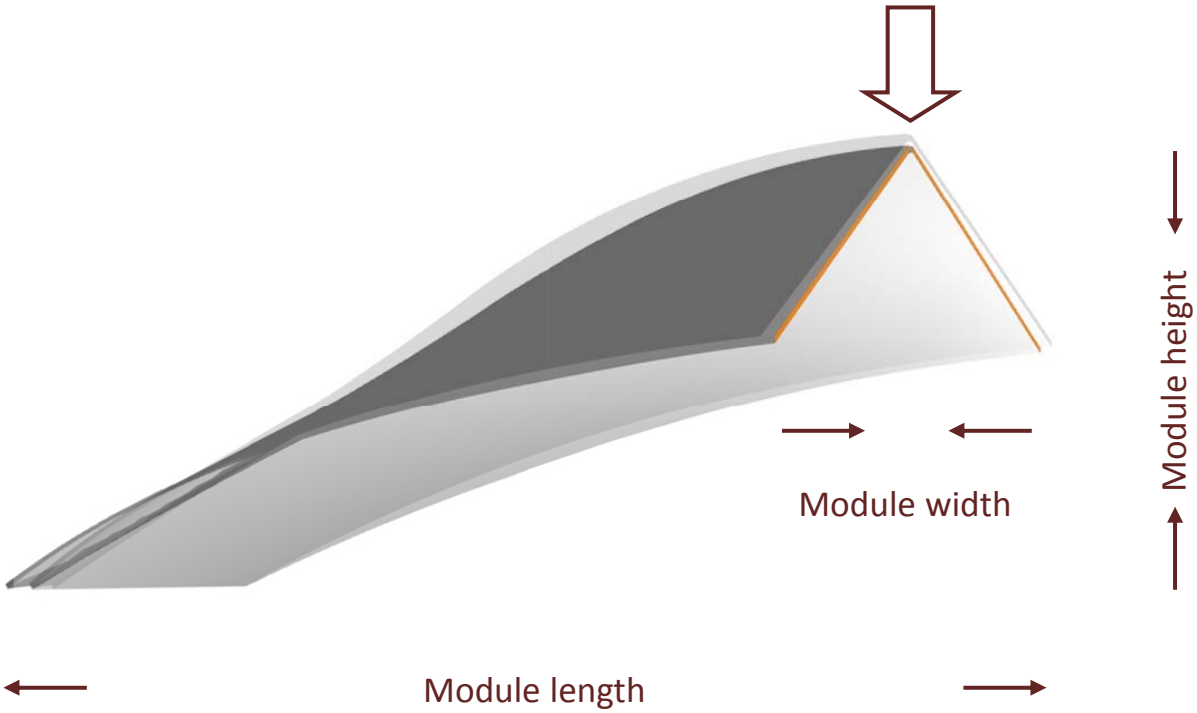
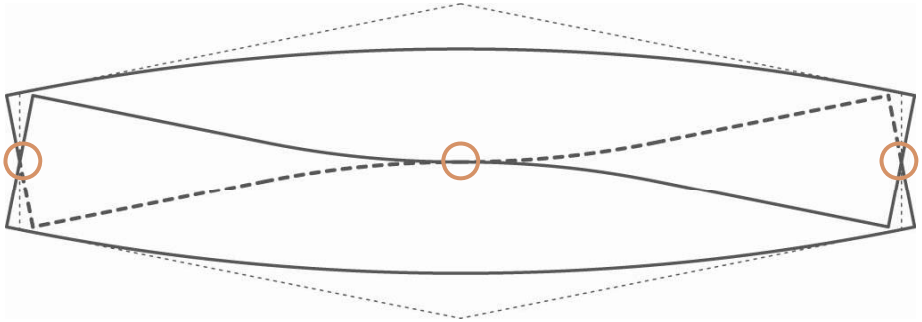


THE TEXTILE MODULE

Two fix points, one contact point



THE TEXTILE MODULE

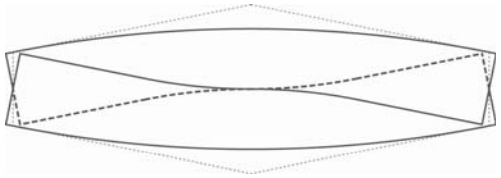
Potential Application: Prototype for the 'Timber Project' exhibition

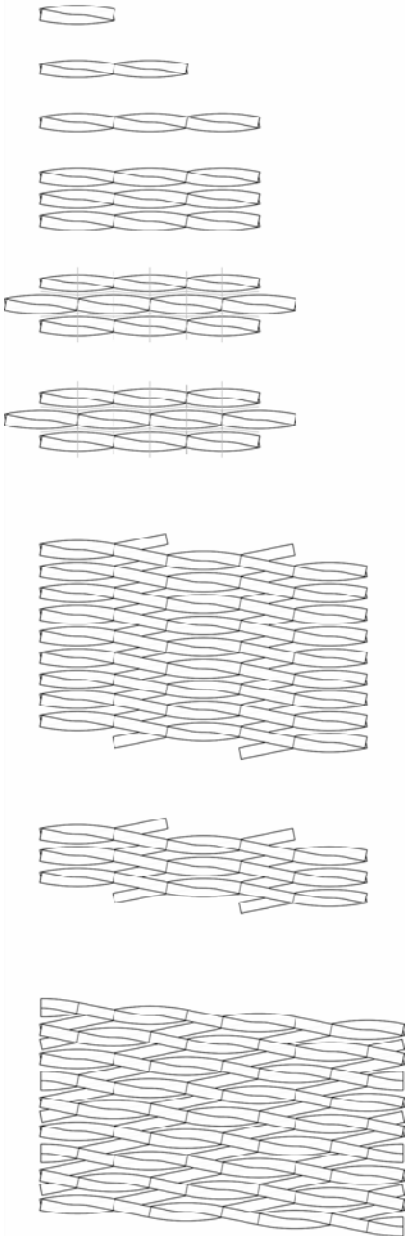
Large scale prototype of the Textile Module leaving the assembly hall;

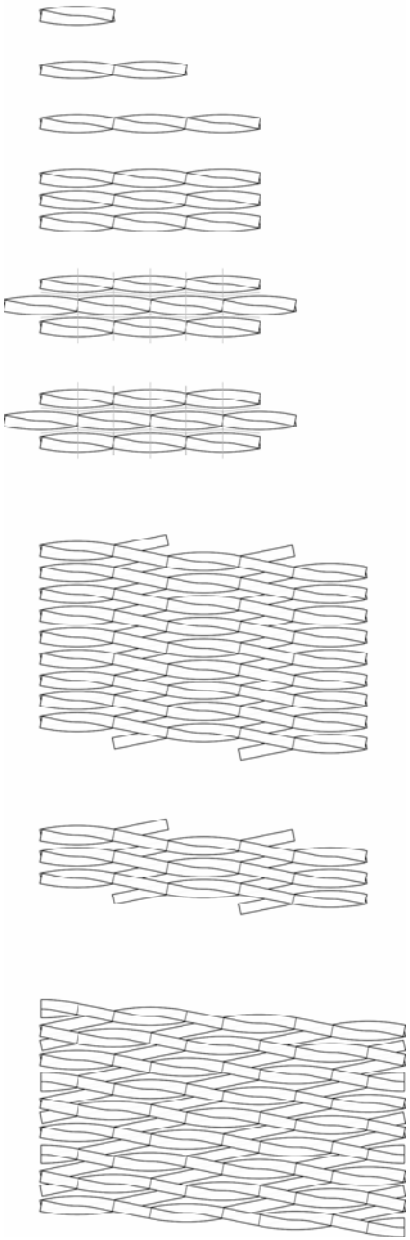
Large scale prototype of the Textile Module on the EPFL campus;

DEVELOPING STRUCTURAL FABRIC

From Textile Module to Timberfabric

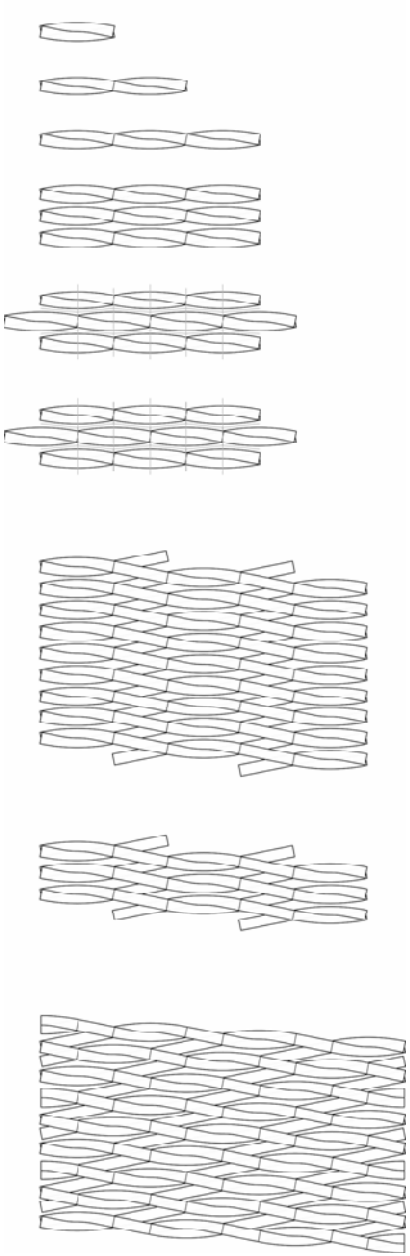


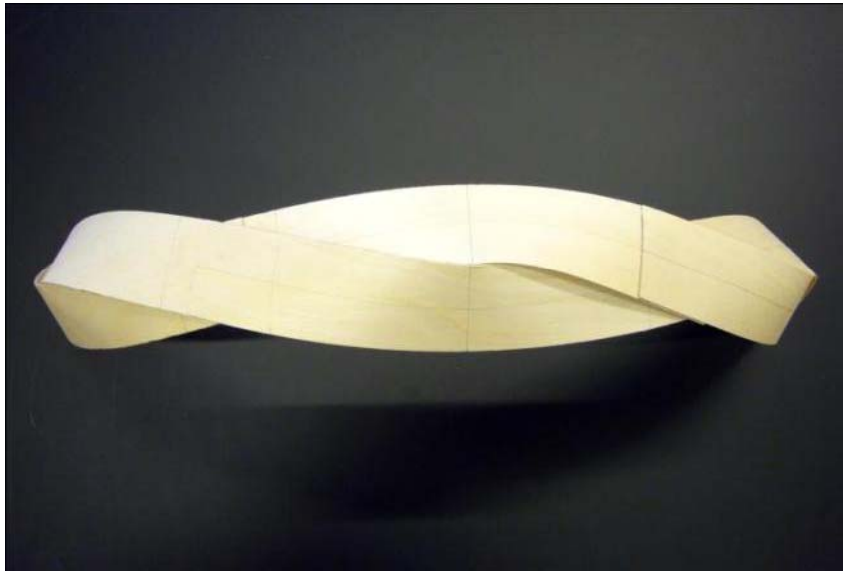




Model of the Textile Module, top view.

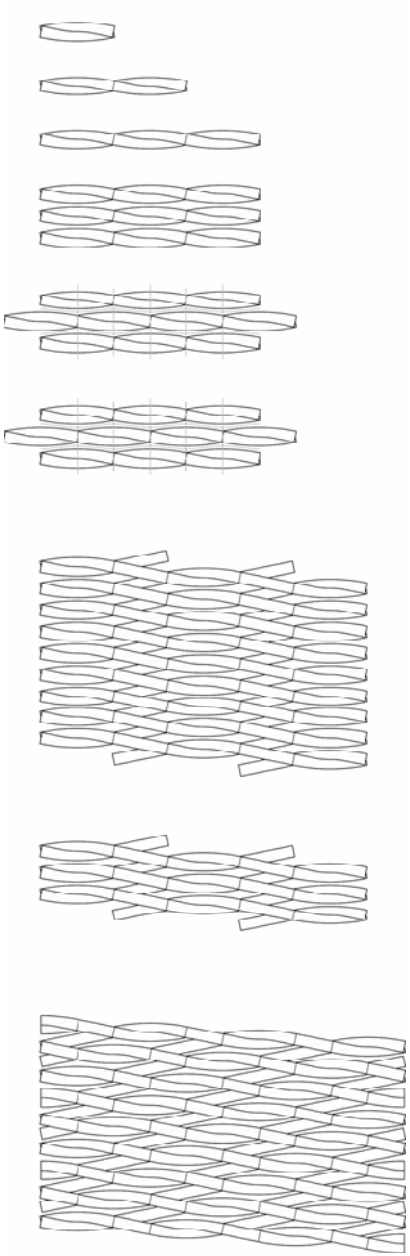
Model of the Textile Module, perspective view.

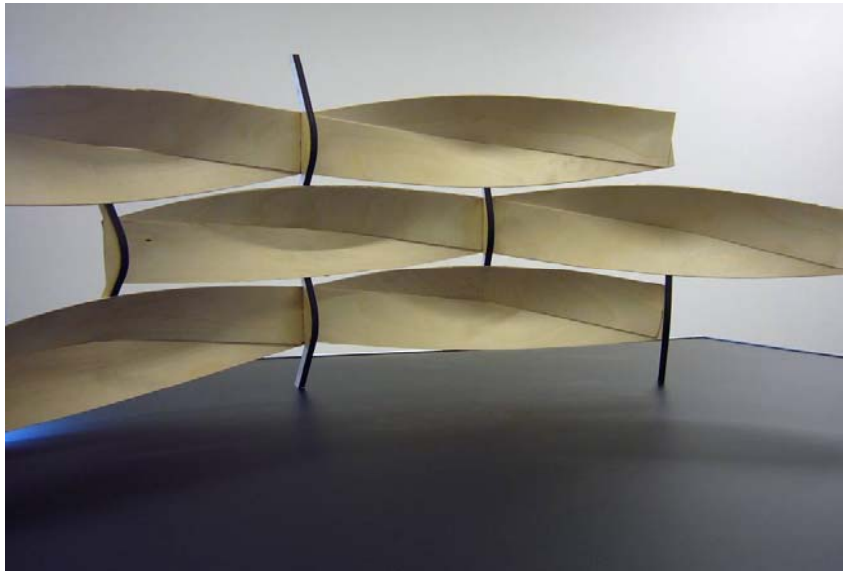




Model of braided arch composed of three modules, top view;

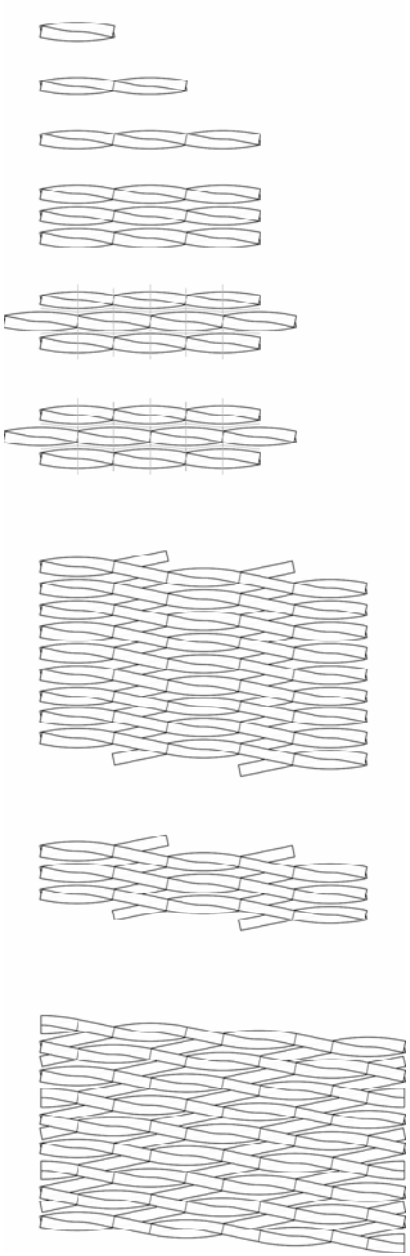
Model of braided arch composed of three modules, front view;





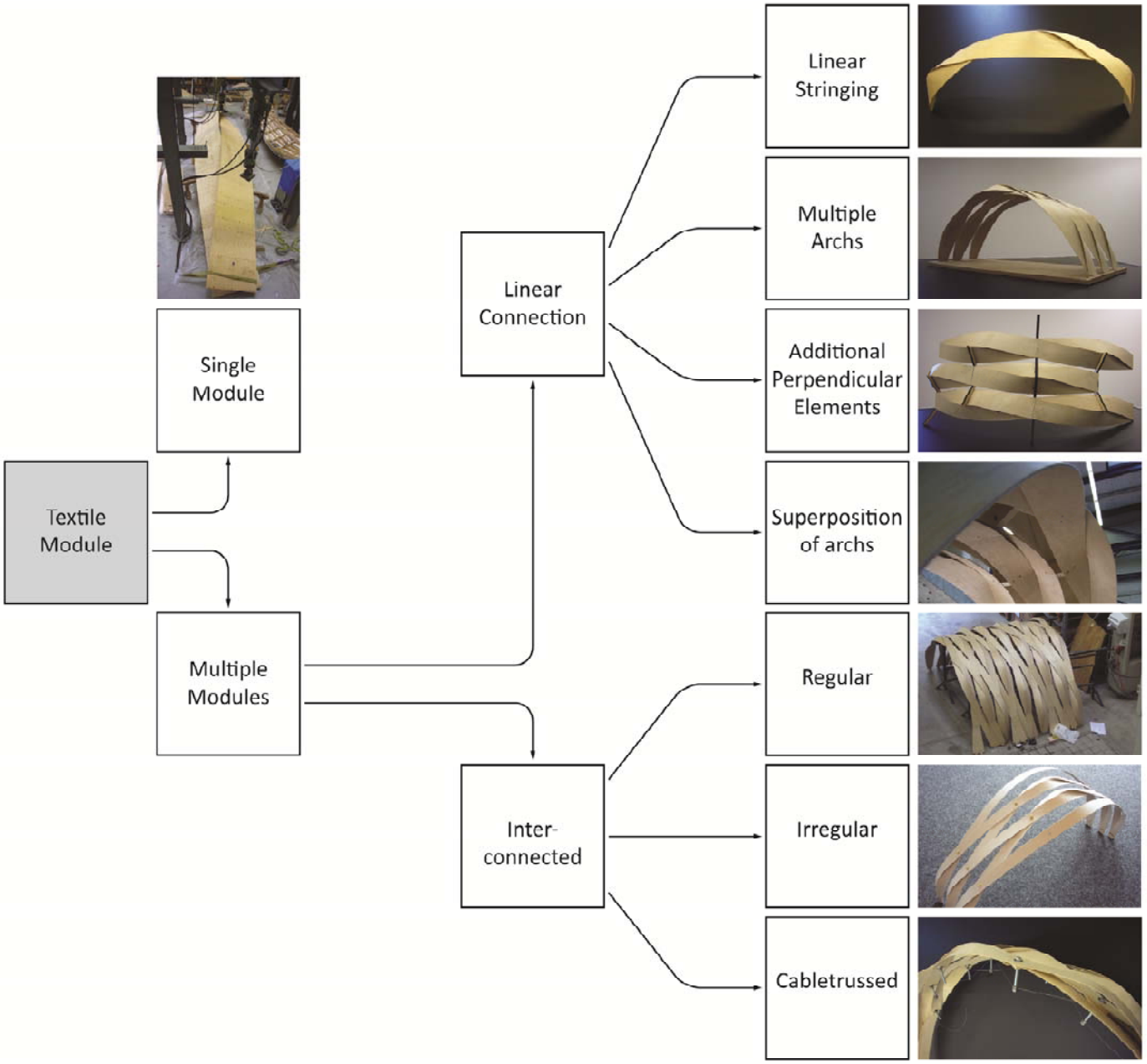
Model with elements in perpendicular direction, interior view;

Model with elements in perpendicular direction, exterior view;



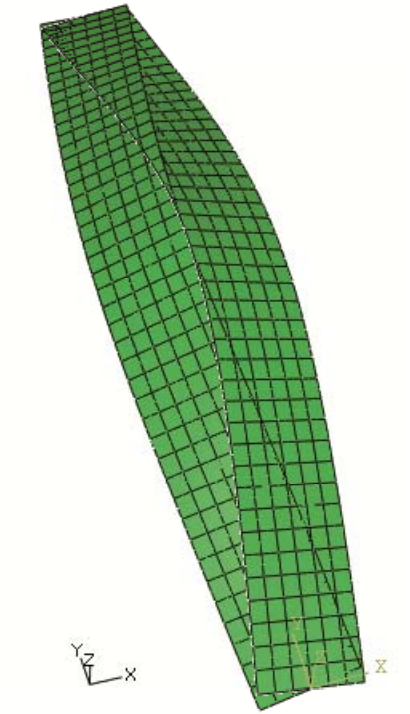
Timberfabric, interconnected elements, continuity in two directions;

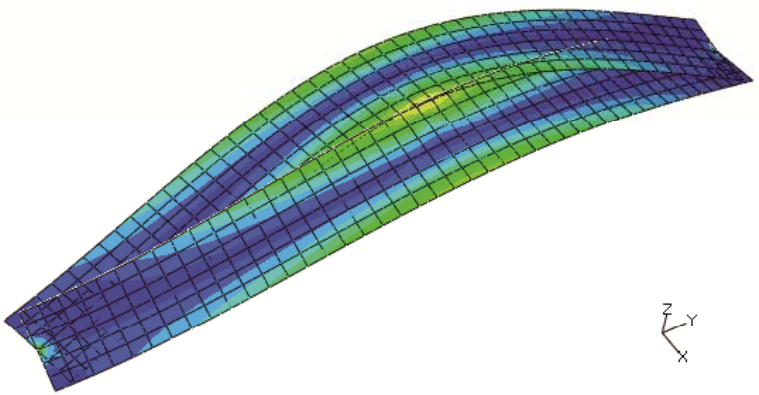
Timberfabric, interconnected elements, continuity in two directions;

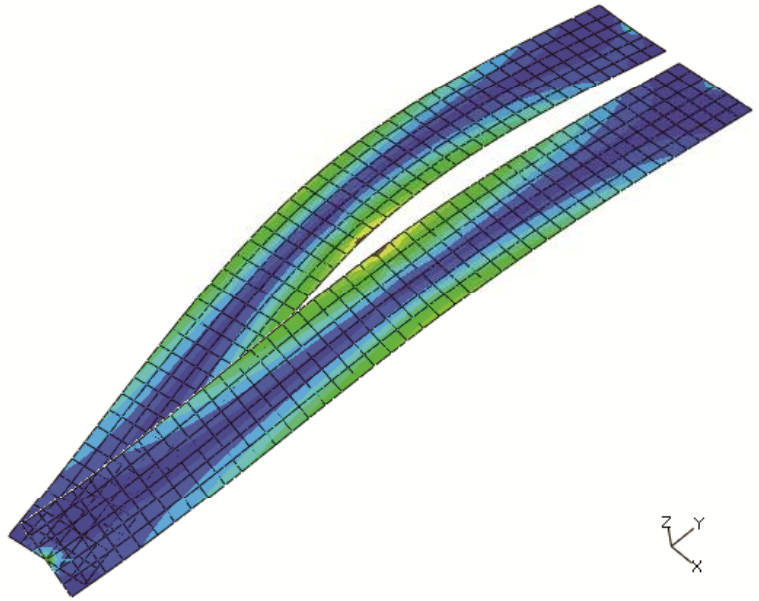

Textile Module
Single Module
Multiple Modules
Linear Connection
Inter-connected
Linear Stringing
Multiple Archs
Additional Perpendicular Elements
Superposition of archs
Regular
Irregular
Cabletrussed

OUTLOOK

- Continuation of beforehand described research
- Mathematical description of geometry
- Simulation and analysis with FEM software







Images by Masoud Sistaninia, mechanical engineer, research assistant IBOIS

THANK YOU FOR YOUR ATTENTION.

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