Experimental investigation of individual embossed mechanical bond in composite floor

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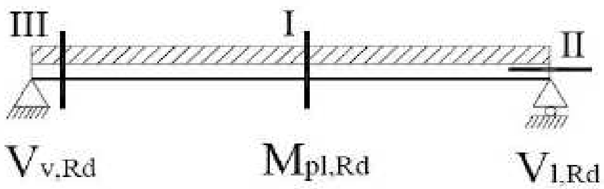
Introduction

- Structural layout

Concrete slab
Profile deck
Steel beam

Frictional interlock
Mechanical interlock – rolled embossments

- Failure modes

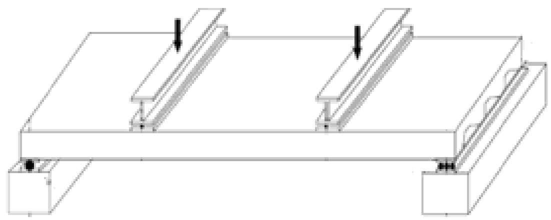


(I) flexural failure (II) longitudinal shear failure (III) vertical shear failure

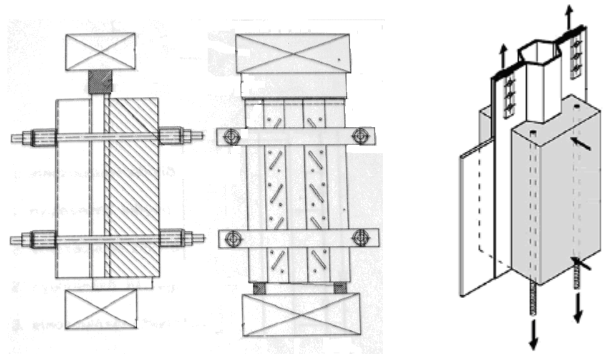
Introduction

- Performance tests

a)



b)



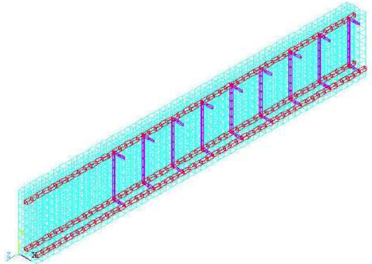
(a) Full – scale specimens (b) Small scale specimens of push – out test

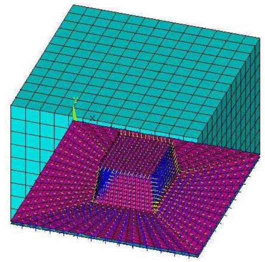
- Scope
  - Simplify the experiments
  - Develop an advanced numerical model for the simulation

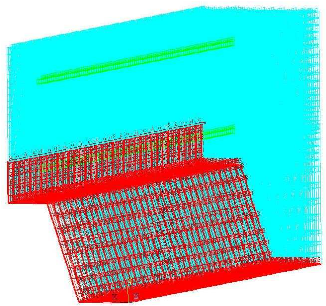
Numerical pre-study

- Model levels

1. Concrete material model
2. Composite connection model
3. Composite beam model



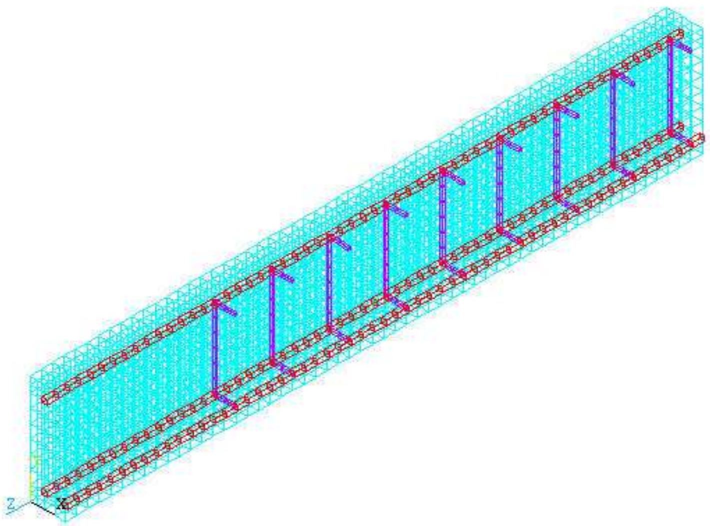


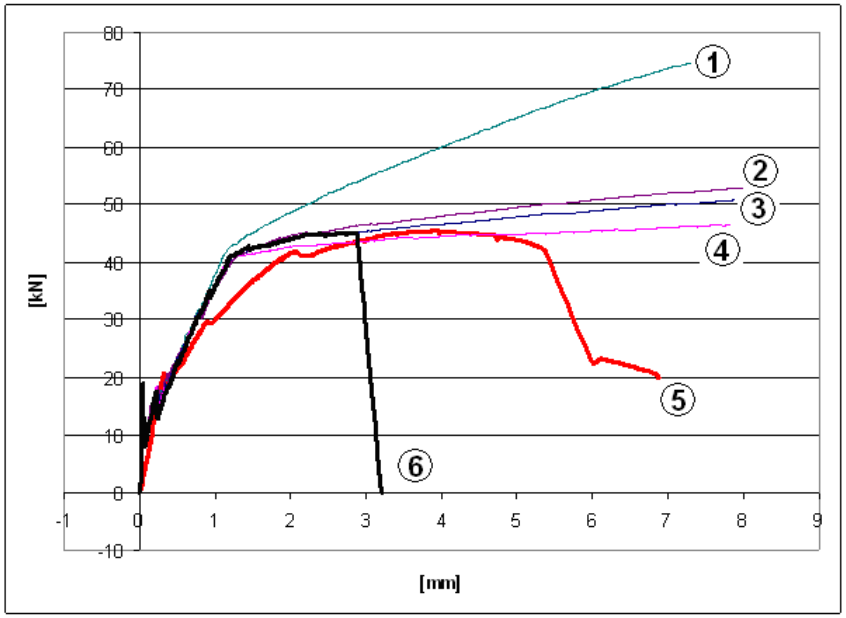


ANSYS

Numerical pre-study

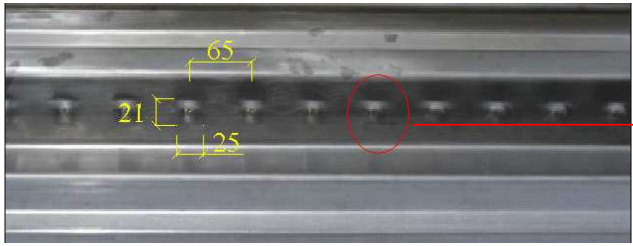
- Concrete material model
  - Simply supported RC beam
  - ANSYS code
  - Appropriate concrete material model



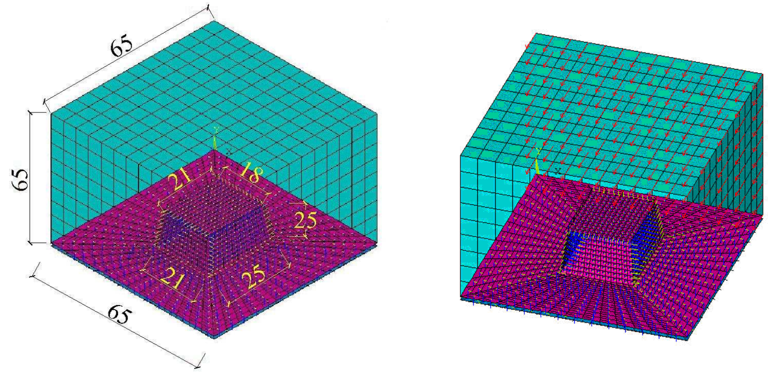


Numerical pre-study

- Local model of embossed mechanical bond



Simplified geometry



  - Basic behaviour
  - Parametric study

Complex behaviour

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Experimental verification

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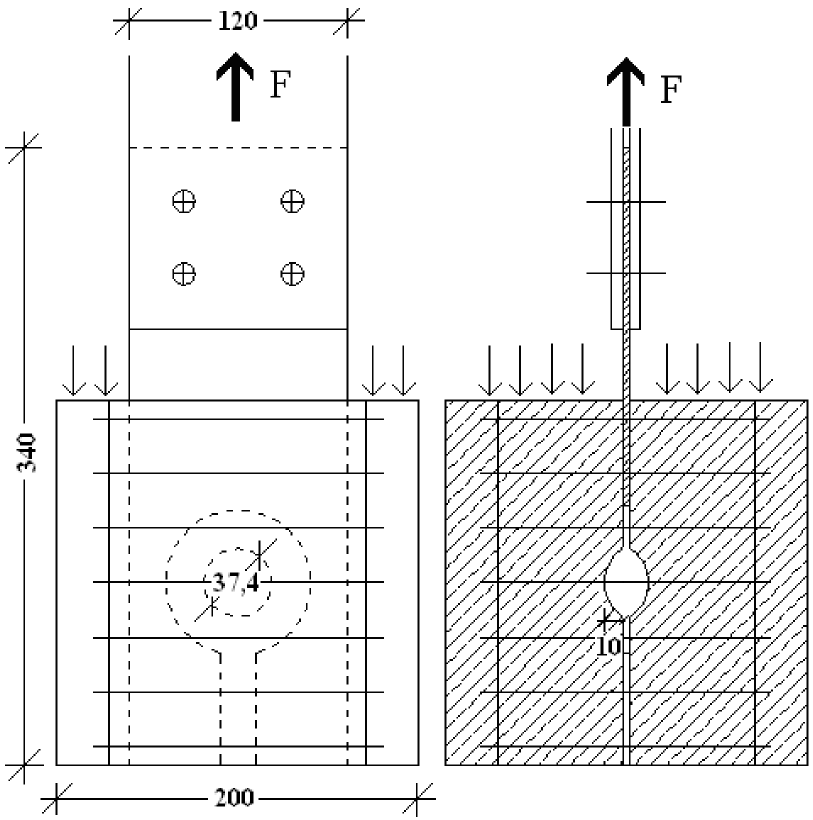
Benchmark experiments for local model verification

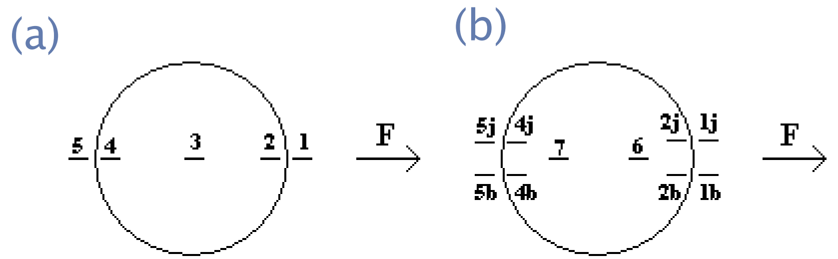
Experimental program

- Layout
  - Two plate thicknesses
  - Six specimens
  - One enlarged embossment
  - Strain gauge measurement
  - Two plates back-to-back in the concrete cube
  - Separation with spacer plate
  - Free deformation of the embossment is insured
  - Avoid global failure in concrete→ stirrups



Experimental program

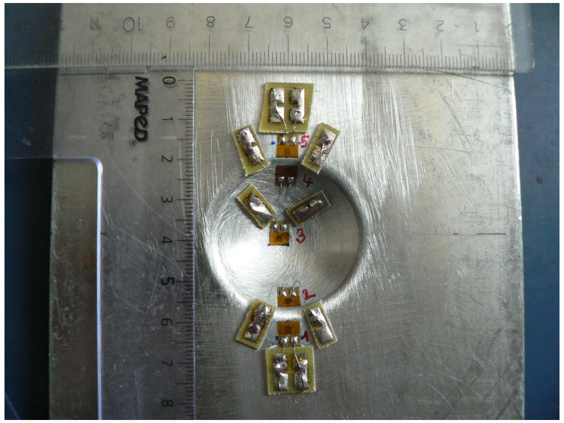
- Strain gauges

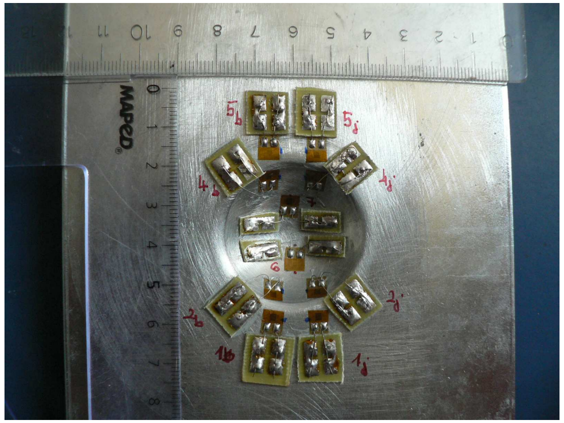


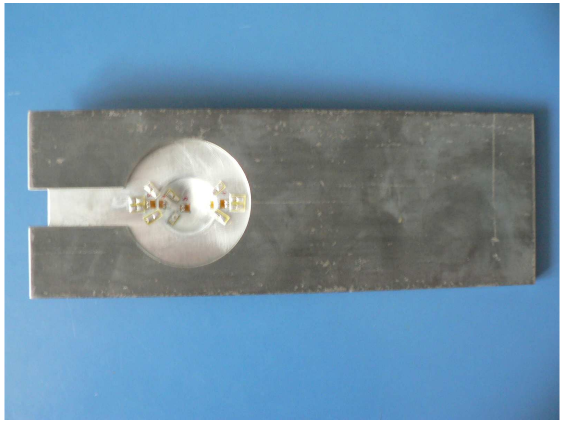
Strain gauges (a) basic and (b) supplementary

Experimental program

- Strain gauges

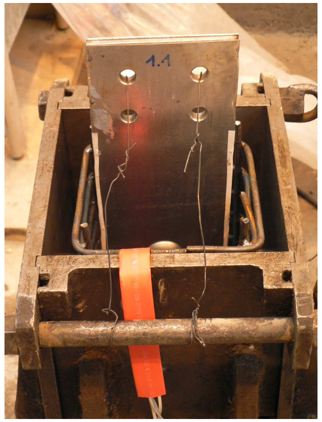


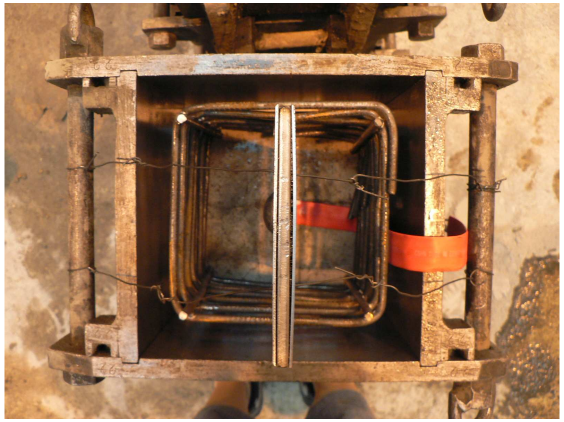


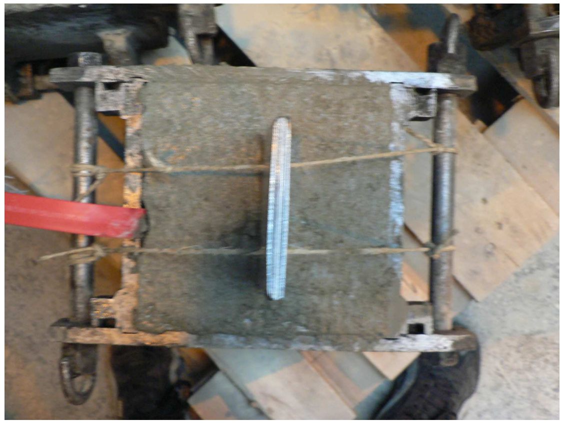


Experimental program

- Specimens







Experimental program

Sign	Sheeting thickness [mm]	Strain gauges [pc]	Concrete cube size [cm]	Steel plate size [mm]	Embossment diameter/height [mm]	f_y/f_u* of steel [N/mm^2]	f_{ck}** of concrete [N/mm^2]
1.1	1,5 mm	5	20x20x20	340x120	37,4/10	444/510	43,35
1.2	1,5 mm	5	20x20x20	340x120	37,4/10	444/510	43,35
1.3	1,5 mm	15	20x20x20	340x120	37,4/10	444/510	43,35
2.1	2 mm	5	20x20x20	340x120	37,4/10	459/534	43,35
2.2	2 mm	5	20x20x20	340x120	37,4/10	459/534	43,35
2.3	2 mm	15	20x20x20	340x120	37,4/10	459/534	43,35

* yield stress/ultimate stress
** compressive strength

Experimental program

- Execution
  - Loading frame
  - Support from above
  - Centralized and uniform load transfer

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  - Hard rubber pad on the supported concrete surface
  - Strain measurement
  - Relative displacement measurement

Test results

- Failure
  - First crack on the exterior side of concrete
  - Crack propagation
  - Slip of the plate

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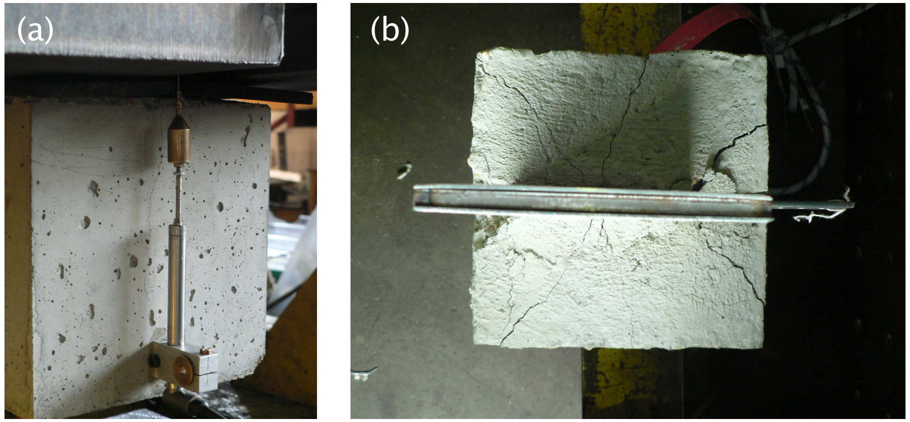
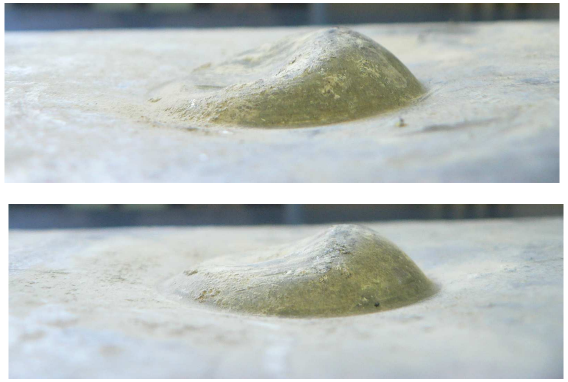
  - Two kinds of cracks



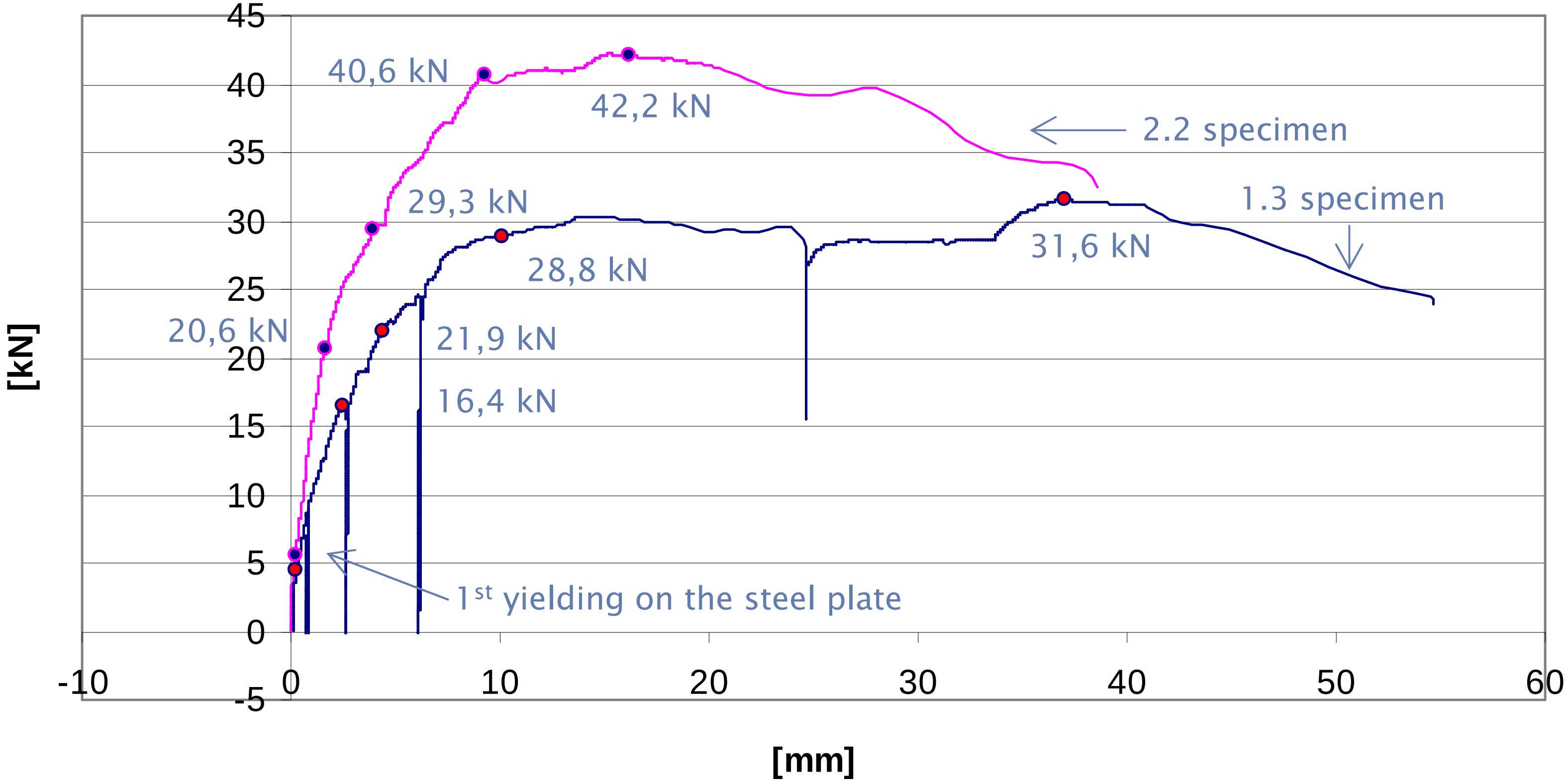
Concrete failure: (a) crack type #1 (b) crack type #2



Embossment's failure

Test results

- Force – displacement



Test results

- Results

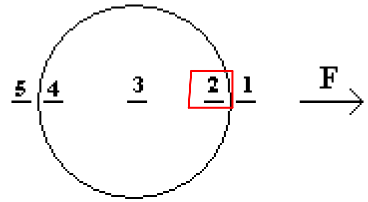
Sign	End of linear phase [kN]	1st crack [kN]	Slip of plate [kN]	Ultimate load [kN]	1st yielding on steel plate [kN]
1.3	16,4	21,9	28,8	31,6	4,39
2.2	20,6	29,3	40,6	42,2	5,62

- Design characteristics

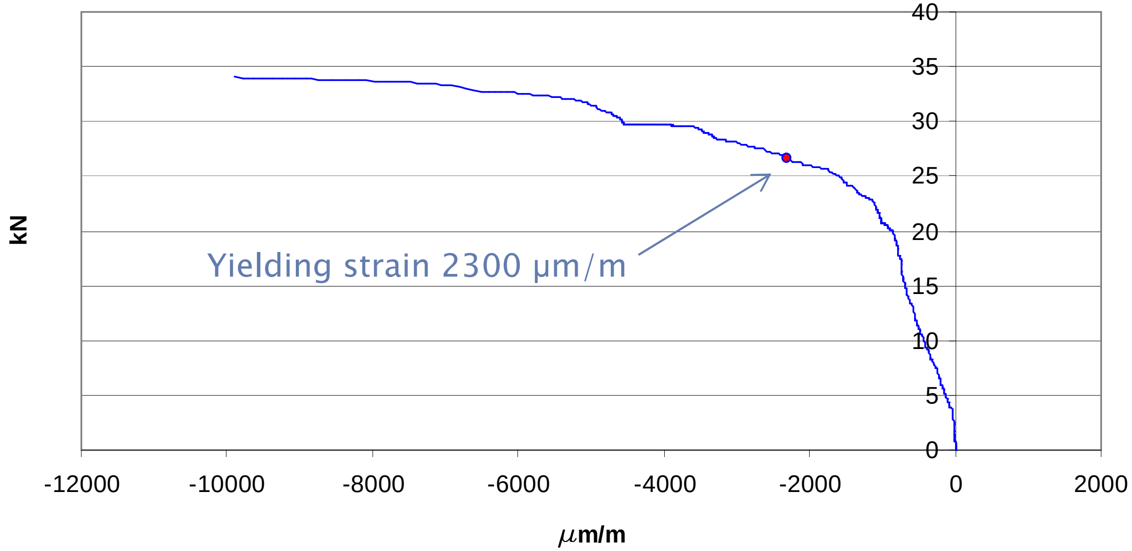
Plate thickness [mm]	Initial stiffness [N/mm]	Load carrying capacity [kN]
1,5	5 722	34,33
2,0	11 637	42,2

Test results

- Strain measurement
  - same behaviour by position and by specimen type
  - yielding at very low load level (5–10 kN)
  - yielding at #2 gauge position



Strains on specimen 2.2 at gauge position #3



Concluding remarks

- Experimental investigation of an individual embossment
- New test specimen is introduced ⟶ local analysis
- Basic behaviour modes are observed
- Quantitative evaluation of the results

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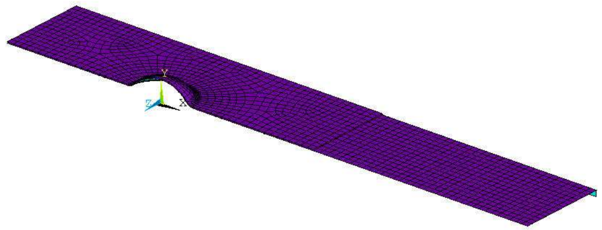
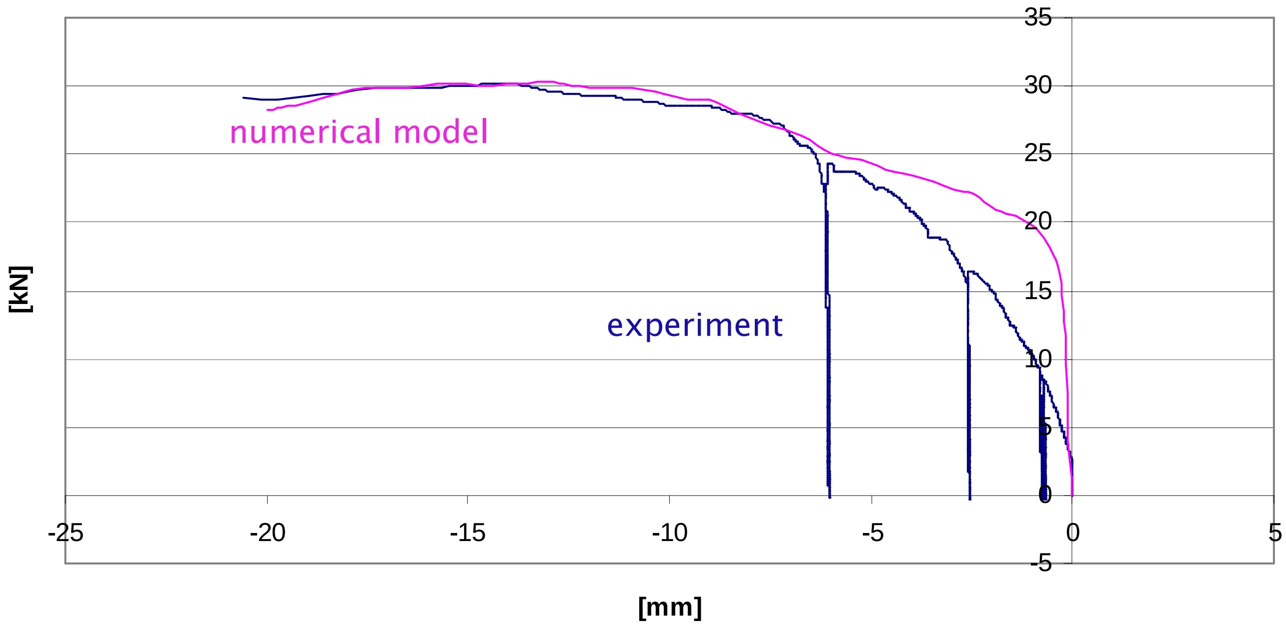
- Validation of the developed advanced numerical model for the embossment's behaviour
- Embossments interaction

Next step of the research

- Numerical modelling



Force – displacement



Acknowledgement

- Special thanks for the financial support:
  - OTKA T049305 project, Hungary
  - Hungarian Academy of Engineering Foundation–Rubik International Foundation

Thank you for your attention