



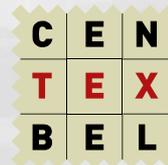
# SHELL ELEMENTS OF ARCHITECTURAL CONCRETE USING FABRIC FORMWORK

## PART 1: CONCEPT

**Cauberg N.  
Parmentier B.**



**M. Vanneste**



**Mollaert M.**



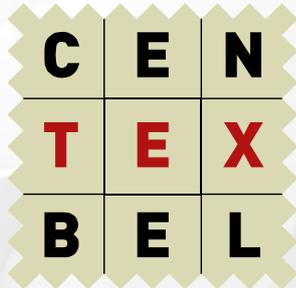
Vrije  
Universiteit  
Brussel



# Introduction: Partnership

## Construction sector

- Non-profit, private research institute
- Statutory members, + 70.000 Belgian contractors
- Collective research, Development & Innovation
- Information transfer



## Textile industry

- Non-profit, private research institute
- Members: 900 textile producers, 100 associated members
- Collective research, Development & Innovation
- Information Transfer

## Architecture

- 9000 students, 2500 staff members, 8 faculties
- ARCH: Department of Architectural engineering
- 25 members, head prof. Mollaert, focussing on:
  - Renovation and re-use
  - Lightweight structures -> Tensile surface structures
  - 4D Design



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## Doubly curved shell elements

1. Flexible formwork

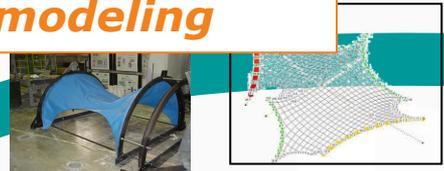
2. Flexible reinforcement

*Design, the Nomad Concept*



# Introduction: Concept

**Shaping and modeling**



**Introduction**



**Materials**



**Modern, organic architecture creates the need for new formwork techniques**

*Design central station, Stuttgart*

**Experiments**



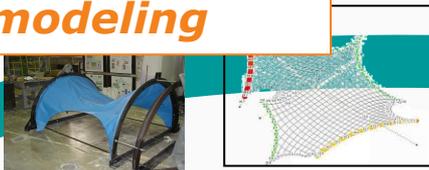
**Conclusions, further work**





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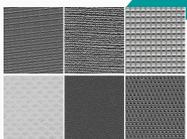
**Shaping and modeling**



**Introduction**



**Materials**



**Fabric formwork allows for a great shape flexibility**

**Experiments**



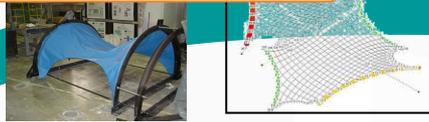
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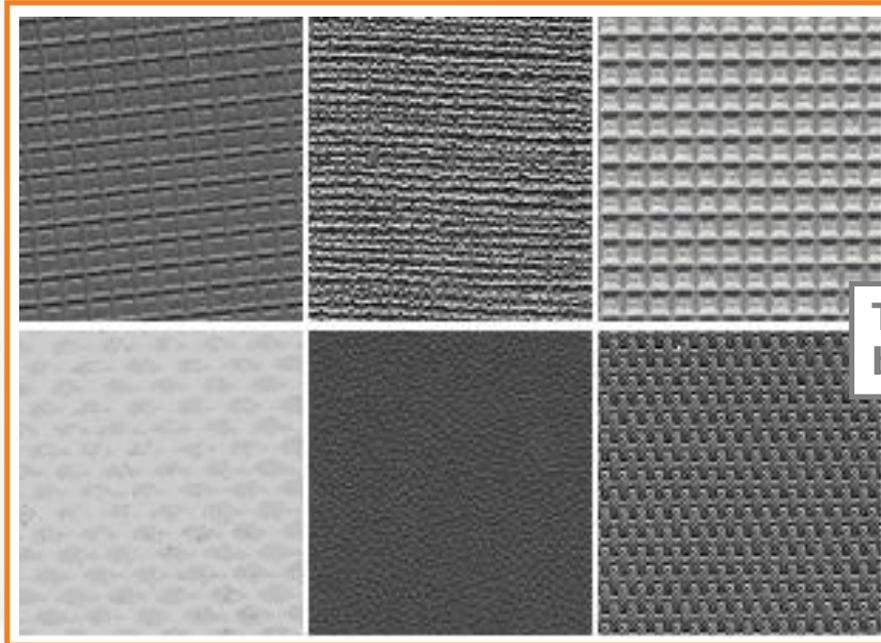
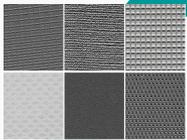
**Shaping and modeling**



**Introduction**



**Materials**



**Thin shell elements, based on shotcrete**

**Experiments**



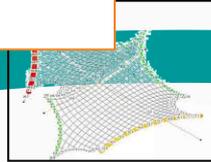
**Conclusions, further work**





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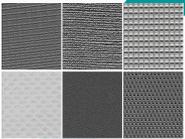
**Shaping and modeling**



**Introduction**



**Materials**



**Experiments and case study**



**Experiments**

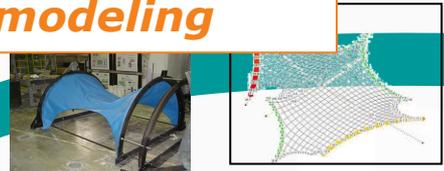


**Conclusions, further work**



# Introduction: Concept

**Shaping and modeling**



**Introduction**



**Materials**



**On site, permanent formwork, ... : new possibilities for architectural concrete**

**Experiments**



**Conclusions, further work**



# Introduction: Why fabric formwork?



Concrete, poured in a formwork  $\approx$  fluid

- Shape flexibility: Creative or organic shapes, intelligent design structural members
- Surface quality of the concrete
- Transport
- But: More complex!



Ghent Music Centre – Toyo Ito with prof. Andrea Branzi





# Introduction: Reference work

## Practical Solutions

- Slope/dike reinforcement,
- Under water concreting,
- Foundations, ...

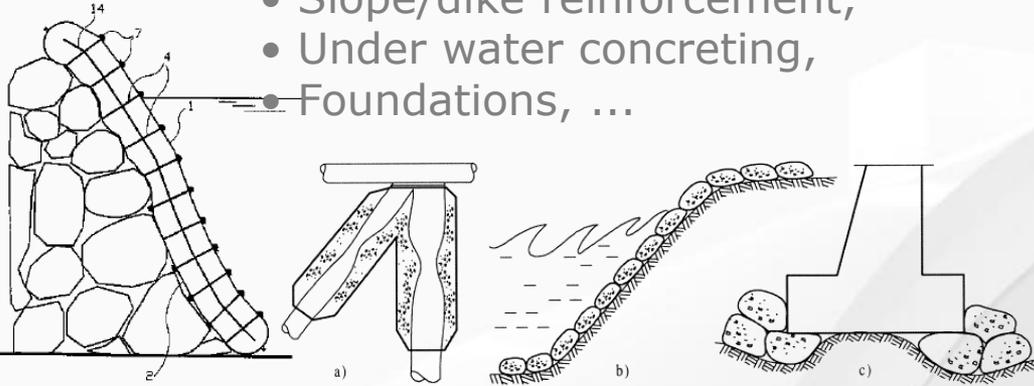


Fig. 4



## Design and Architecture

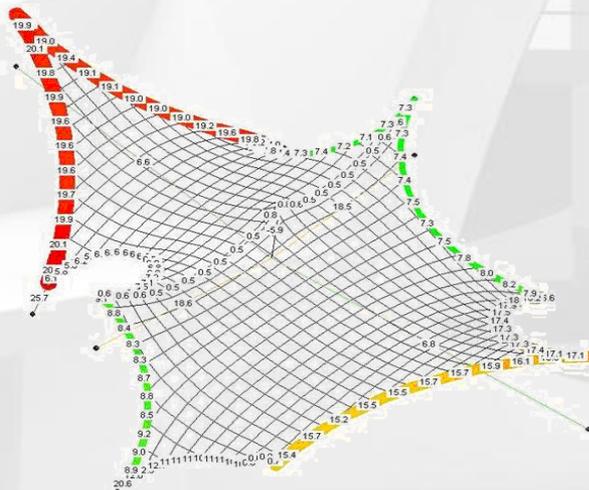
- Mark West:  
Beams, panels, columns, ...
- Pedreschi, Pronk, Schmitz, ...



# Modeling and shaping

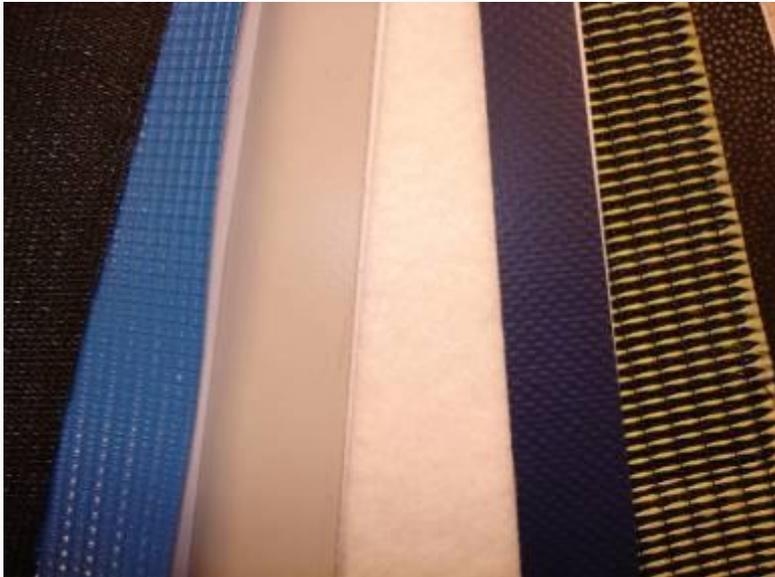
## Approach similar to « textile architecture »

- Shaping
- Material choice and prestress condition
- Loading conditions (concrete)
- Calculation of stresses and deformations
- Iteration...

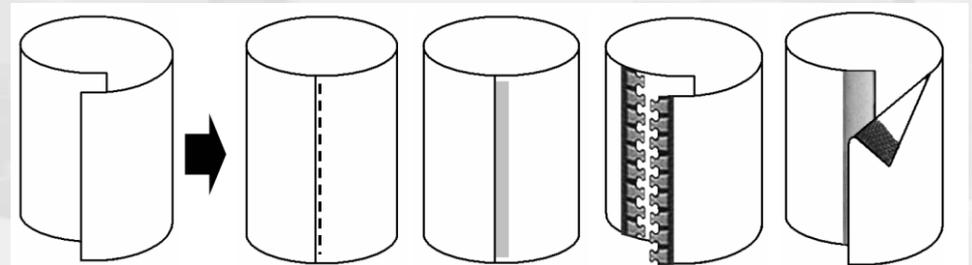
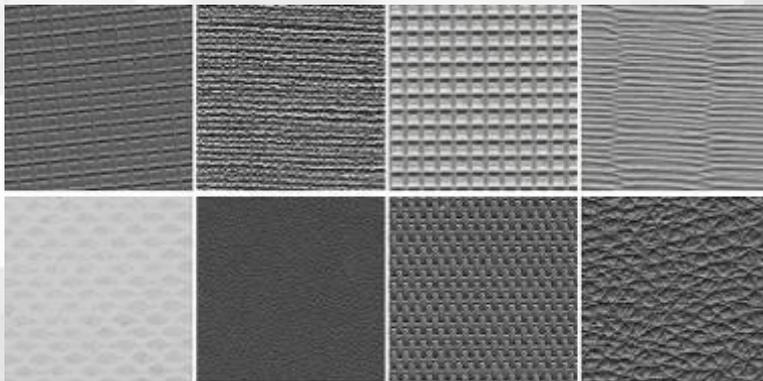


## Manufacturing

- Cutting pattern
- Confection step
- Actual formwork set-up
- « Prefabricated »



- PP, PE and PVC
- Tensile strength: 40-150 kN/m
- Young modulus: 0.1 – 1 GPa
  - > deformations
- Stiffness: 100 – 600 kN/m
- Coated and non-coated
  - > demoulding, impermeability
- Texture
  - > surface aspect
- Assembly: stitching, welding, ...

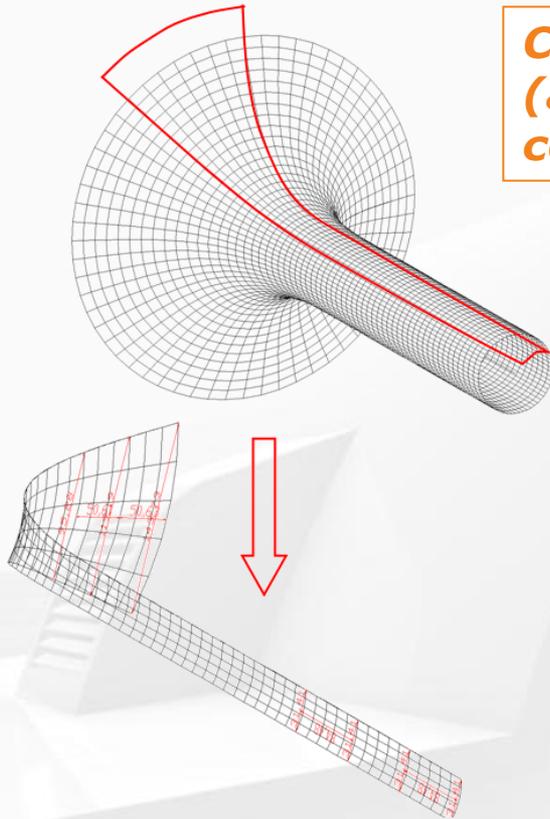




# Experiments: Case studies

## Columns, shells, wall panels, ...

*Columns with specific heads  
(axial symmetry, square, ...)  
combined with slab formwork*



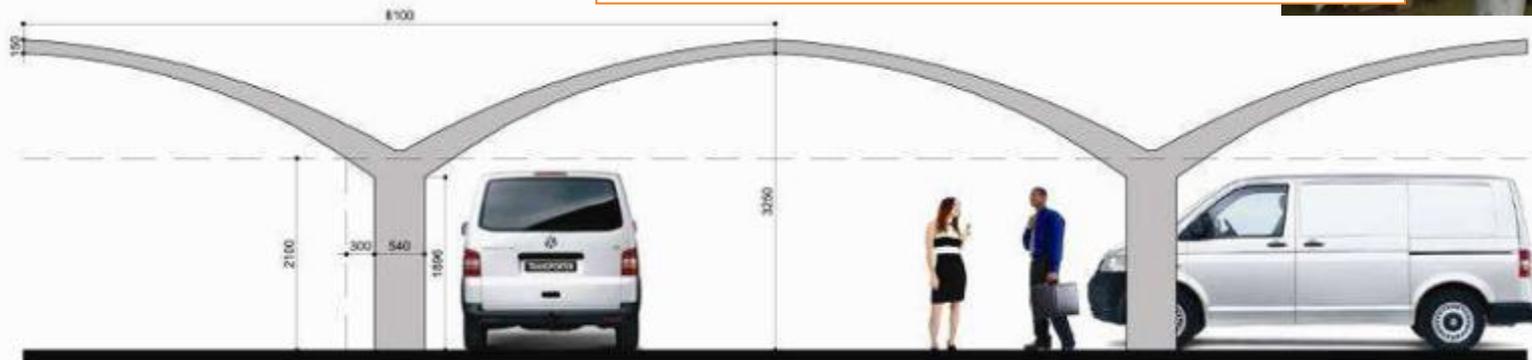


# Experiments: Case studies

## Columns, shells, wall panels, ...



- *Arch and column combined*
- *Specific shape adapted for fabric formwork*



« PARKgarage » idea of Pronk (TU/e)



# Experiments: Case studies

## Columns, shells, wall panels, ...

Brodzki



*Mould for precast element*

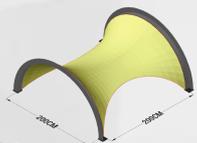




# Experiments: Case study - Doubly curved shell



- Complex geometry for traditional formwork
- Textile choice, confection
- Prestress  $\pm 2$  kN/m
- Sprayed concrete
- Small deformations  $< 2$  mm
- Reinforcement: important issue



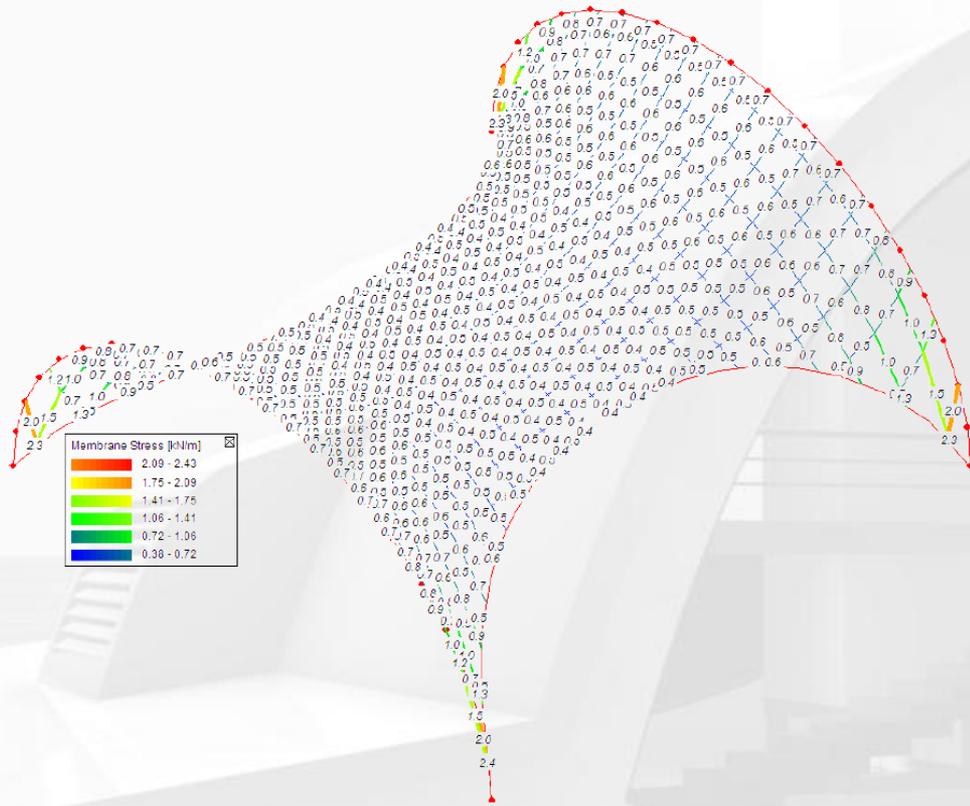
Design The Nomad Concept



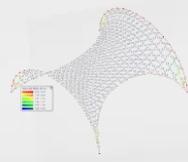
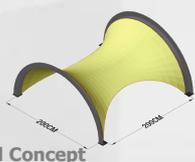


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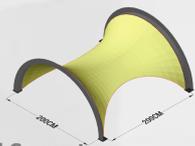




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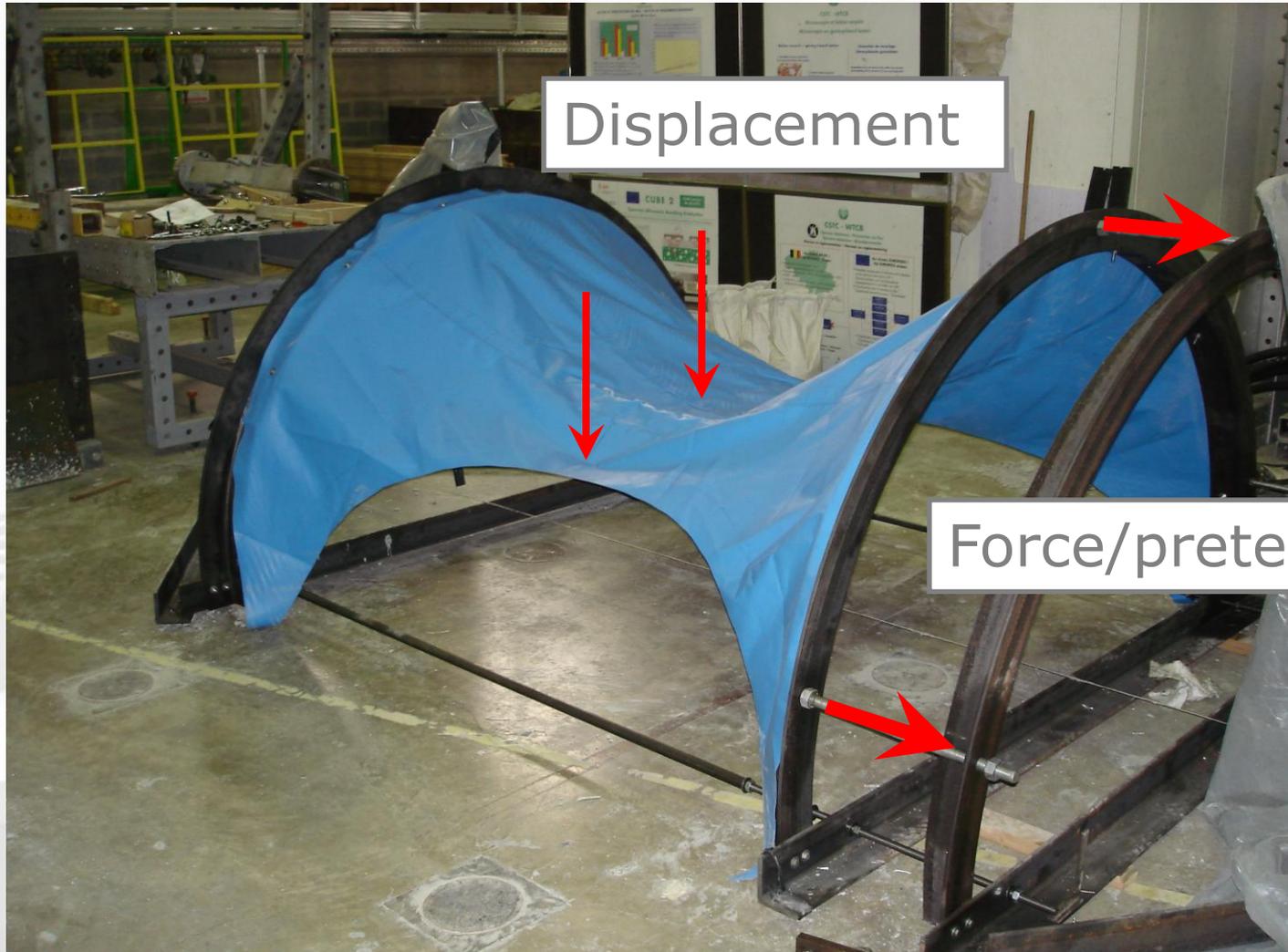
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Design The Nomad Concept



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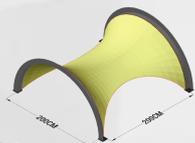
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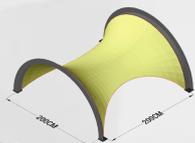




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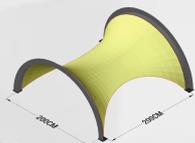




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Design The Nomad Concept



# Conclusions and further work

## New possibilities for architectural concrete

- Preliminary study, modeling and manufacturing
- Preparation depends on element type
- On-site construction or precast production

## Further steps

- Optimize formwork manufacturing
- Reinforcement: traditional and polymer reinforcement

**-> Part 2: Case study!**

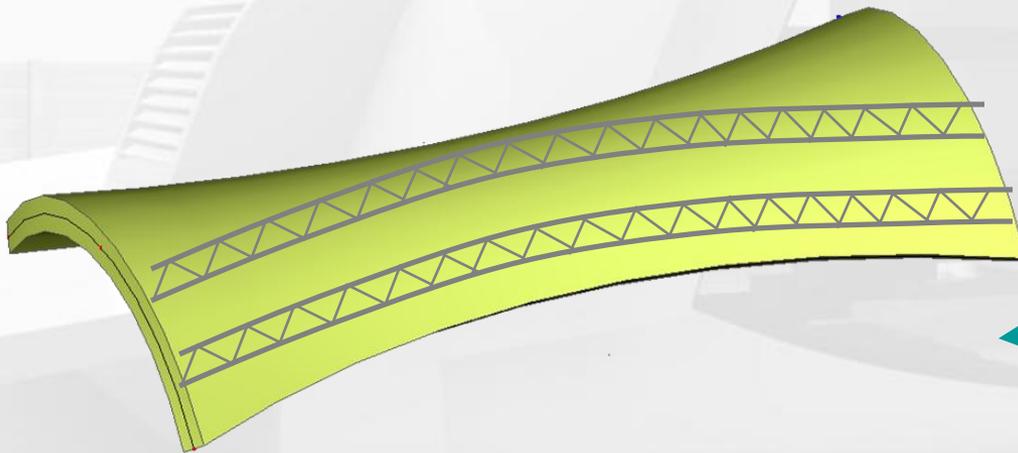
New Central Station Stuttgart



# Conclusions and further work

## Further steps and research

- Shell element for permanent formwork (type « wide slab »)
- Integration of steel reinforcement
- Integration of polymer fiber reinforcement
- Use of fabric formwork as actual reinforcement





# Thank you for your attention!

Partnership:

**BBRI**

[Niki.Cauberg@bbri.be](mailto:Niki.Cauberg@bbri.be)



**Centexbel**

[Pieter.Heyse@Centexbel.be](mailto:Pieter.Heyse@Centexbel.be)



**VUB**

[Marijke.Mollaert@vub.ac.be](mailto:Marijke.Mollaert@vub.ac.be)



Vrije  
Universiteit  
Brussel

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