Structural behaviour of RPC sandwich façade elements with GFRP connectors

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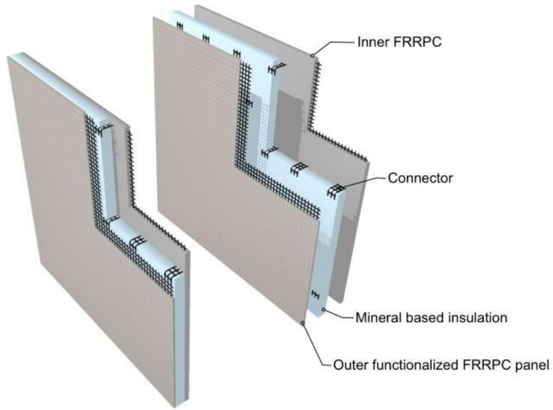
SESBE - Smart elements for sustainable building envelopes



Source: www.sesbe.eu

Development of lightweight, energy efficient and multifunctional "smart" façade elements:

- Increasing energy efficiency by optimized sealing systems and inorganic insulation
- Increasing fire resistance of materials by surface functionalization
- Implementing easy-to-clean/self-cleaning properties of the façade elements
- Gaining cost efficiency and an affordable price of the façade elements by using cost effective raw materials and cost saving technologies

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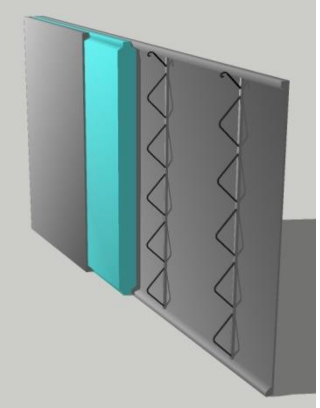
Structural concept



Structural challenge: ensure that it will be an integral part of the building envelope and resist the anticipated structural loads.

- Panels: 20-25 mm thin reactive powder concrete (RPC)
- Reinforcement: carbon fibre grids
- Insulation: light weight foam concrete
- Load transfer between the RPC layers: glass fibre reinforced polymer (GFRP) truss-like connectors

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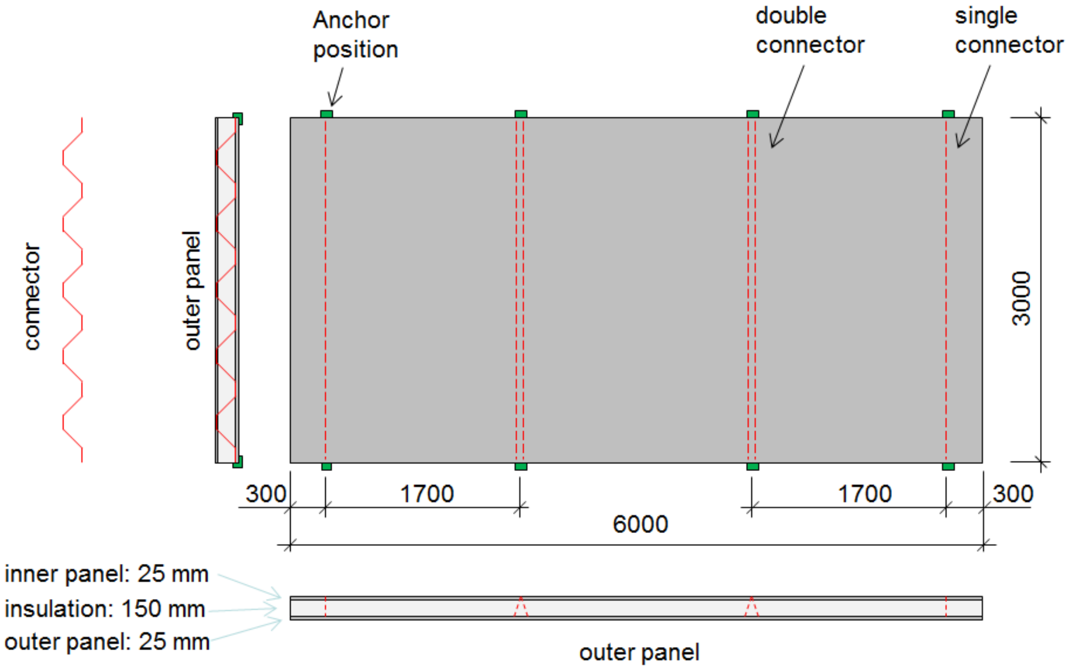
Structural concept



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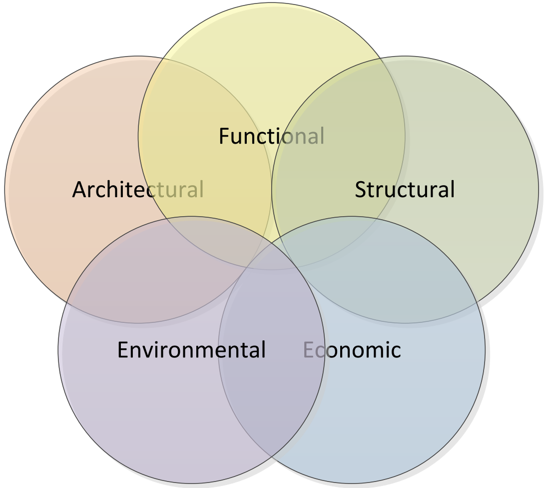
Design considerations

Structural

- Anchoring to the primary load bearing structure
- Connectors between the panels
- Manufacturing process
- Handling, transportation, assembly
- Loads and boundary conditions
- Accidental situations, robustness
- Different shrinkage between the materials
- Durability issues



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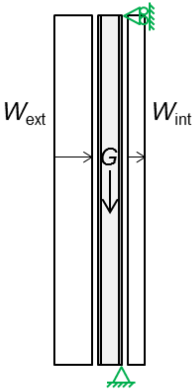
Structural behaviour and modelling

System level

- Typical buildings, non-load bearing elements: simple analytical model seems sufficient
- Design choice: elements fixed separately/self-supporting
- Effect of settlements and (long-term) deformations of the supporting structure
- Robustness issue: prevent elements from falling

Component level

- Combination of novel materials → FE-model: stresses, deformations, cracking
- ”Normal” and accidental design situations
- Verification of ULS and SLS



Load case	Combination	Limit state
LC1	$1.35G+1.5(W_{e1}+W_{i1})$	ULS
LC2	$1.35G+1.5(W_{e2}+W_{i2})$	ULS
LC3	$1.35G+1.5(W_{e3}+W_{i3})$	ULS
LC4	$1.0G+1.0(W_{e1}+W_{i1})$	SLS
LC5	$1.0G+1.0(W_{e2}+W_{i2})$	SLS
LC6	$1.0G+1.0(W_{e3}+W_{i3})$	SLS

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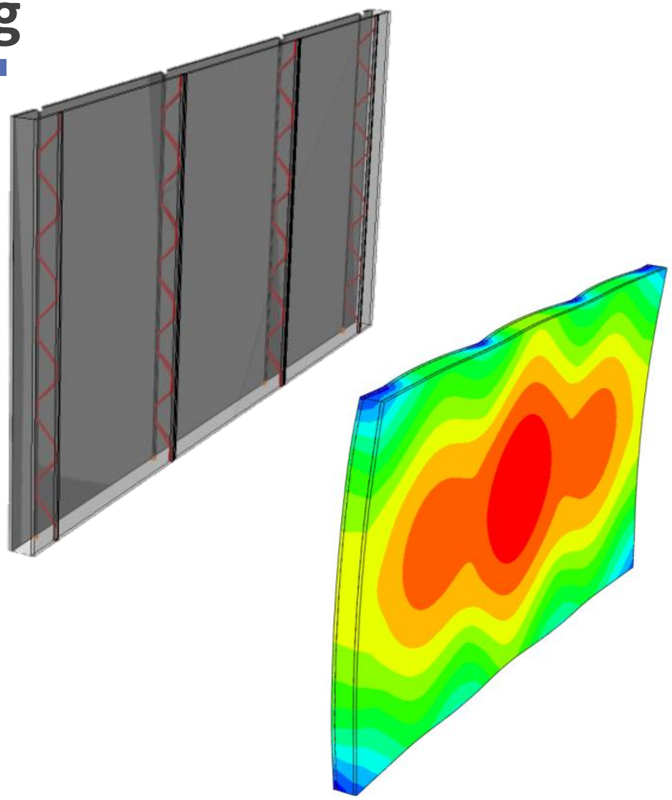
Structural behaviour and modelling

Structural FE-model

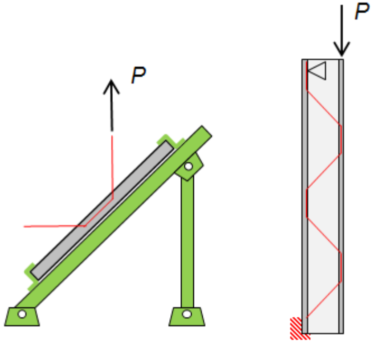
- Analyse the structural behaviour of the sandwich element under different load conditions
- The model is used to evaluate internal forces, stresses, deformations, cracking, resistance etc.
- Basis for design of the sandwich element
- Basis for design of mechanical tests
- Input from material tests
- Verified by mechanical tests on components



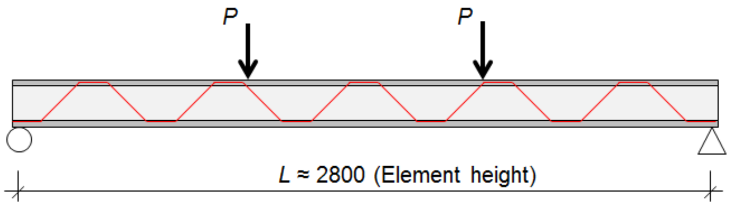
Experimental program

Material testing: accompanying paper (Mueller et al. 2015)

Sub-component testing (GFRP connectors)



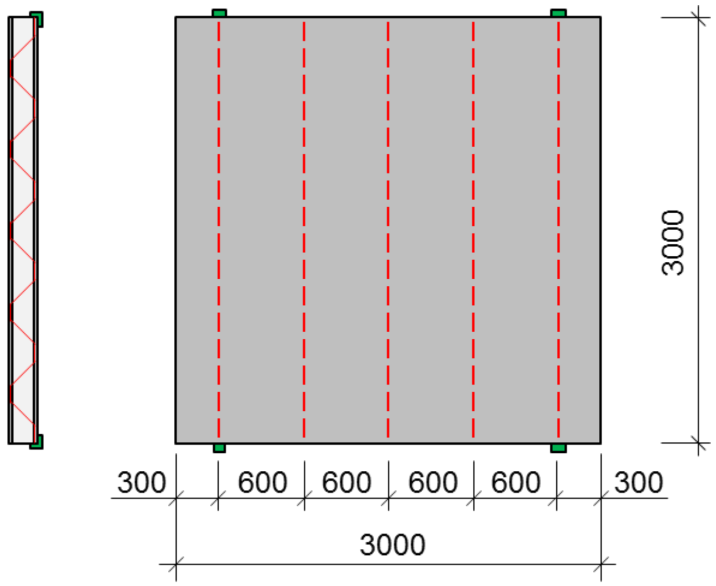
- Local failure test (pull-out):
  - Select the optimal geometry
  - Determine required concrete cover
- Shear test (short panel strip with single connector)
  - Shear behaviour of the connectors
- 4-point bending (long panel strip)
  - Verification of connector performance and composite action
  - Calibration of the numerical model
  - M-N diagrams for design



Experimental program

Component testing

- Cyclic wind loading (pressure & suction) in pressure chamber (capacity ≈ ± 3 MPa)
- Maximum element size approximately 3 x 3 m
- Verification of structural performance
- Validation of the numerical model taking into account connectors and anchorages



Thank you for your attention!