Prefabricated Concrete Walls with Recycled Concrete Elements

PREUSE – PREcast reUSEd concrete
Full-scale test of shear wall element

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DTU Structural Lab

The Person Speaking

- **Jesper Harrild Sørensen**
  Researcher in Experimental Mechanics
  and Concrete Structures
- Head of **DTU Structural Lab**

- Background in Civil Engineering, Structural behavior of Reinforced Concrete Structures
  and Concrete Plasticity (Limit Analysis)

- Primarily research on:
  - Precast shear walls
  - Size effect in 3D concrete structures (Pile Caps)
  - 3D printed fiber reinforced concrete
  - Geopolymer Concrete
  - And a few other projects:

DTU Structural Lab

1990's

A bit of history:

Main lab facilities was built in the 1960s during the establishment of Technical University of Denmark, Lyngby premises.

Structural Lab aims at mechanical testing at full-scale, sub-structural or component testing.

Since 2000 a collaboration between the departments of **Mechanical** Engineering and **Civil** Engineering.

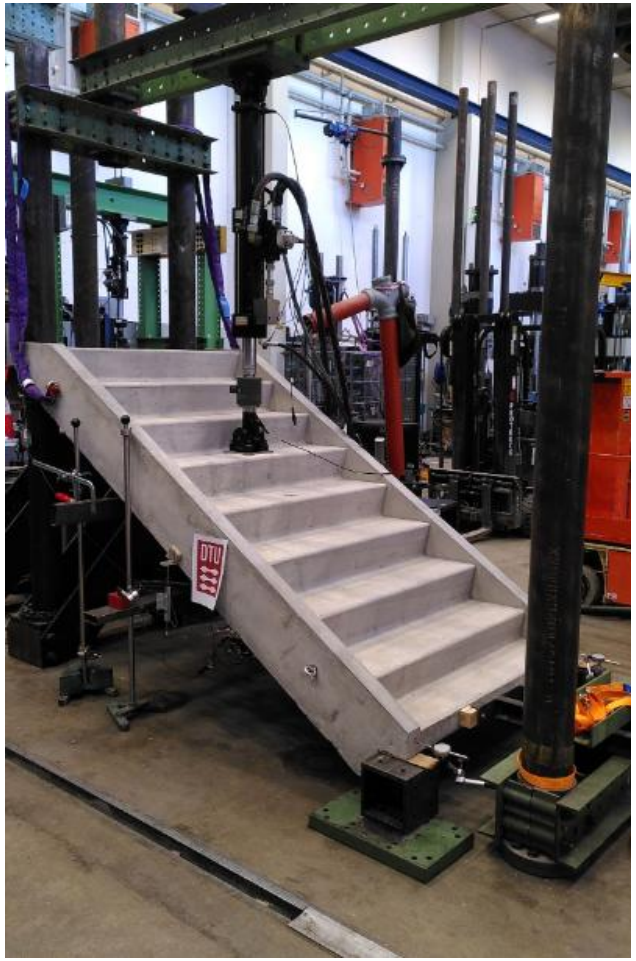
2015 – **CASMaT** established, and facilities dramatically expanded (equipment, strong wall etc.)

2022 – Departments merged,
now **DTU Construct**

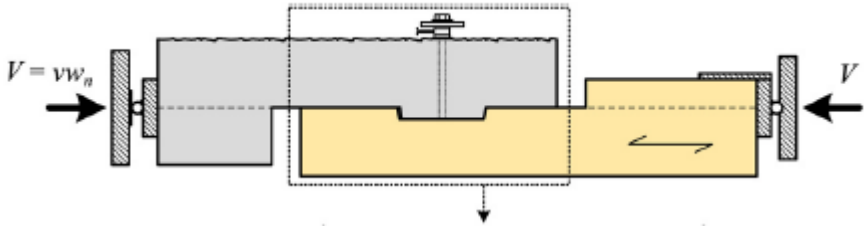
Present


Sven
JCB
JCB
BGS

Design Optimized Prefabricated Concrete Staircase



Timber-Concrete Composite Deck structures



Research significance:

- Prefabricated solutions
- Low concrete strengths
- Improved ductility
- Enable reuse at End-of-Life

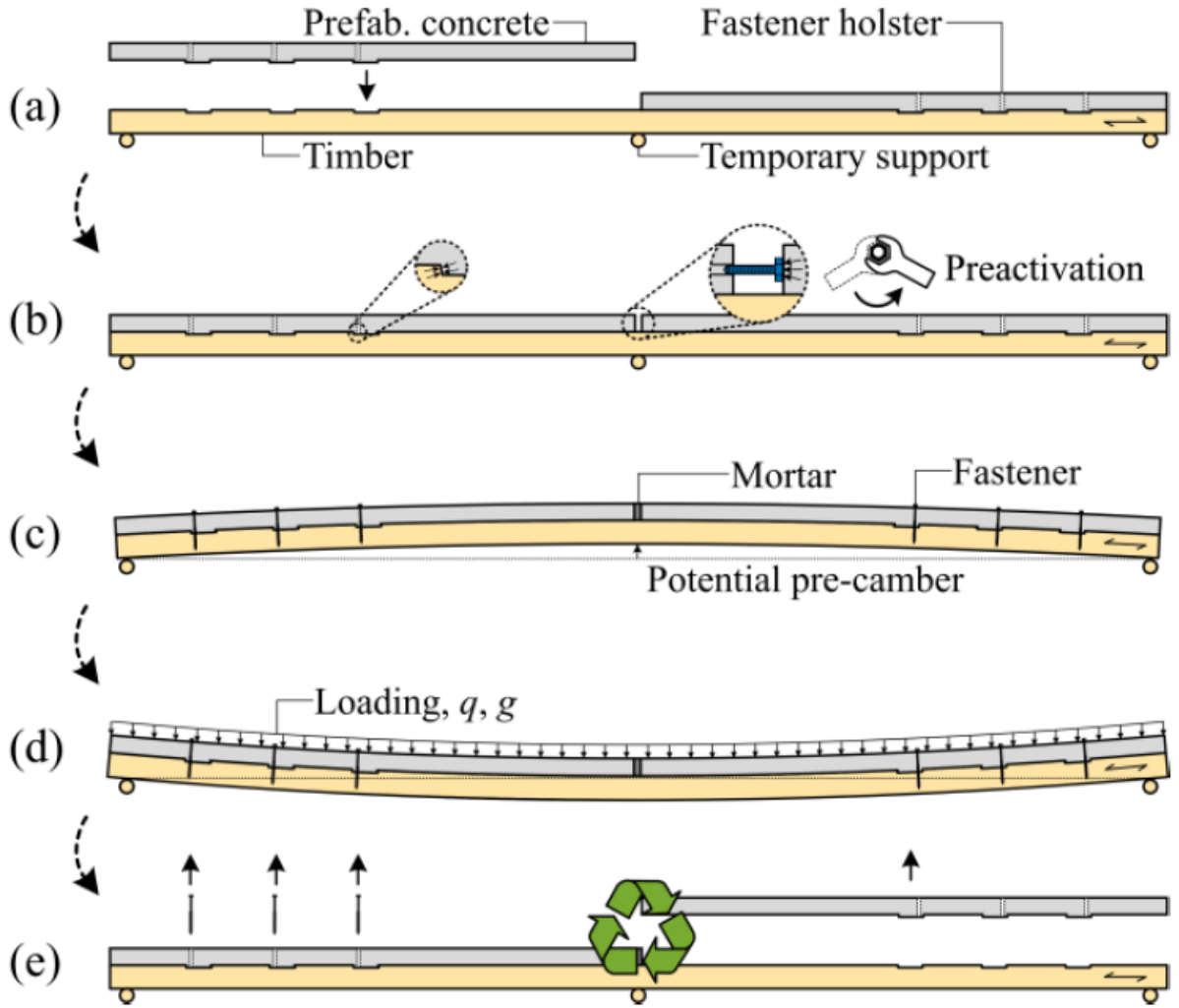
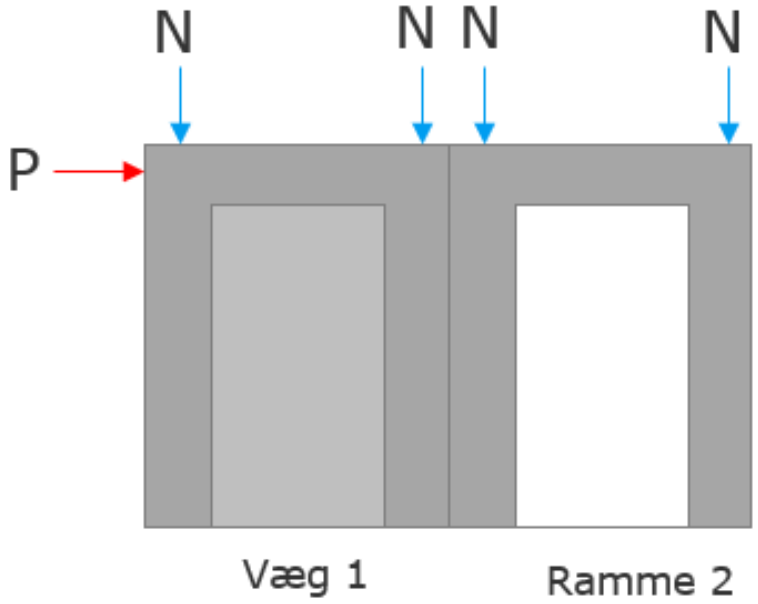


Figure 1 – Principle of construction of deck element.

Precast wall elements with flexible zones

Industrial PhD project by Sara Vestergaard with Rambøll



Precast wall elements with flexible zones

Flexible Zones:

- Low strength concrete
- Low amount of reinforcement
- Ductility ensured by conventionally reinforced frame

Challenges:

- Sound insulation – after cracking?
- Structural capacity? Frame or disk?

Reuse of existing concrete?

- Available
- Low environmental footprint

PREUSE

What is PREUSE?

What is PREUSE?

A ‘Sandbox’ collaboration that gathers relevant partners to try innovative things out – Is there a way forward?

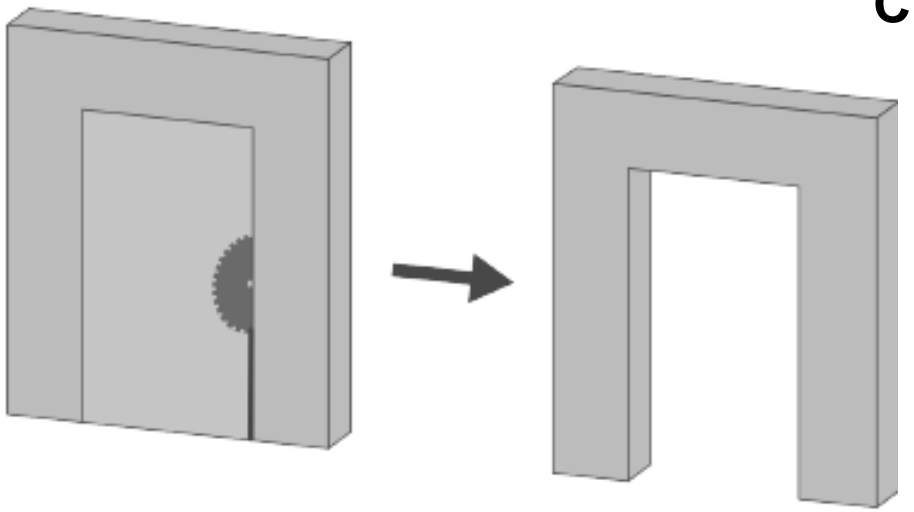
Why are we doing this particular project?

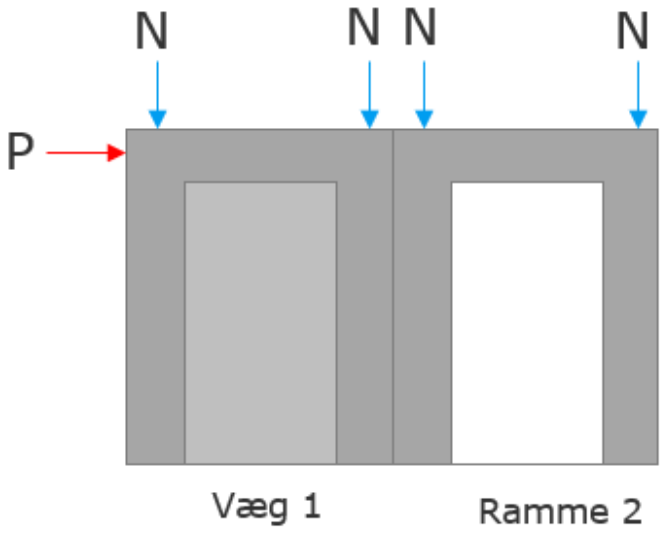
- There is a huge potential to reuse existing precast concrete structures in new applications
- This project demonstrates a one-to-one reuse of existing concrete – a high level in the Waste Hierarchy

Central questions:

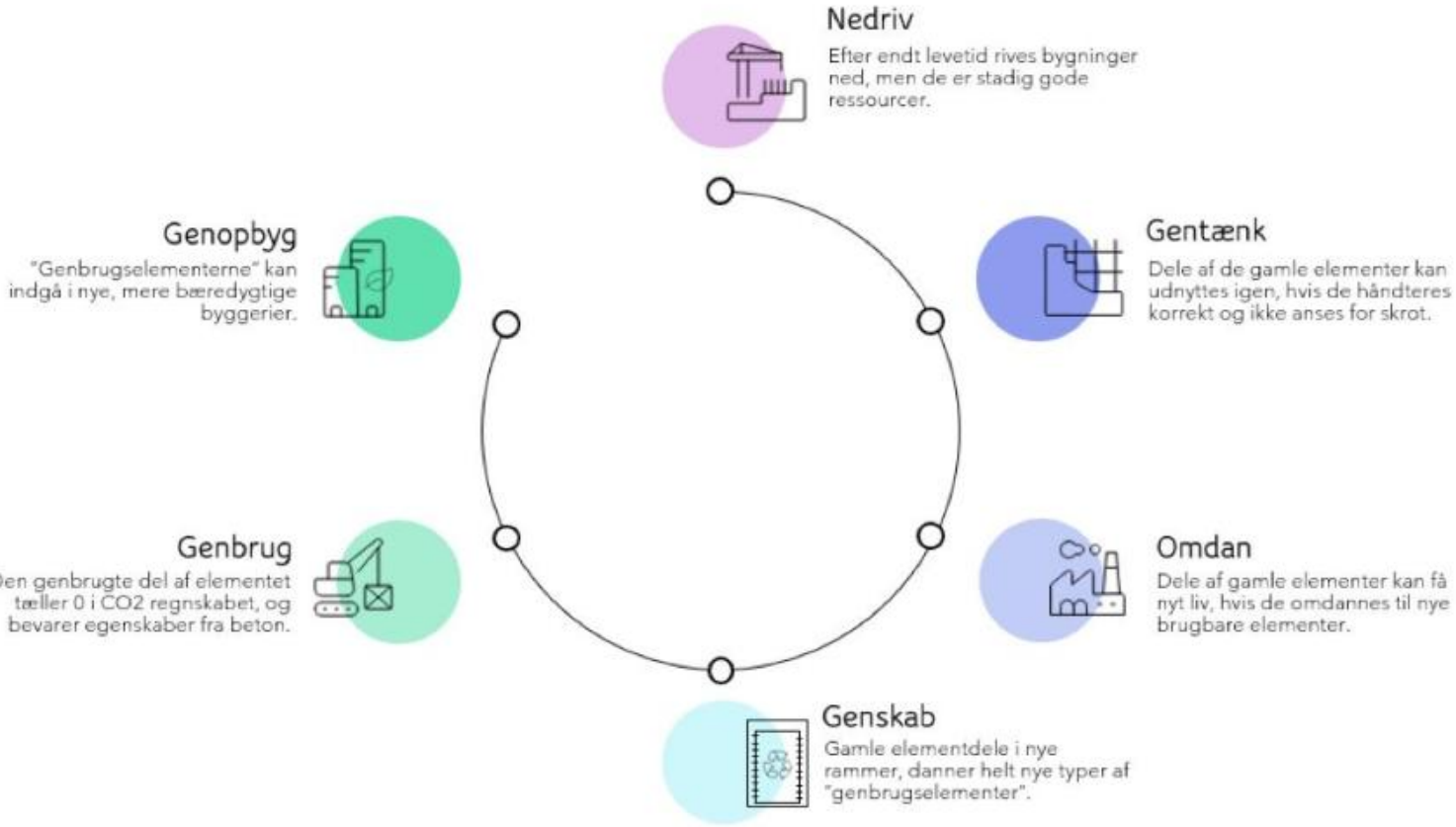
- Can it be produced?
- How is the structural behaviour?
- Do we maintain the benefits of the concrete with a much smaller CO_2 footprint?

Phase 0:
Design concept





Circular and adaptive design



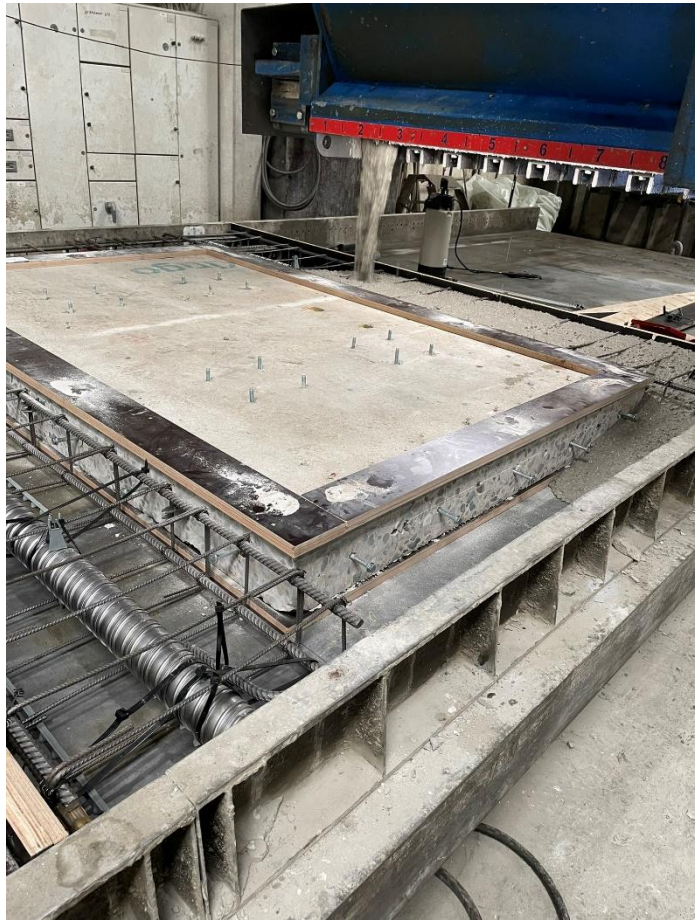
Phase 1:
Demolition/Preparation for new life

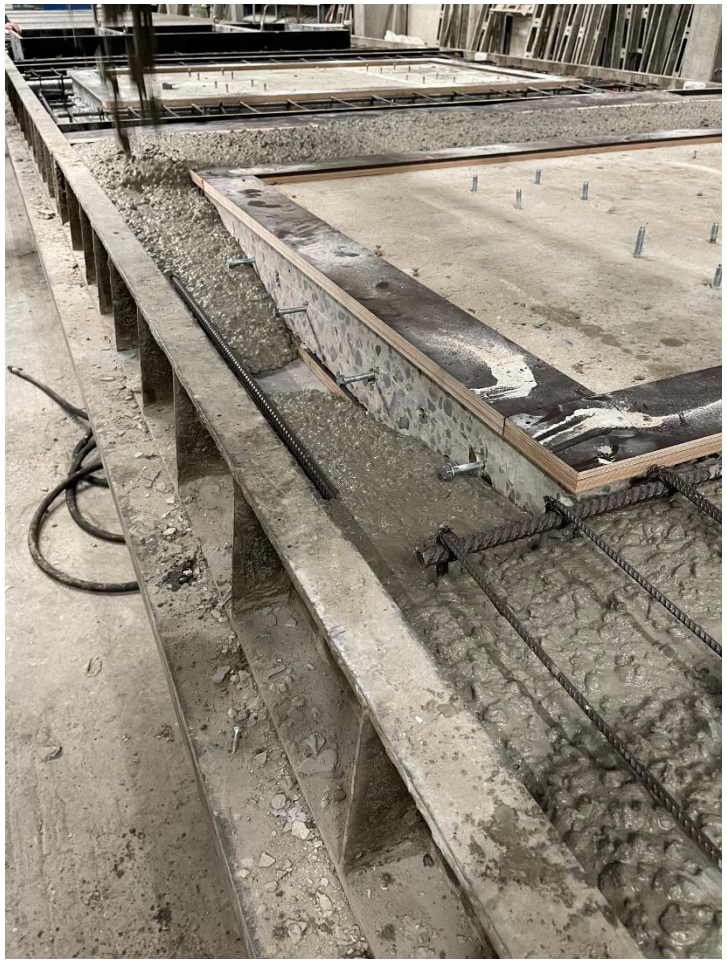
Recent progress in demolition

Søren Malund Thomsen
Forretningsudvikler, Kingo

- https://www.linkedin.com/posts/soerenmalundthomsen_shoppetur-efter-genbrugte-betonelementer-activity-7328637095076319232-LIvc?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAY0GbMB4DFuZQQ54CaxdjAzYecUBHCKbAA

Phase 2: Production





Phase 3: Structural test

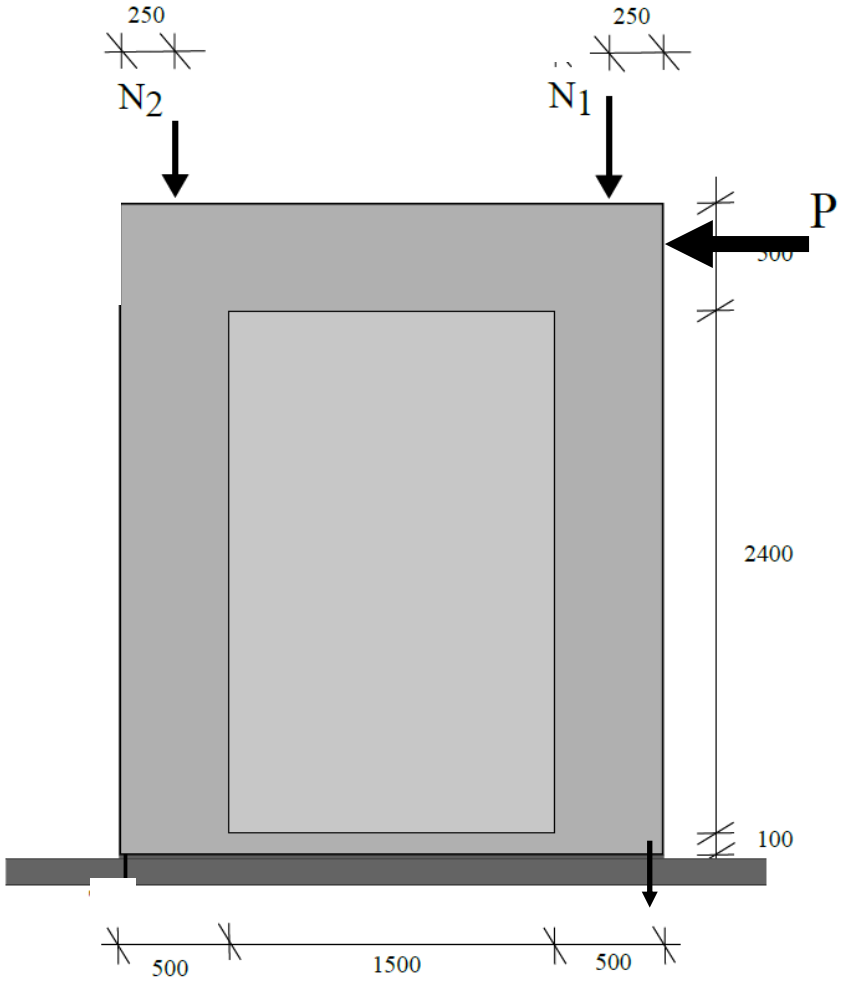
- ✓ Demolition phase
- ✓ Production phase

- ❑ Structural performance?
- ❑ Serviceability limit state?
  - ❑ Does the concrete crack at service load?
- ❑ Ultimate limit state?
  - ❑ What is the load carrying capacity compared to the Precast Frame alone?

Key point of interest:

- ❑ Does the interface between the two zones crack?
- ❑ What is the failure mode?
- ❑ What does a lack of reinforcement mean?

Loading conditions and Design



Concrete strengths:

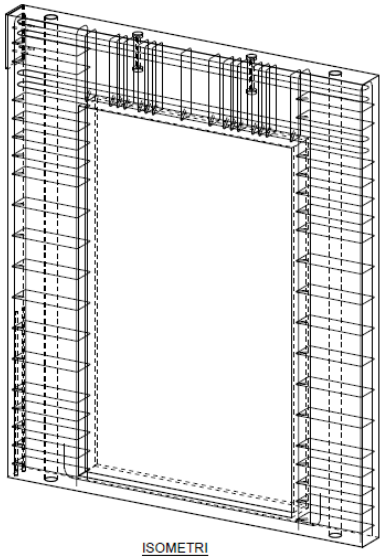
Precast frame 32 MPa

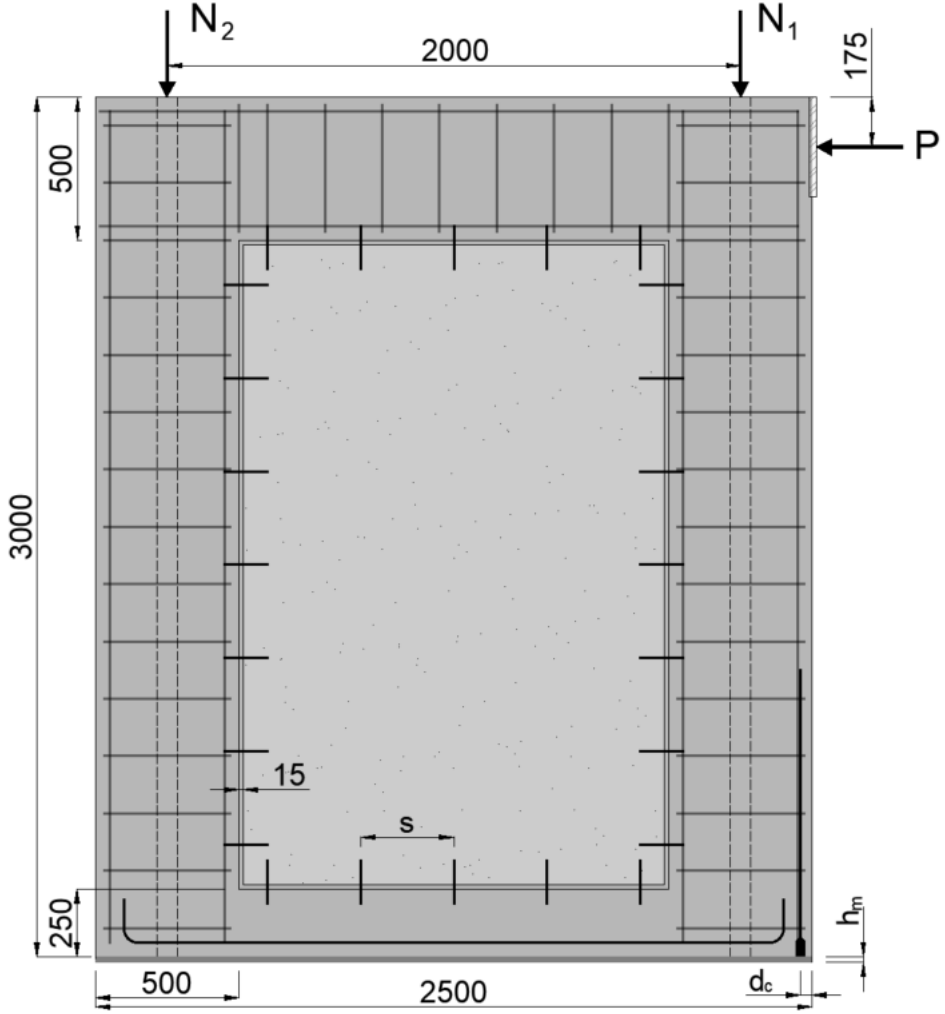
PREUSED concrete: ~30 MPa

Reinforcement:

Ø6 513 MPa

Ø16 544 MPa





Live streaming of Experimental test

DTU Structural Lab
890 followers
8mo • Edited •

Maybe you remember the concrete shear wall element with a reused piece of old concrete cast inside? Before the summer break, we promised to share more insight with you once we progressed: https://lnkd.in/eN6yrjQY ...more

PREUSE - Live broadcast of shear wall test with PREcast reUSED concrete

Linkedin Live

Load protocol

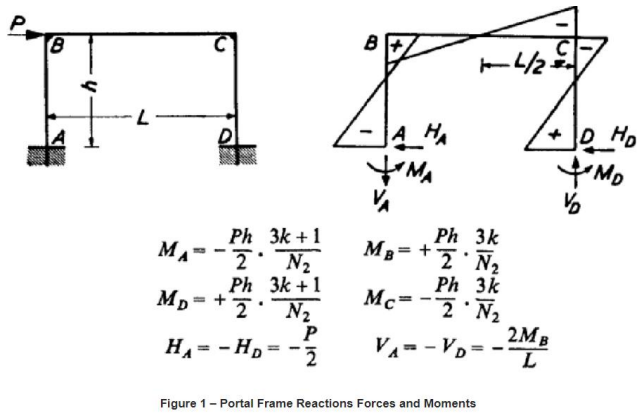


Figure 1 – Portal Frame Reactions Forces and Moments

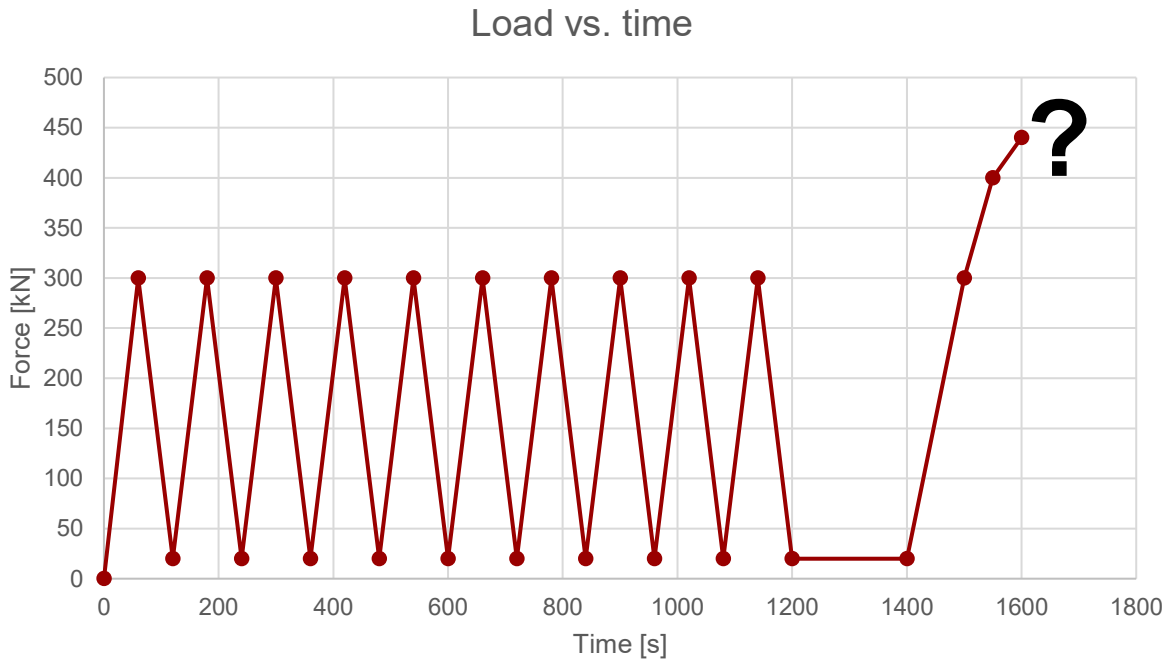
Frame without in-fill:

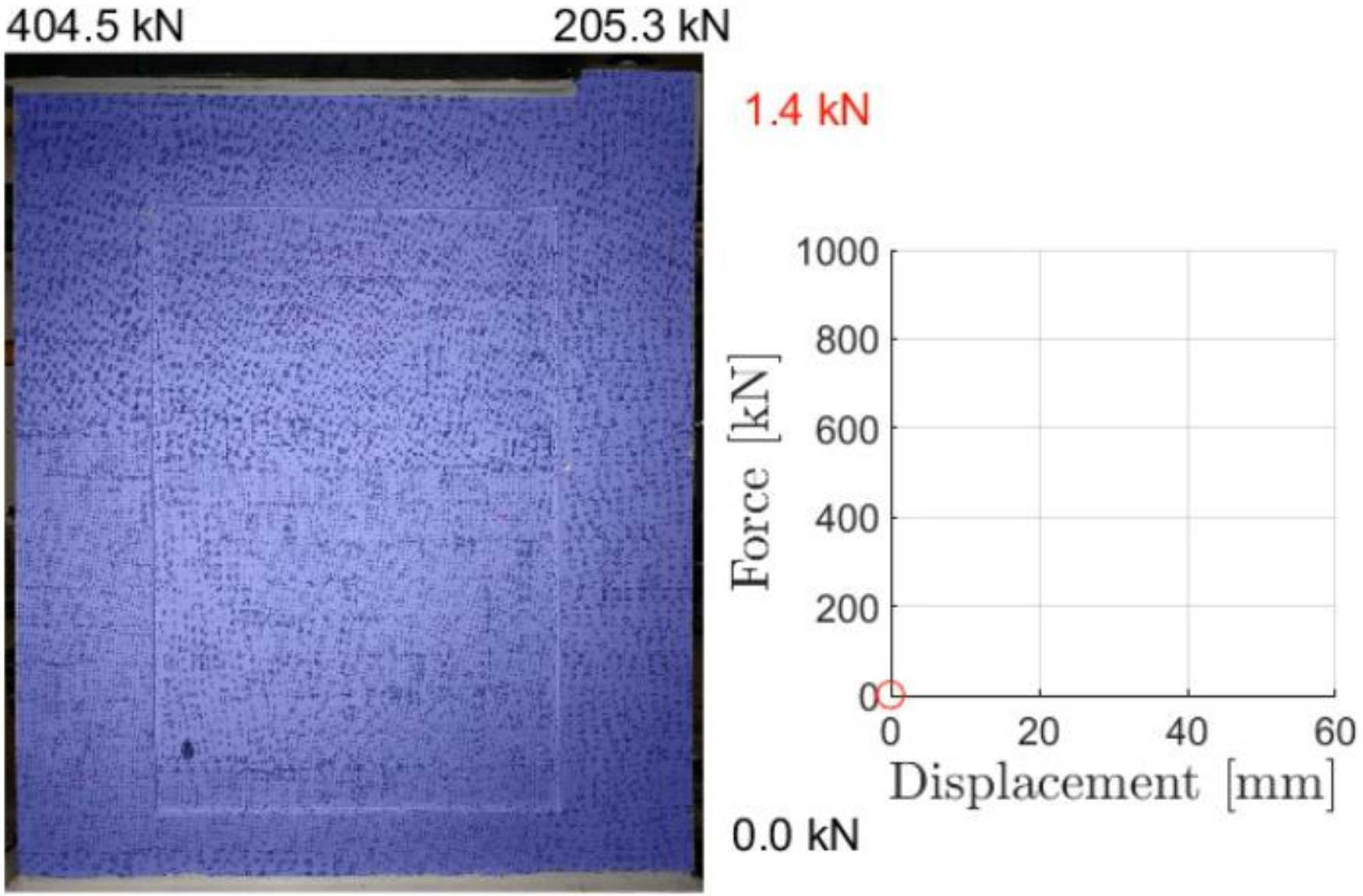
- Known capacity.
- Test cycles exceeded this capacity

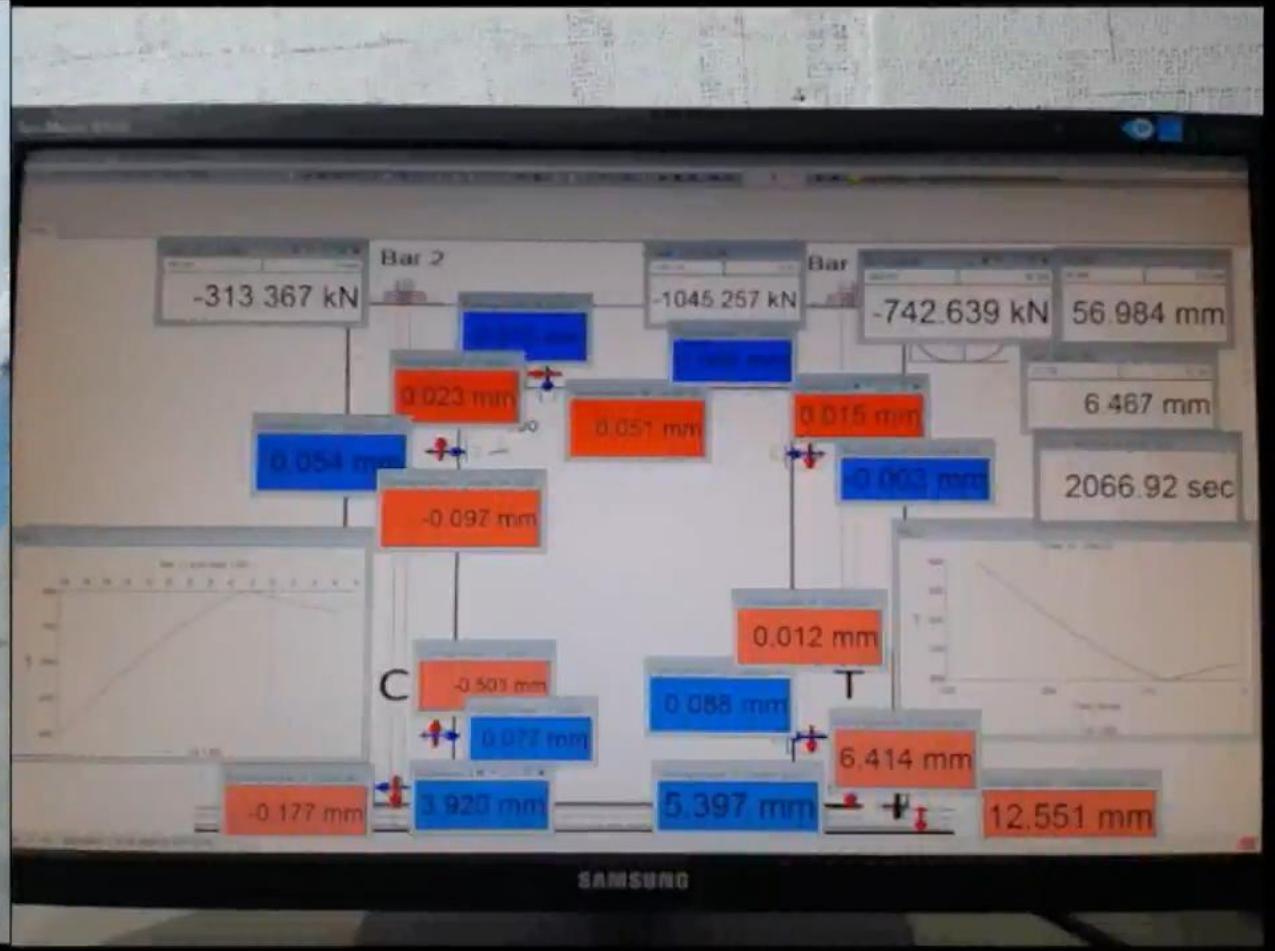
Loading Scheme:

- 10 cycles to 300 kN (Load control)
- Small break for visual inspection
- Displacement control to failure
- Visual inspection

- Synchronized logging of signals
- Automatic triggering of camera (DIC)
  - At local peaks and valleys
  - With specific time interval




404.5 kN
205.3 kN
1.4 kN
1000
800
600
400
200
0
Force [kN]
0
20
40
60
Displacement [mm]
0.0 kN


Bar 2
-313.367 kN
Bar
-1045.257 kN
-742.639 kN
56.984 mm
6.467 mm
2066.92 sec
0.023 mm
0.051 mm
0.015 mm
-0.097 mm
0.012 mm
C
T
0.088 mm
6.414 mm
-0.177 mm
3.920 mm
5.397 mm
12.551 mm
SAMSUNG

Conclusions

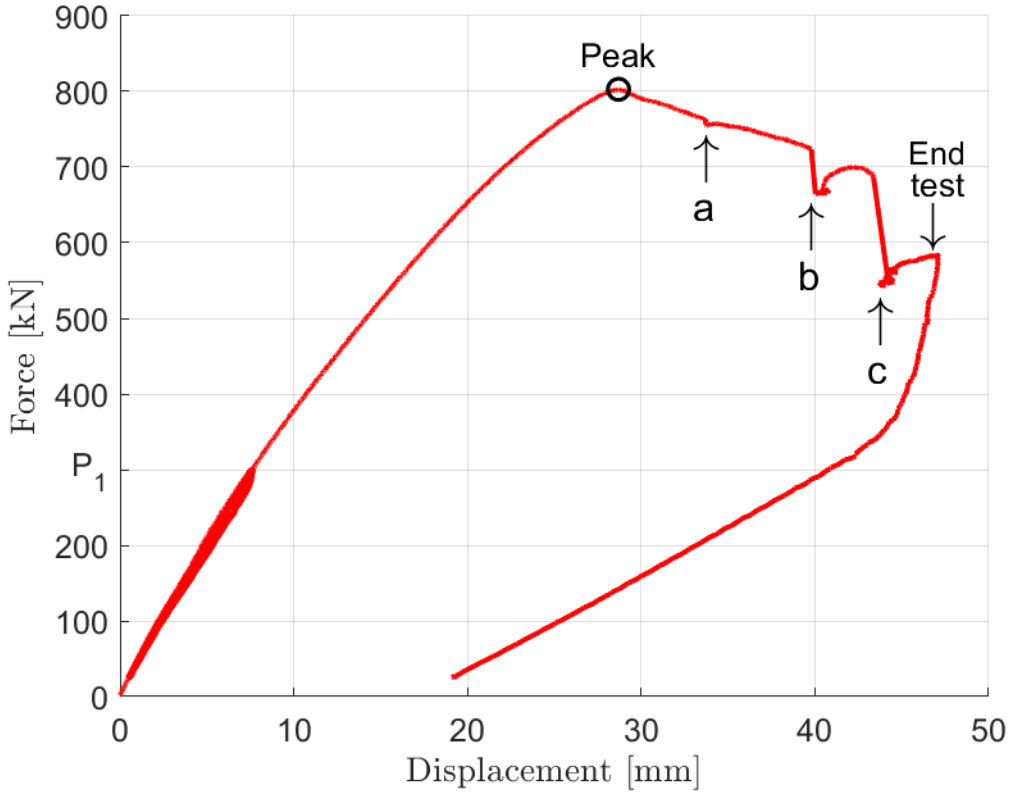
Concerns:

- ✓ Demolition phase
- ✓ Production phase

- ❑ Structural performance
  - ✓ No concrete cracks in Reused Element at service load
  - ✓ No interface failure between the two zones
  - ✓ Load carrying capacity much higher than frame itself

- ❑ Is the solution ready for implementation?
  - ✓ With conservative calculations of structural capacity

  - ➢ Using the unreinforced concrete as load carrying element?
  - ➢ Reversed loading?
  - ➢ What if interface cracks?



Peak: Ductile compression failure

a: Interface slip

b: Diagonal crack

c: Rupture of tie connection