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&
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Robustness – Robust structures by joint ductility

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Prague, 30th & 31st of March 2007

ONGOING RFCS PROJECT

- Title: Robust Structures by Joint Ductility
- 2004-2007
- Partners: Stuttgart University (Germany)
  Liège University (Belgium)
  Trento University (Italy)
  PSP Technologien (Germany)
  Arcelor Mittal

OBJECTIVES OF THE PROJECT

The objective is to derive robustness requirements for various potential exceptional events

➔ recommendations for good practice

WAYS AND MEANS

- Some exceptional situations identified:
  - loss of a column in an office or residential building frame
  - loss of a beam in an office or residential building frame
  - loss of a column in an industrial portal frame
  - loss of a bracing in an industrial portal frame
  - loss of a bracing in a car park
  - unexpected earthquake
  - unexpected fire

STRATEGY FOLLOWED WITHIN THE PROJECT

Experimental tests on a substructure, on joints and on joint components

Validation of the numerical tools

Parametrical numerical studies

Development of simplified analytical methods

Derivation of **design guidelines** for practitioners

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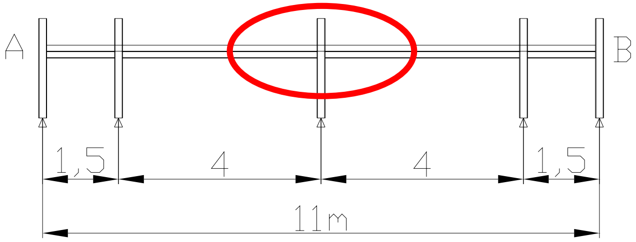
TEST COMPAIGN

- Unique chain for the experimental tests

substructure test



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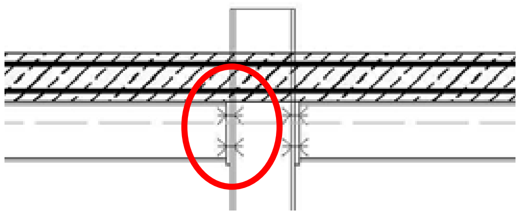
joint tests



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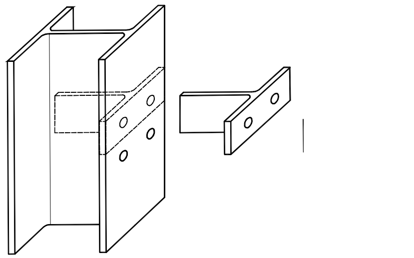
component tests



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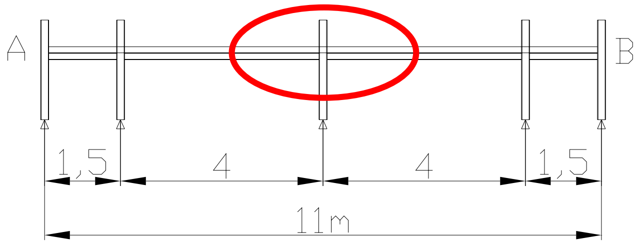

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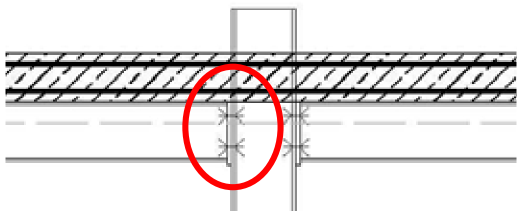

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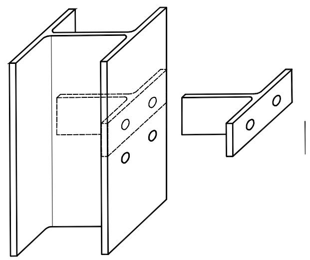

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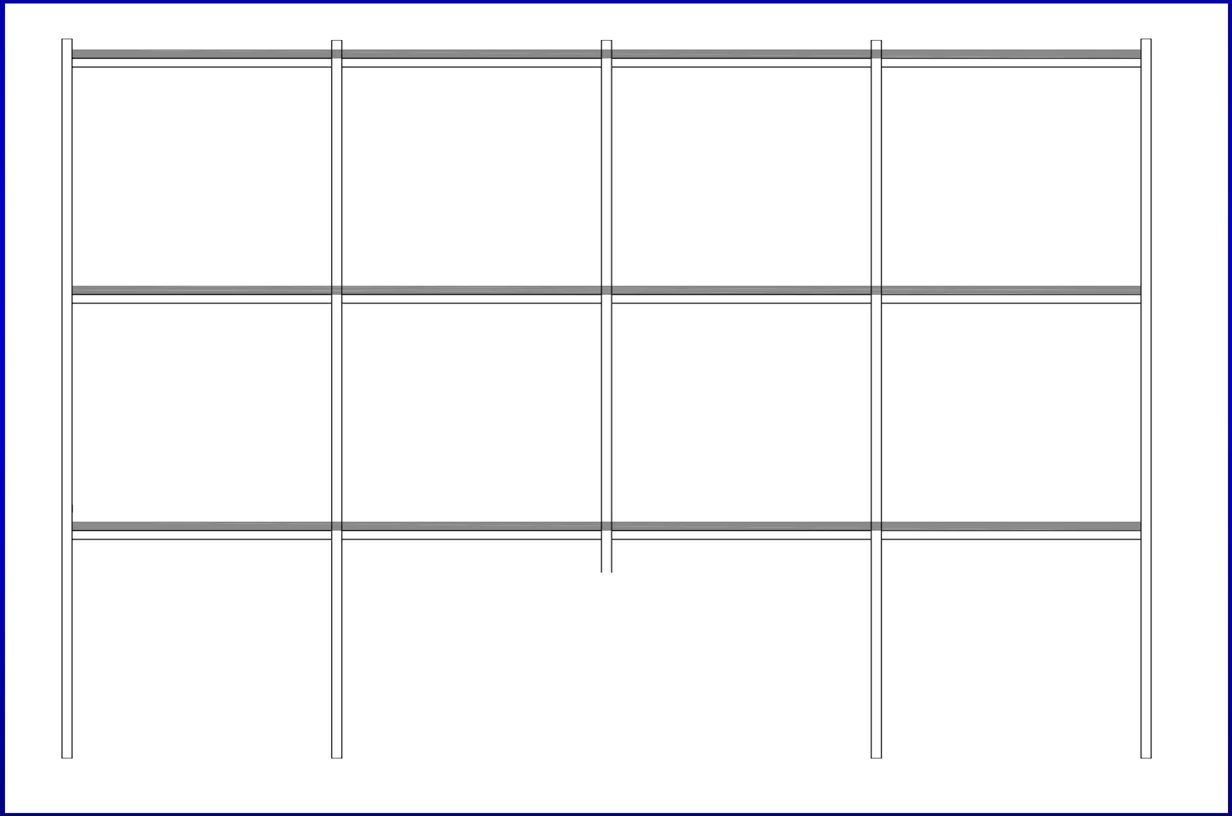
MAIN OBJECTIVES OF THE SUBSTRUCTURE TEST

Loss of a column due to an impact



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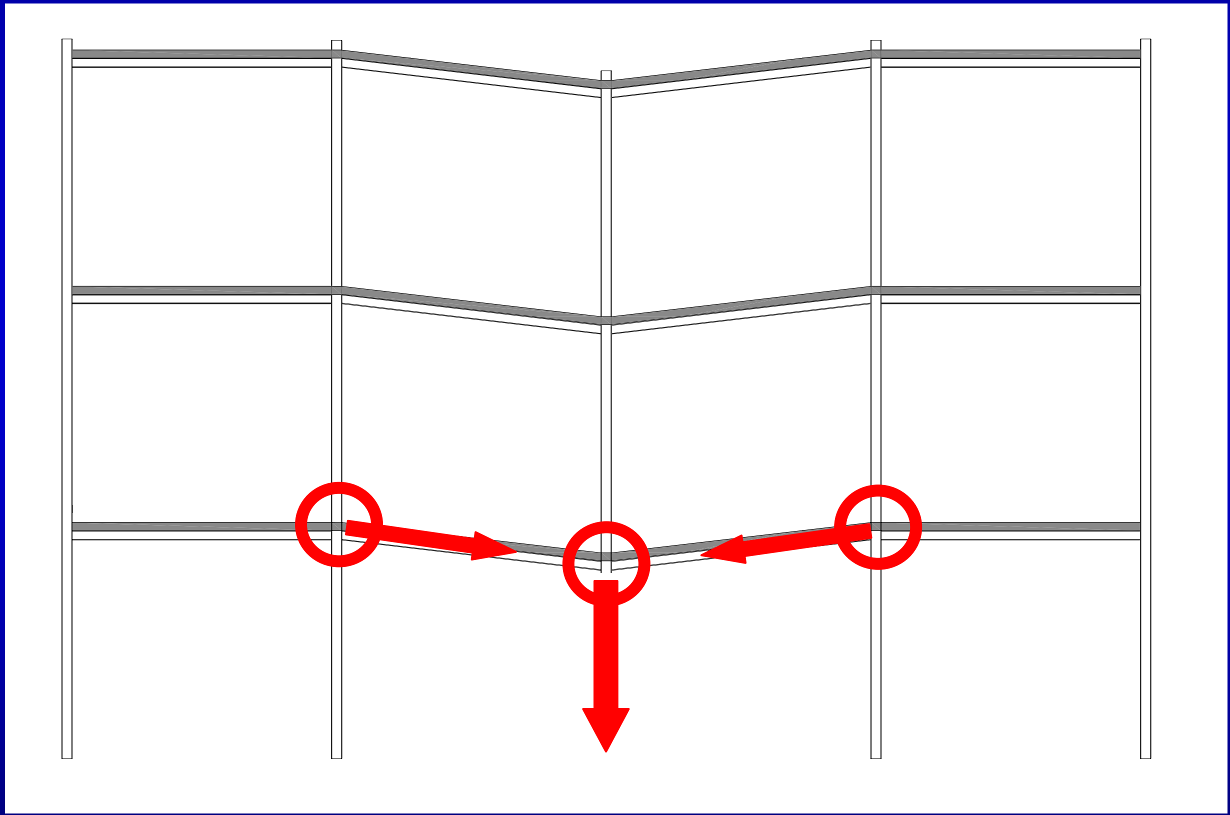
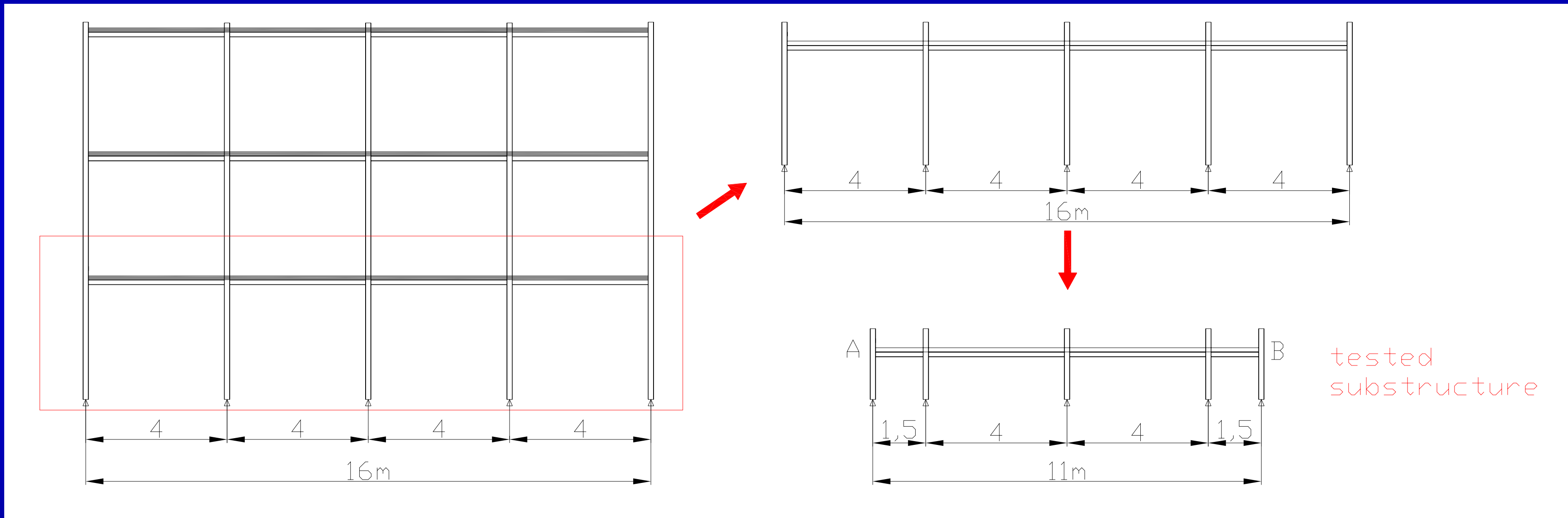
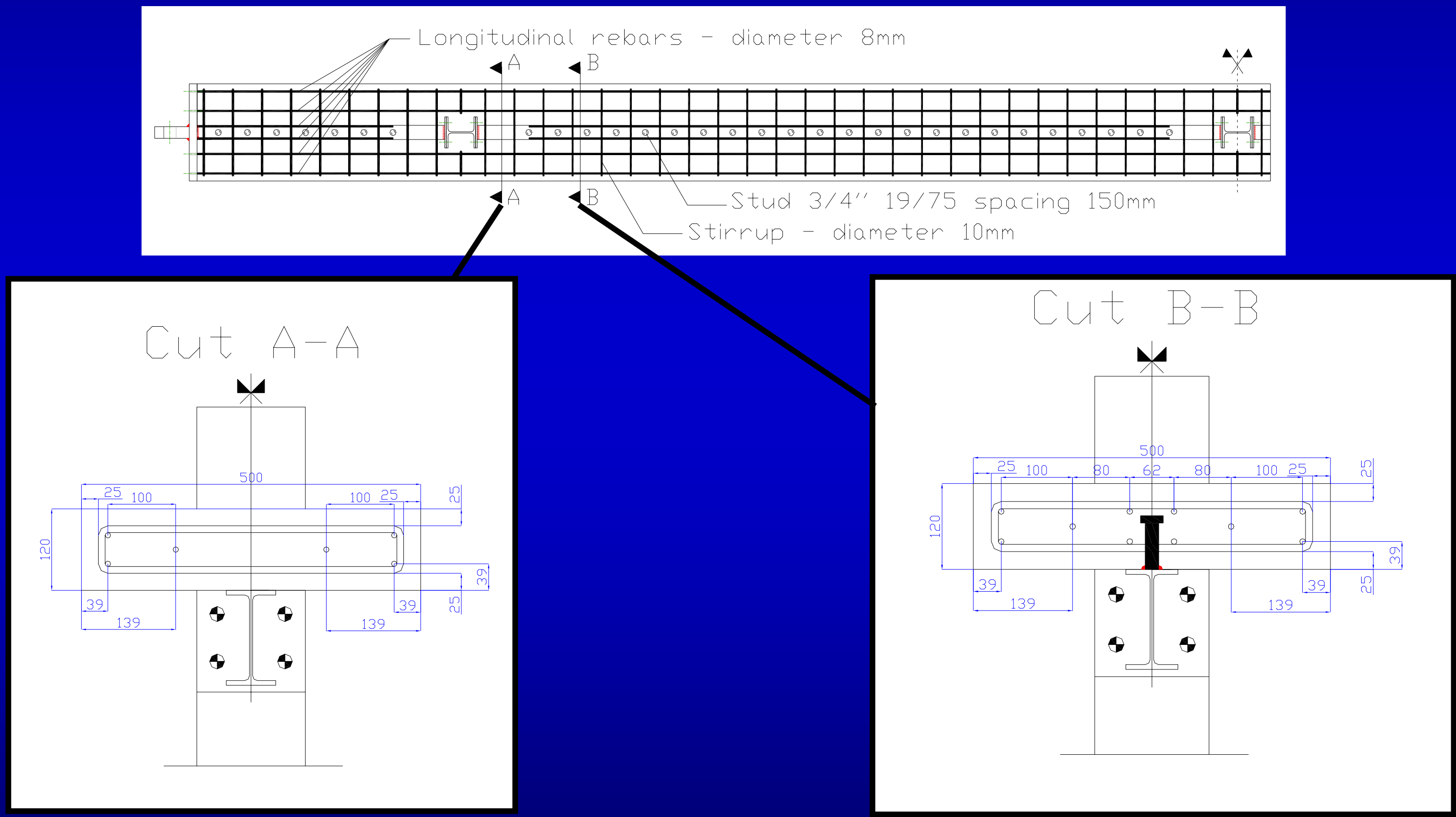


ISOLATION OF THE TESTED SUBSTRUCTURE



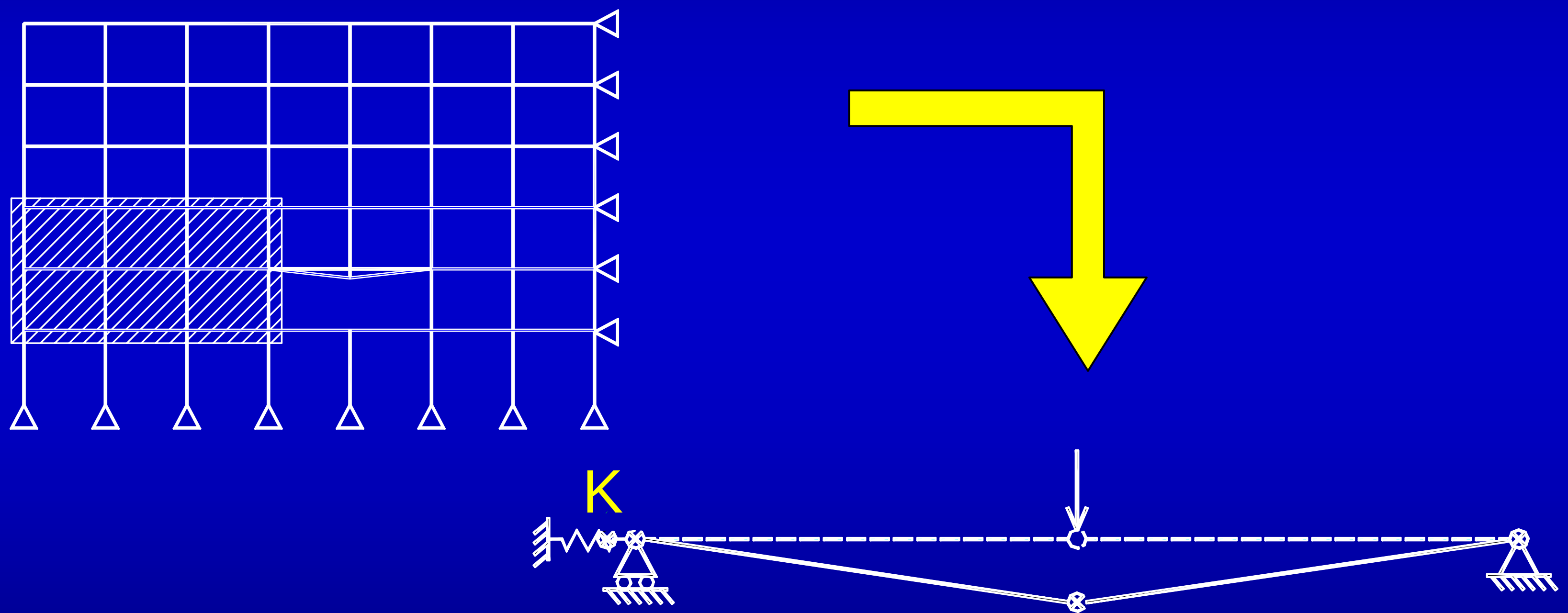
TESTED SUBSTRUCTURE

- Reinforcement and beam-to-slab connection layouts



TESTED SUBSTRUCTURE

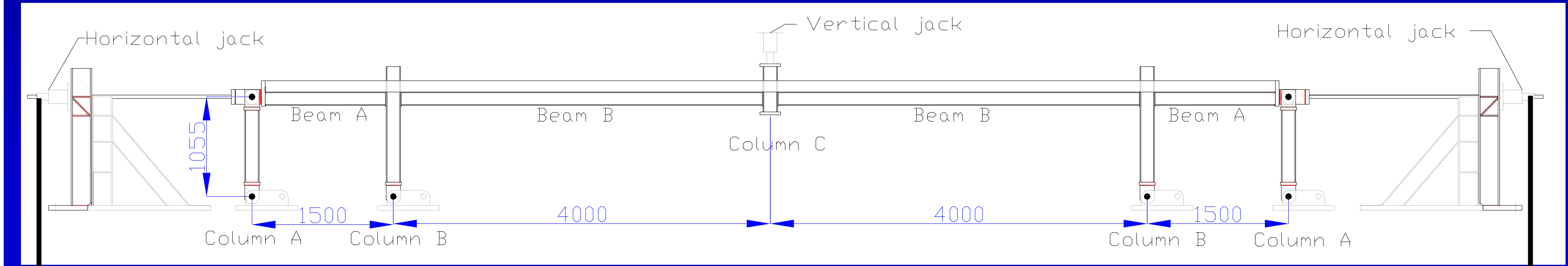
- Key parameter in the development of the catenary action

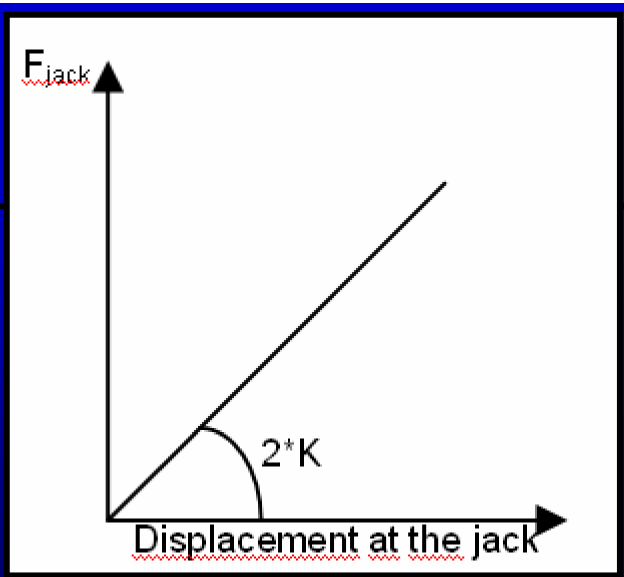


Structural restraint K ➔ catenary action

TESTED SUBSTRUCTURE

- Lateral restraint simulated by horizontal jacks





Calibration of the jacks

TESTED SUBSTRUCTURE

- Lateral restraint simulated by horizontal hydraulic jacks

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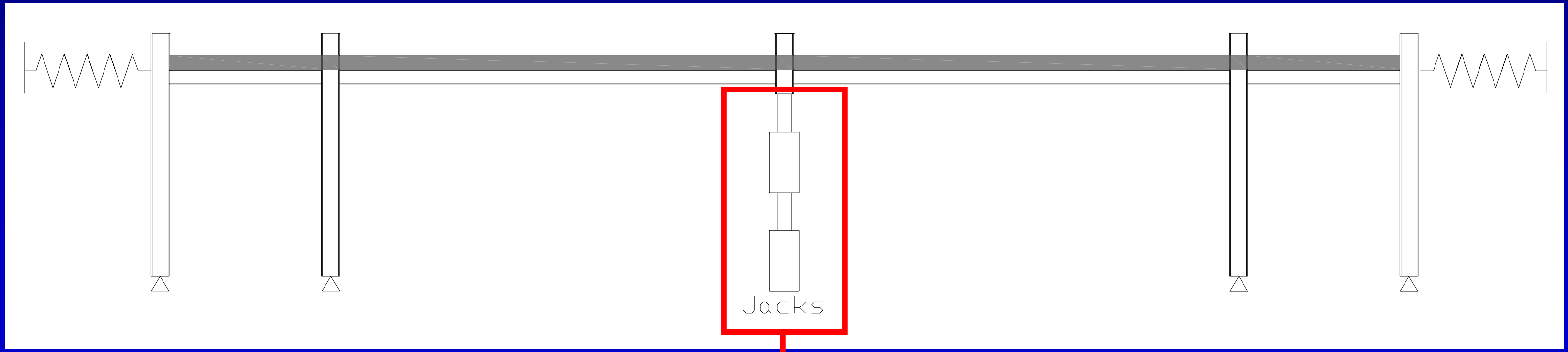
LOADING SEQUENCE



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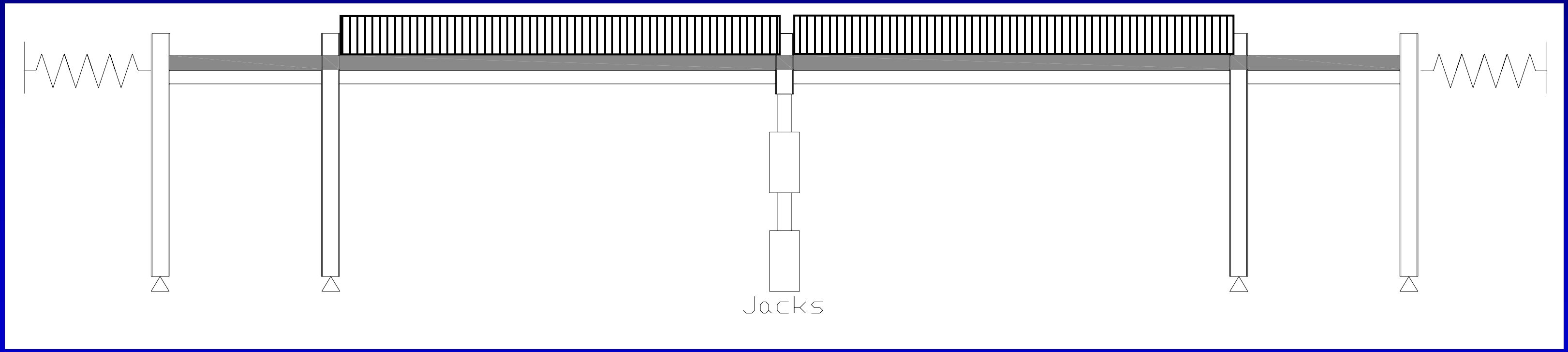

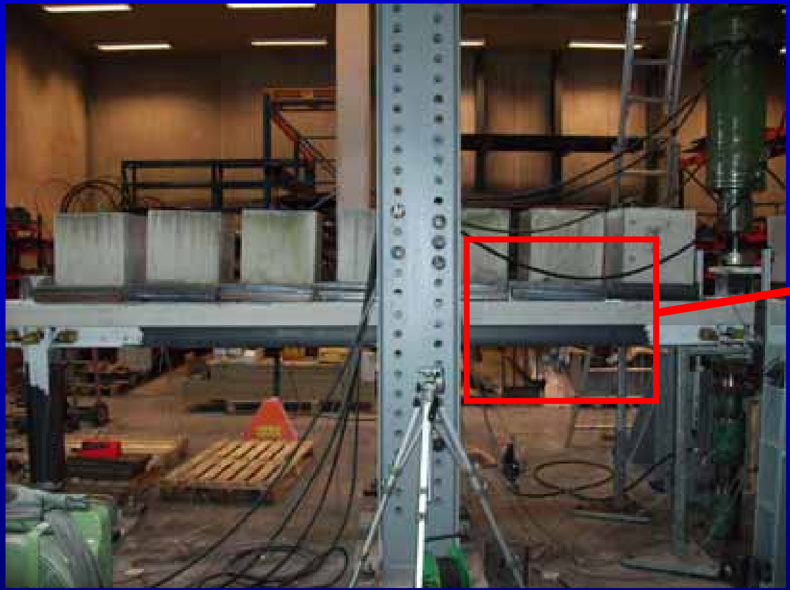

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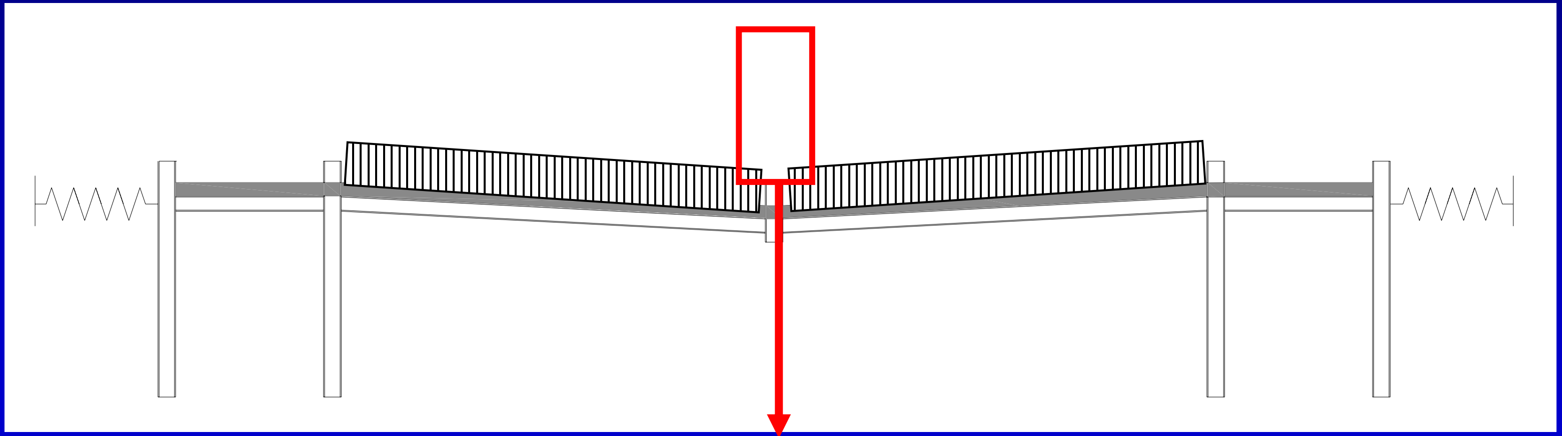
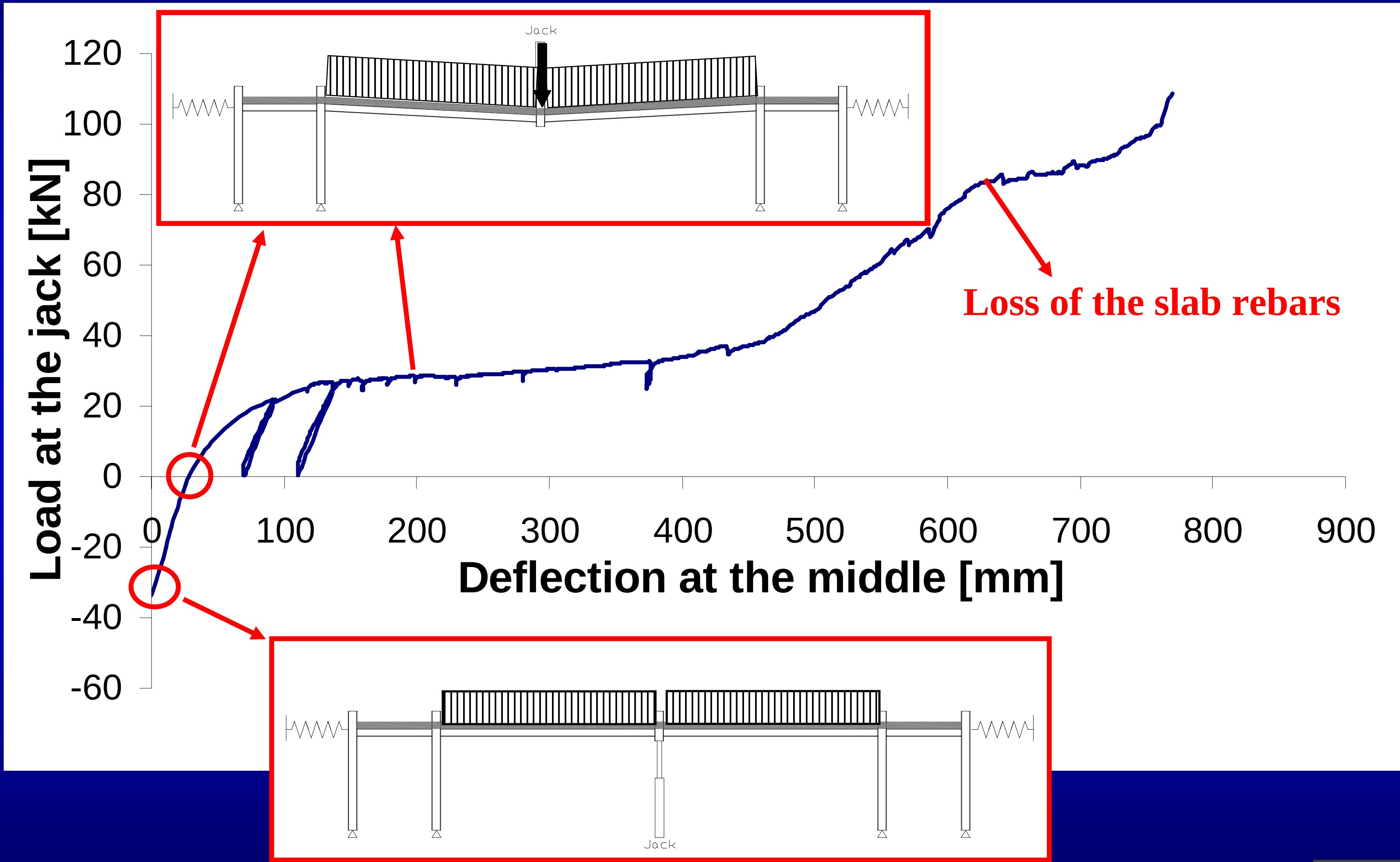
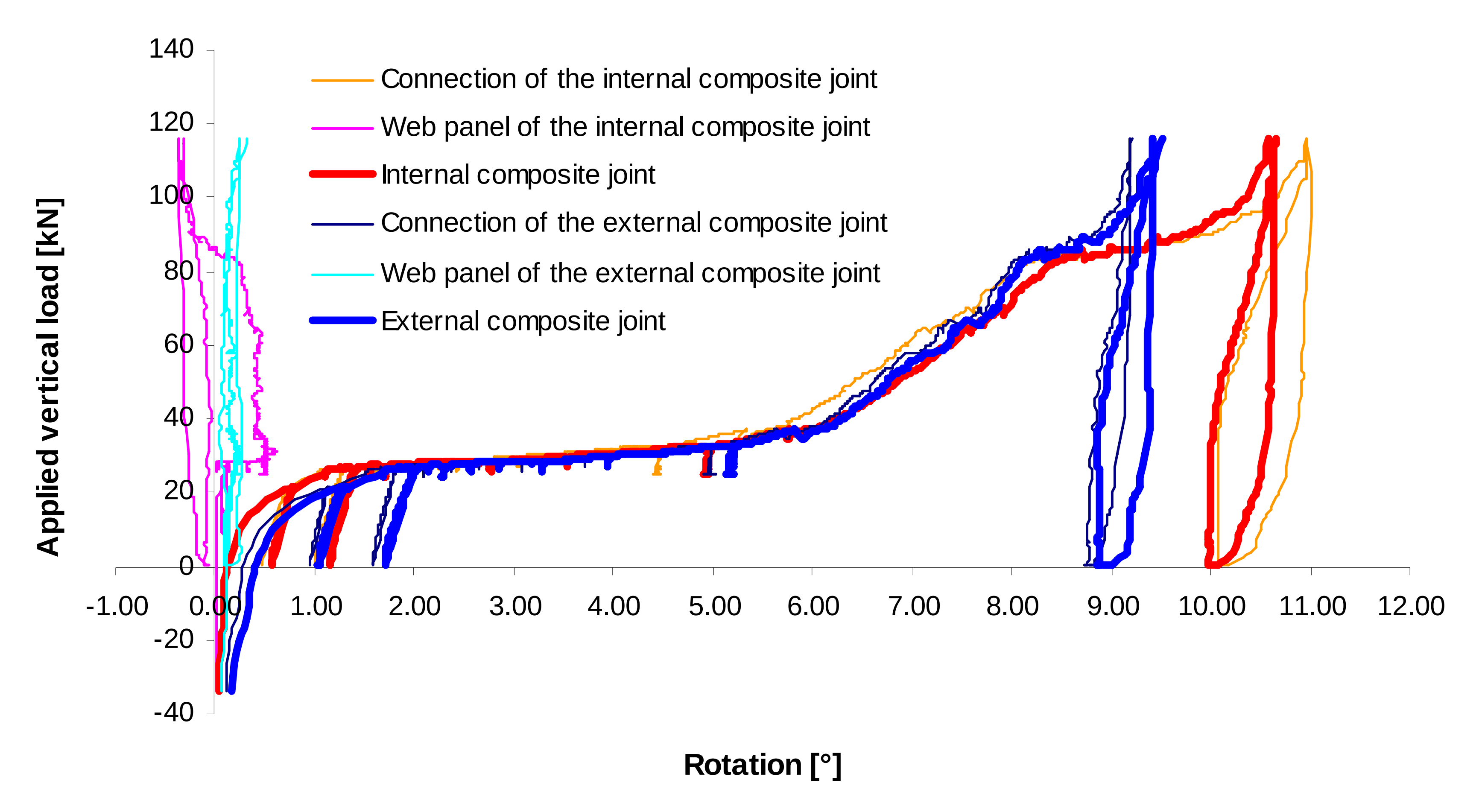


TESTED SPECIMEN

LOAD – DEFLECTION CURVE AT MID-SPAN



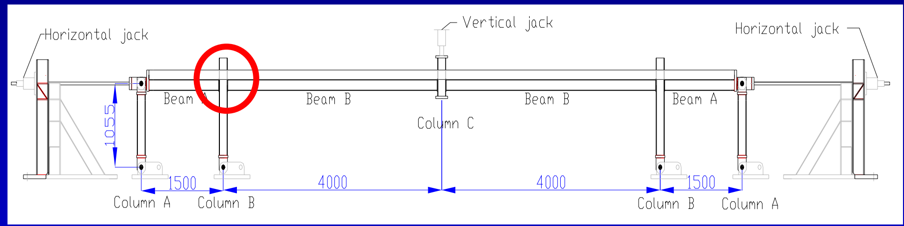
BEHAVIOUR OF THE JOINTS



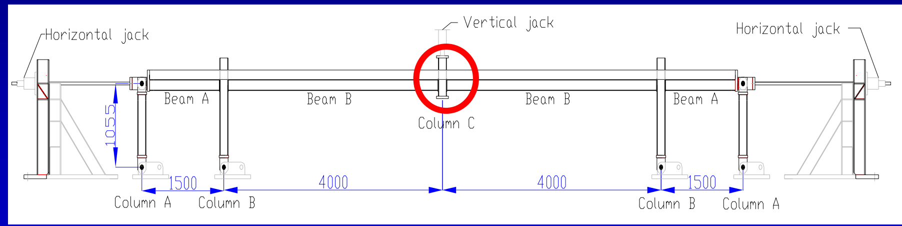
VERT. AND HOR. MAXIMUM DEFLECTION

- Maximum deflection at the middle: 77 cm for a vertical load of 100kN
- Maximum lateral displacement: 4,5cm for an horizontal load of 170kN

EXTERNAL COMPOSITE JOINT



INTERNAL COMPOSITE JOINT

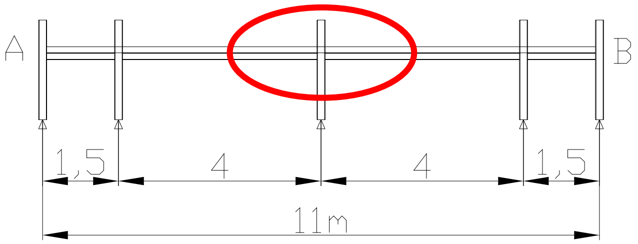


INTERNAL COMPOSITE JOINT

TEST COMPAIGN

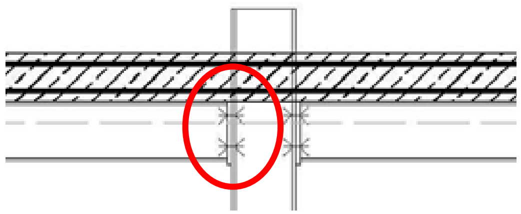
- Unique chain for the experimental tests

substructure test



Liège

joint tests



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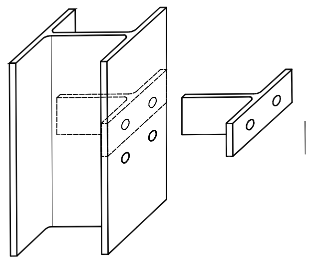
component tests



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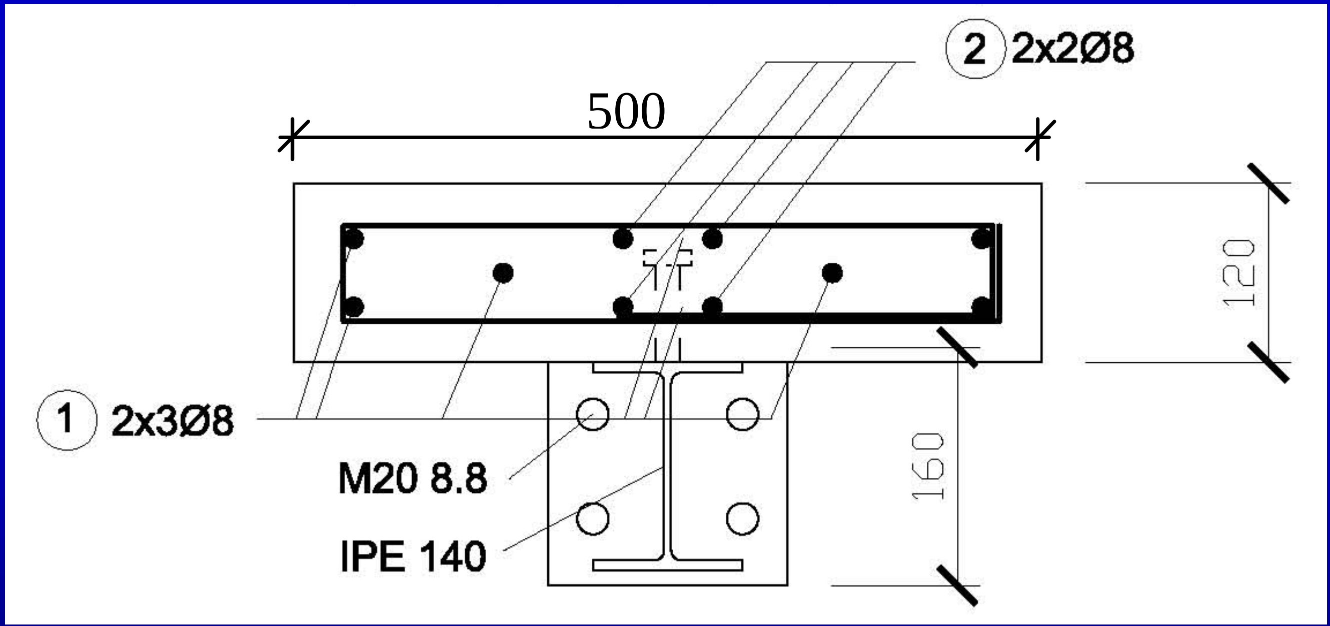
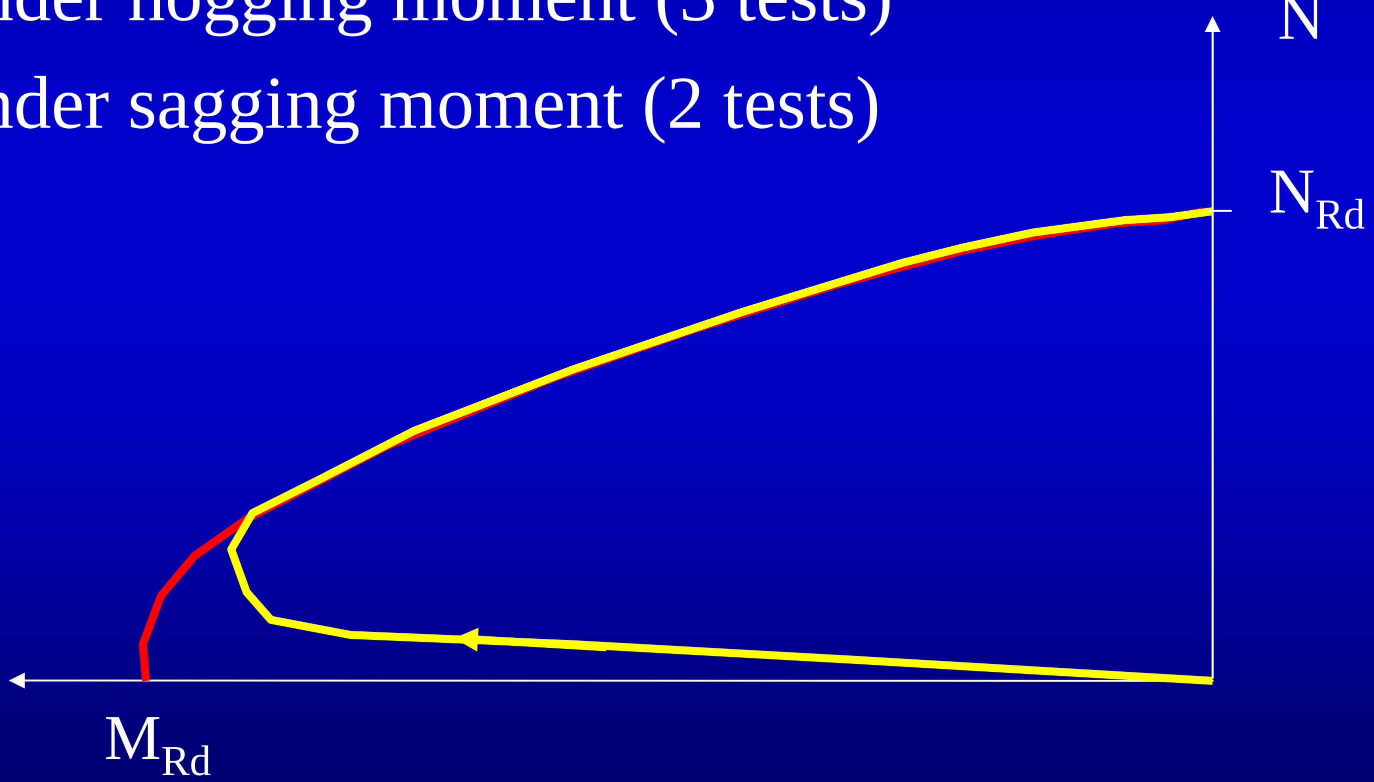
COMPOSITE JOINT CONFIGURATION

- Same configuration as the composite joints in the substructure



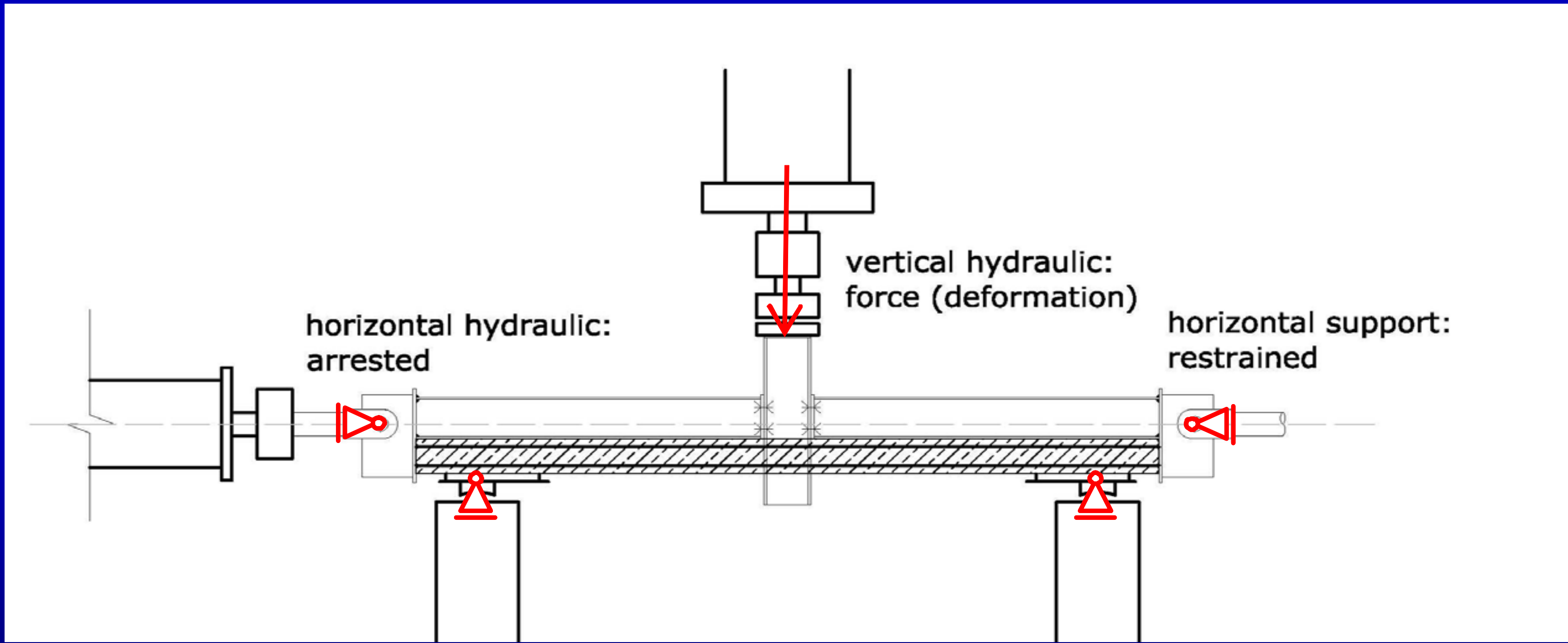
OBJECTIVE OF THE JOINT TESTS

- The objective is to follow the M-N resistant interaction curve of the composite joint
  - Under hogging moment (3 tests)
  - Under sagging moment (2 tests)



LOADING SEQUENCE

- First, a vertical load is applied and the horizontal jack is locked



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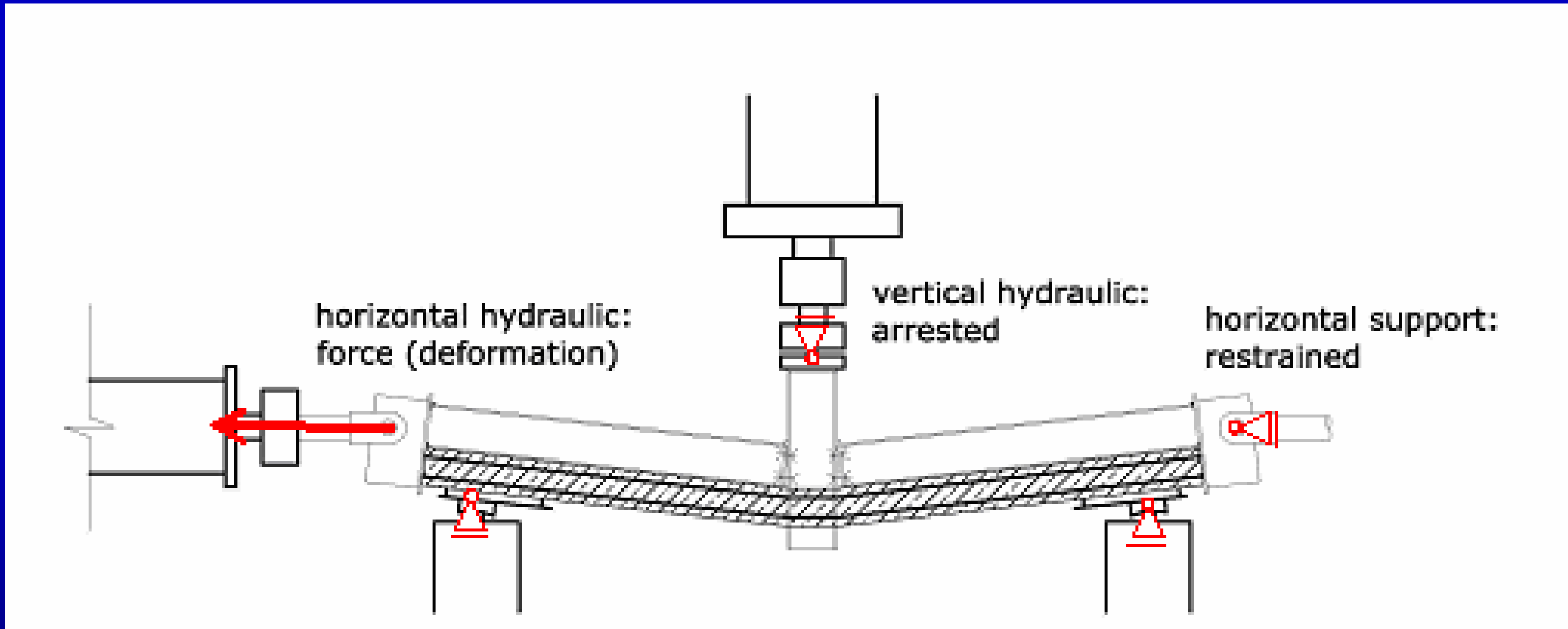
LOADING SEQUENCE

- Secondly, the vertical jack is locked and a horizontal tensile load is applied



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JOINT TEST RESULTS

- Under hogging moment

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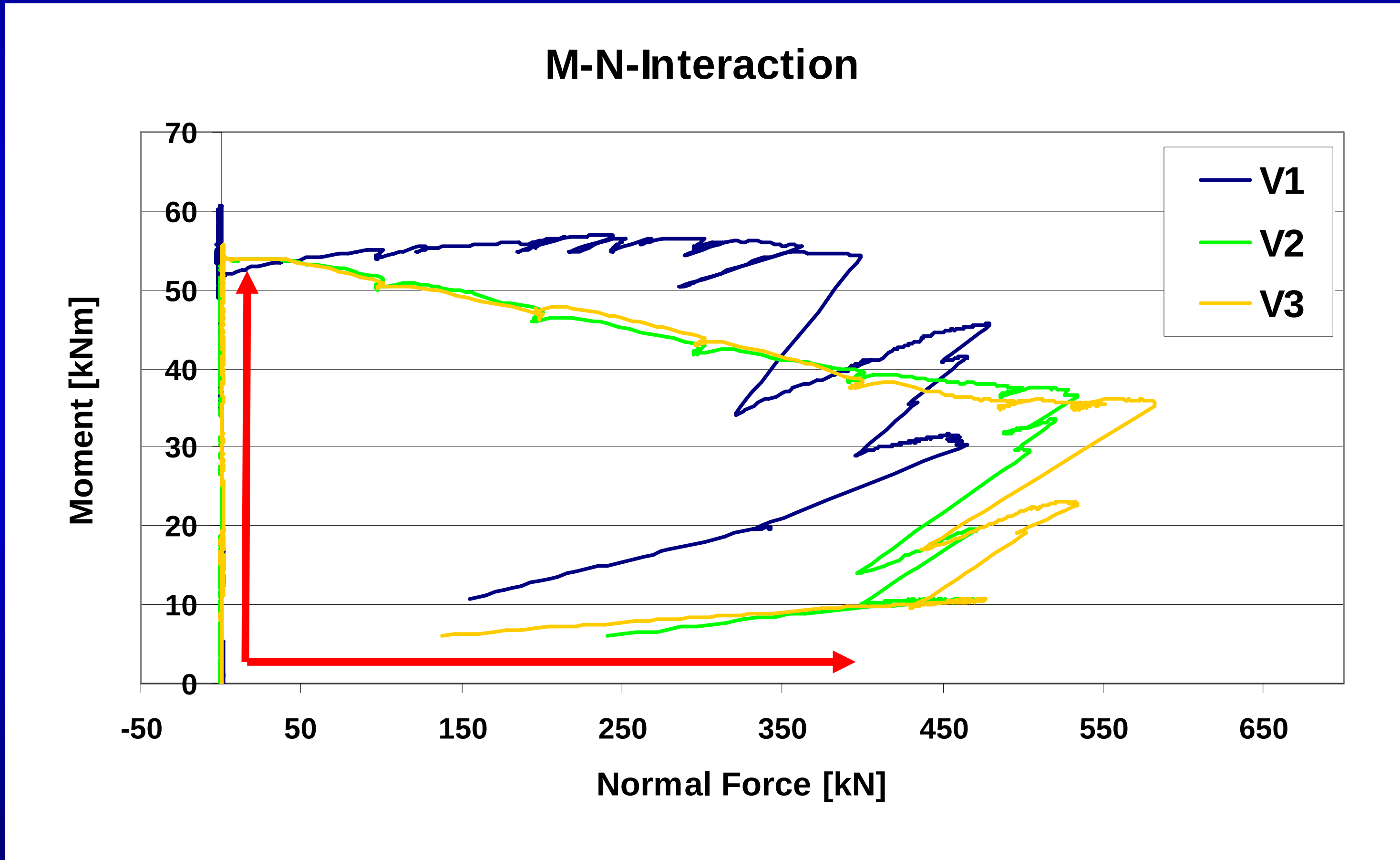
- Under hogging moment

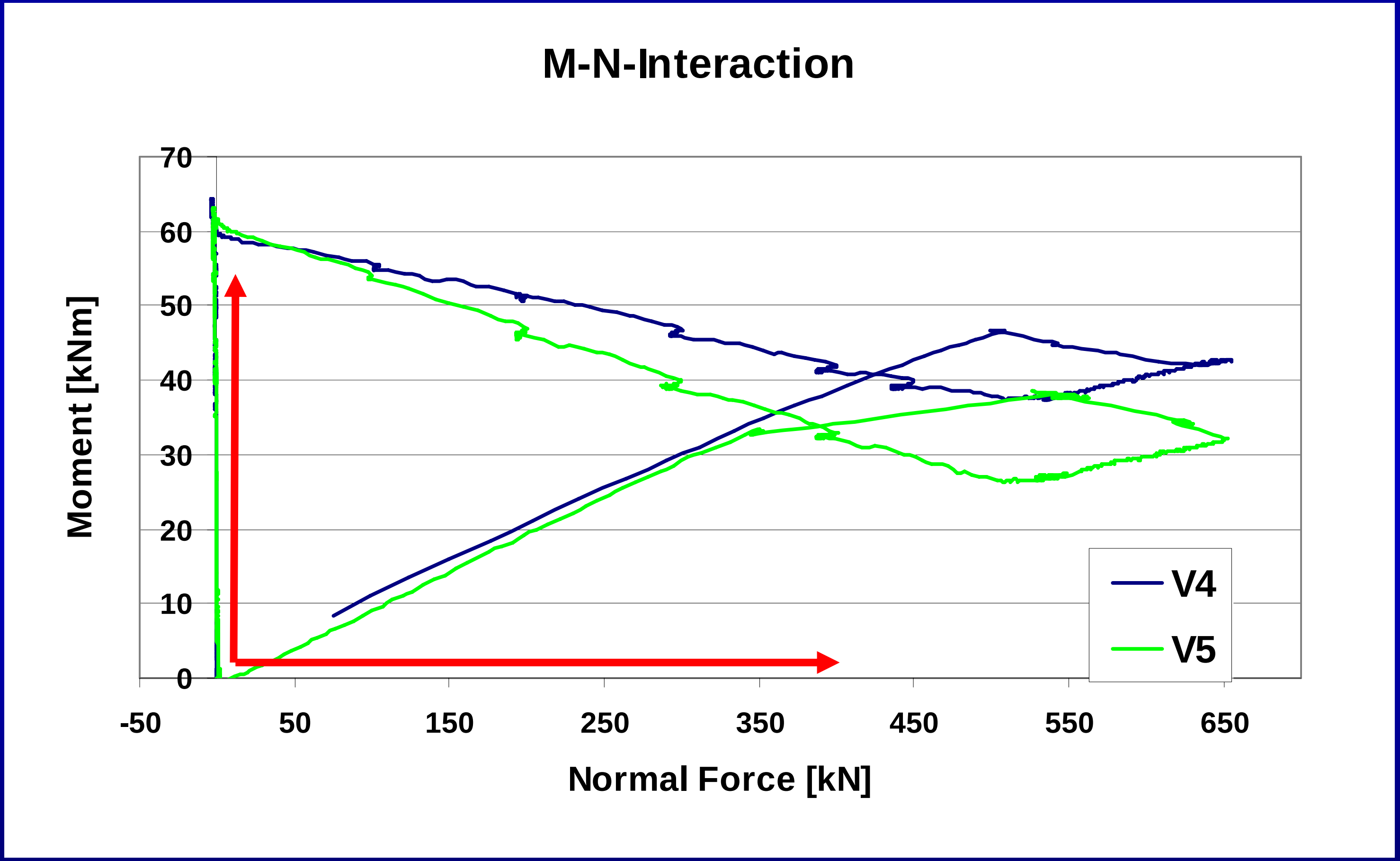


JOINT TEST RESULTS

- Under sagging moment

JOINT TEST RESULTS

- Under sagging moment



CONCLUSIONS

- The results obtained through the substructure test and and the joint tests are comparable (the same collapse modes were observed)
- The performed tests showed the ability of the joints to undergo large rotations (190 mRad in the substructure test)
- At the end of the test, the joints are no more composite ones but steel ones (due to the collapse of the components coming from the concrete slab) which allowed further increase of the rotation

- With the obtained results, the validation of the numerical tools is under progress

Thank you for your attention…

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