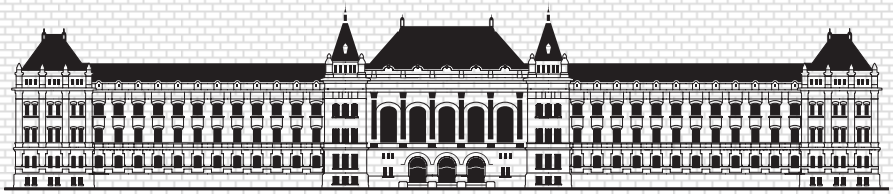

Shear capacity and crack pattern of reinforced and plain masonry walls

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Contents

1) Purpose of research
2) Goals and characteristics of the experiments carried out
3) Presentation of the results
4) Conclusion
5) Further plans

Aim of the test series

1. Analysis of reinforced masonry shear walls

What are the effects of reinforcement application in masonry walls due to shear?

Aims to analyze:

- Shear capacity
- Displacements
- Crack patterns
- Failure modes

Shear failure of reinforced masonry

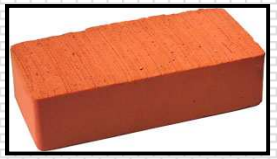
Up to the present

- Cored, concrete blocks

- Reinforcement bars in concrete infill of the cores
- The head joints do not serve as a place for vertical reinforcement
- EC6 does not contain the effect of the vertical reinforcement on the bearing capacity of walls

Proper experiments

- Solid, clay bricks

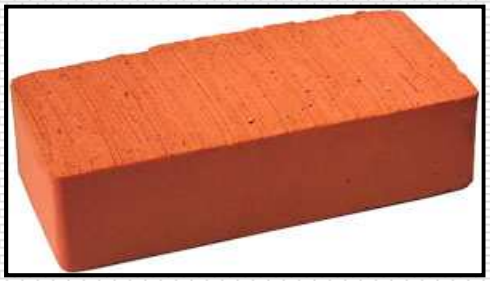


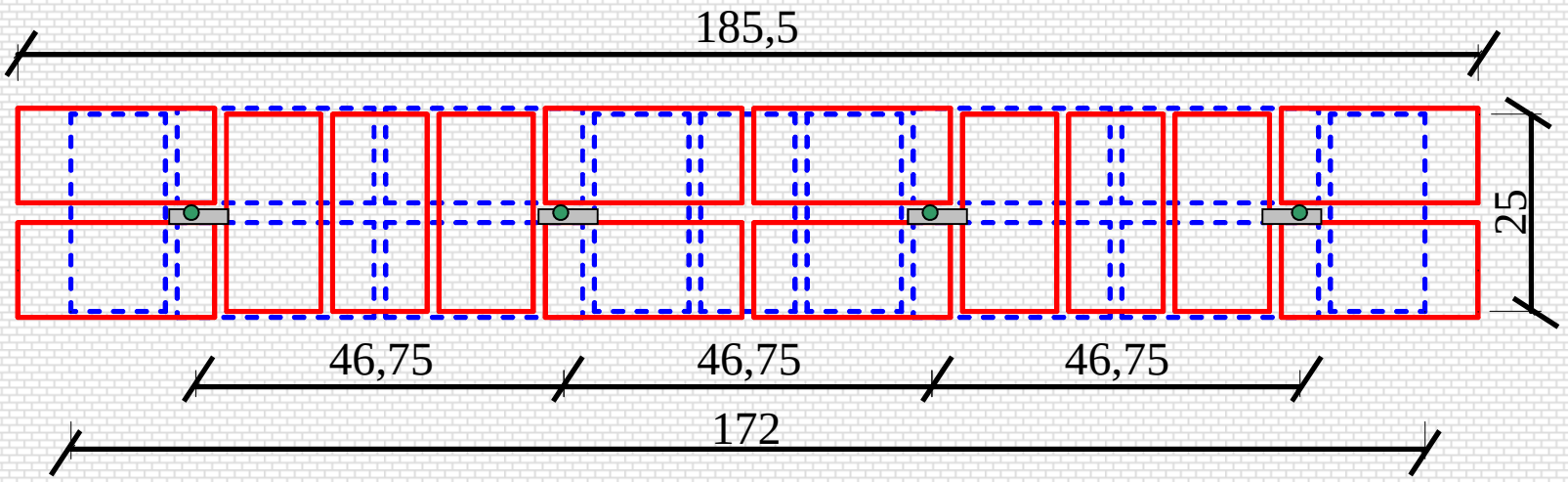
- Advantage: compressive strength is almost the same in each direction
- Reinforcement bars in mortar infill
- Small size of the vertical mortar joint
- The effect of vertical reinforcement can be analysed
- Vertical bars go through head joints that can be filled with mortar because of the size of the joints

Solid reinforced masonry wall

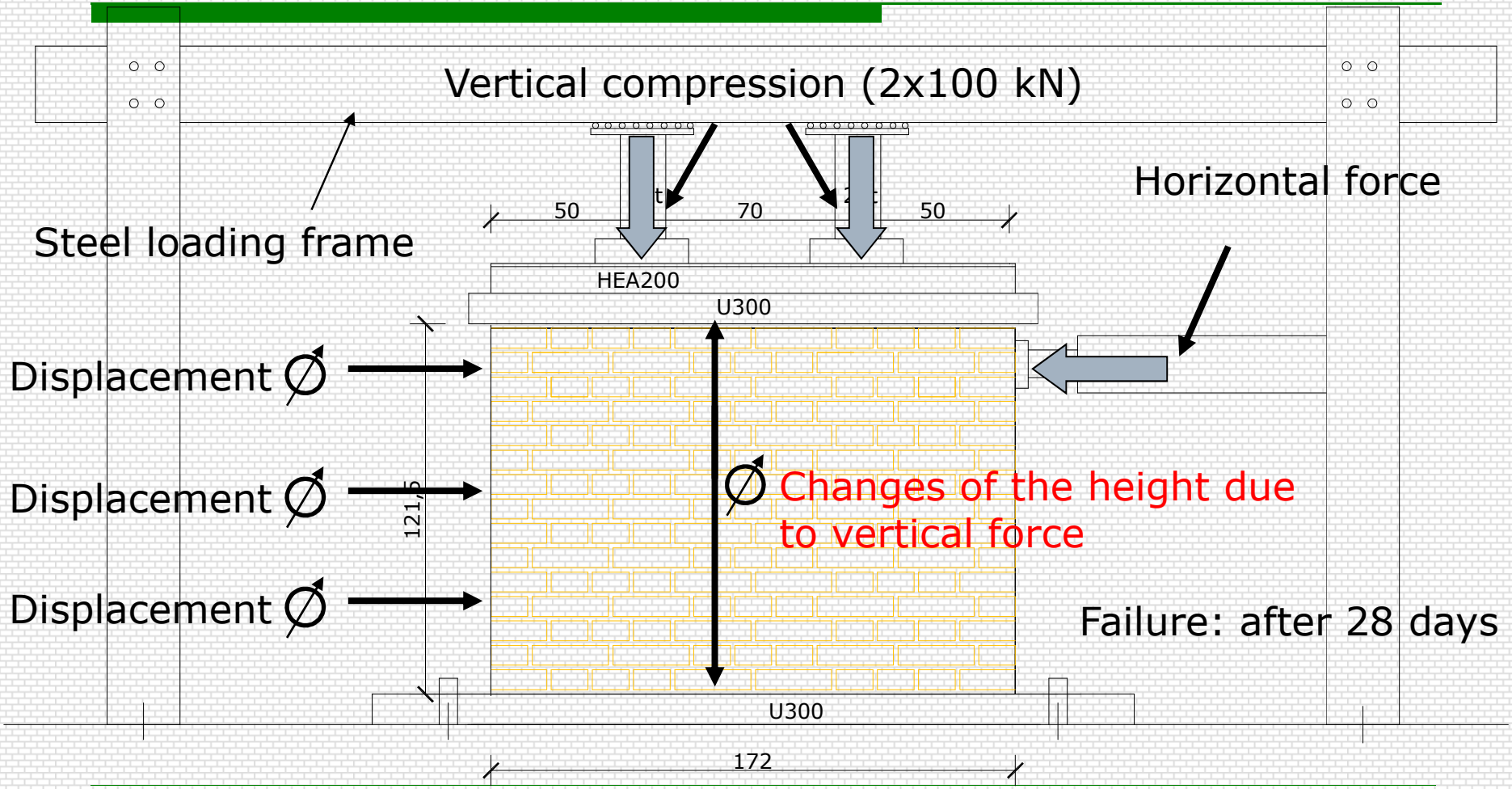
Developed bond of bricks

250x120x65





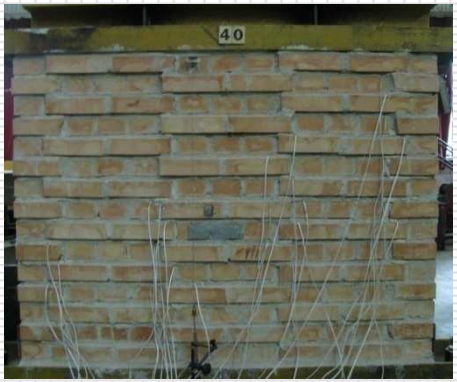
Layout of the test setup



1 2 **3** 4 5 6

The experiments carried out

Aim of the experiments carried out

Plain	Vert. reinforced	Horiz. reinforced	Vert. and horiz.
			
3 walls	2 walls	2 walls	2 walls

PURPOSE: find out for both reinforcement directions whether it can

- enhance the load bearing capacity (if yes, to what extent),
- decrease the width of the cracks,
- modify the type of the failure of the wall,
- alter the crack pattern.

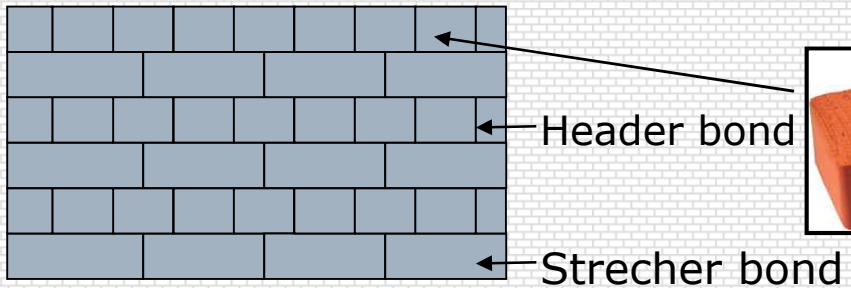
Test specimens

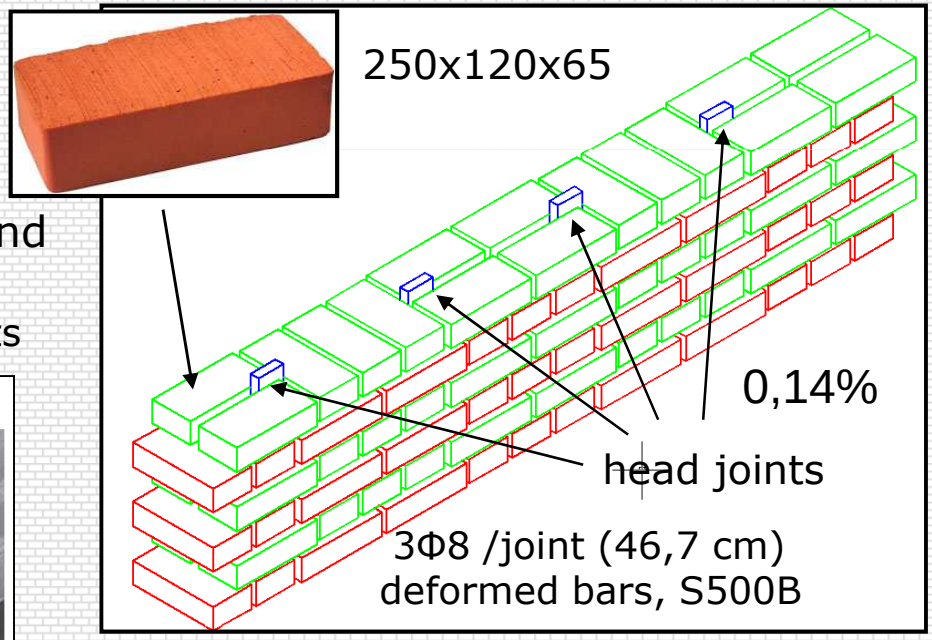
A) PLAIN MASONRY WALLS

B) HORIZONTALLY REINFORCED

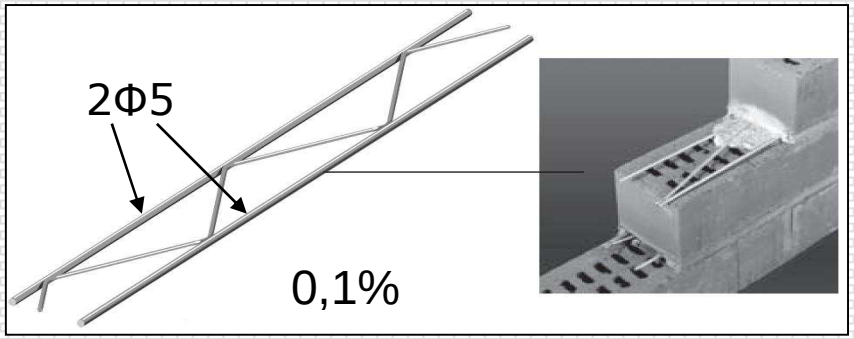
C) VERTICALLY REINFORCED

D) HORIZONTALLY AND VERTI-CALLY REINFORCED





Murfor RND/Z-5-200, in every second joints



1 2 **3** 4 5 6

The experiments carried out

Characteristics of the experiments

- Geometry was the same in all cases (H/L=0,7)
- Vertical compressive force: 200 kN
- Type of the brick was the same (compressive strength: 10 N/mm^2)
- Amount, shape, type and placement of the reinforcement were the same in one direction
- Two types of mortar:
  - the compressive strength of the mortar is less (3 N/mm^2) than that of the brick (10 N/mm^2)
  - and it is the same

  (M30-weaker and M100-stronger mortar)

Crack pattern – plain masonry wall, M30

First crack: 145 kN

(3.2 mm)

The wall decays completely after cracking, the upper part of the wall slipped on the lower „triangle”.

Maximal force: 155 kN,
(4.6 mm)

Residual force: 130 kN

Crack pattern – vertically reinforced masonry, M30

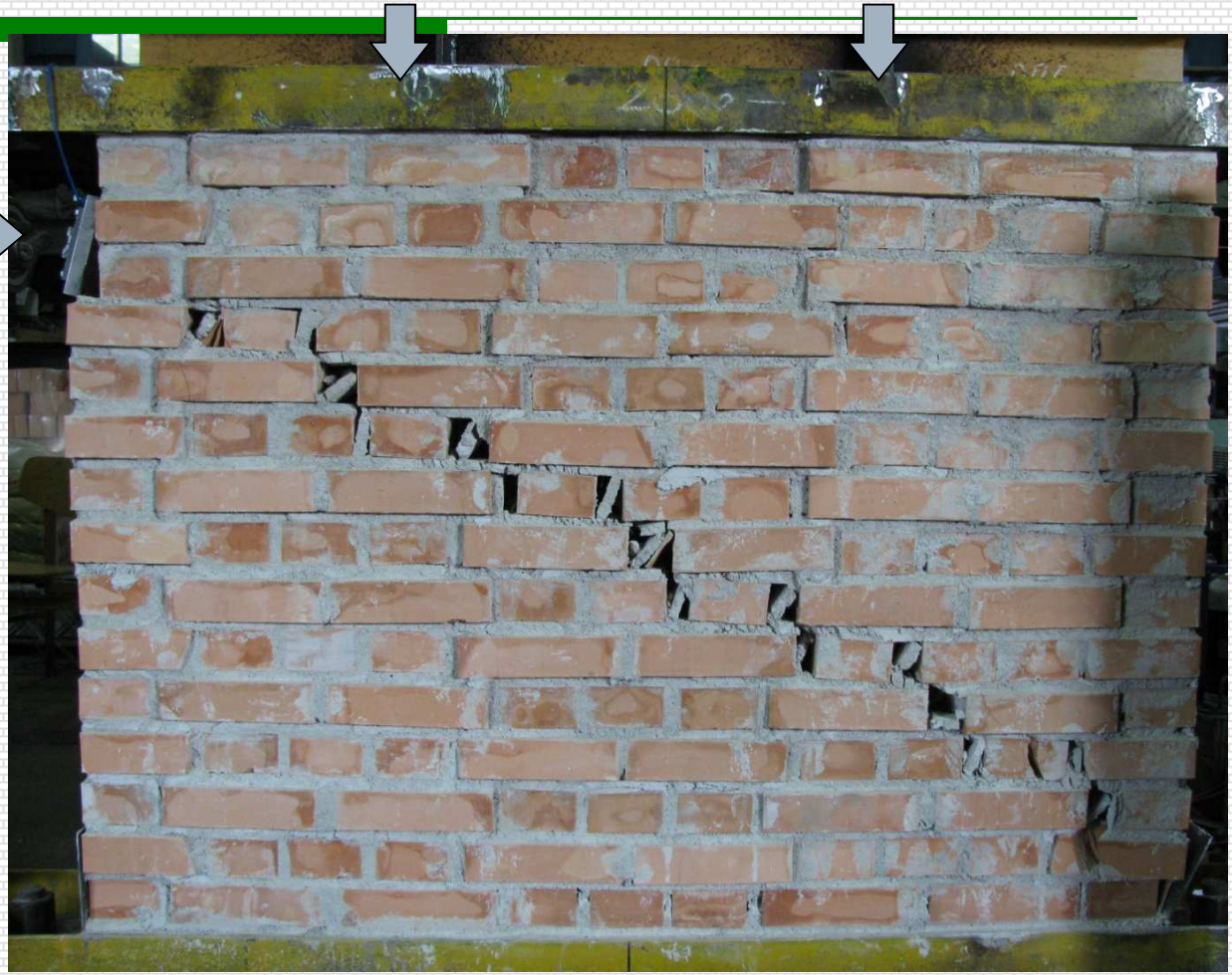
First crack: 121 kN
(3.4 mm)

Displacement at the top, after 163 kN: 60.5 mm

The crack pattern is similar to that of the plain masonry.

The difference is caused by the distinct bond of bricks.

The masonry does not decay after cracking immediately, it is able to carry load in an amount that is provided by the reinforcement.



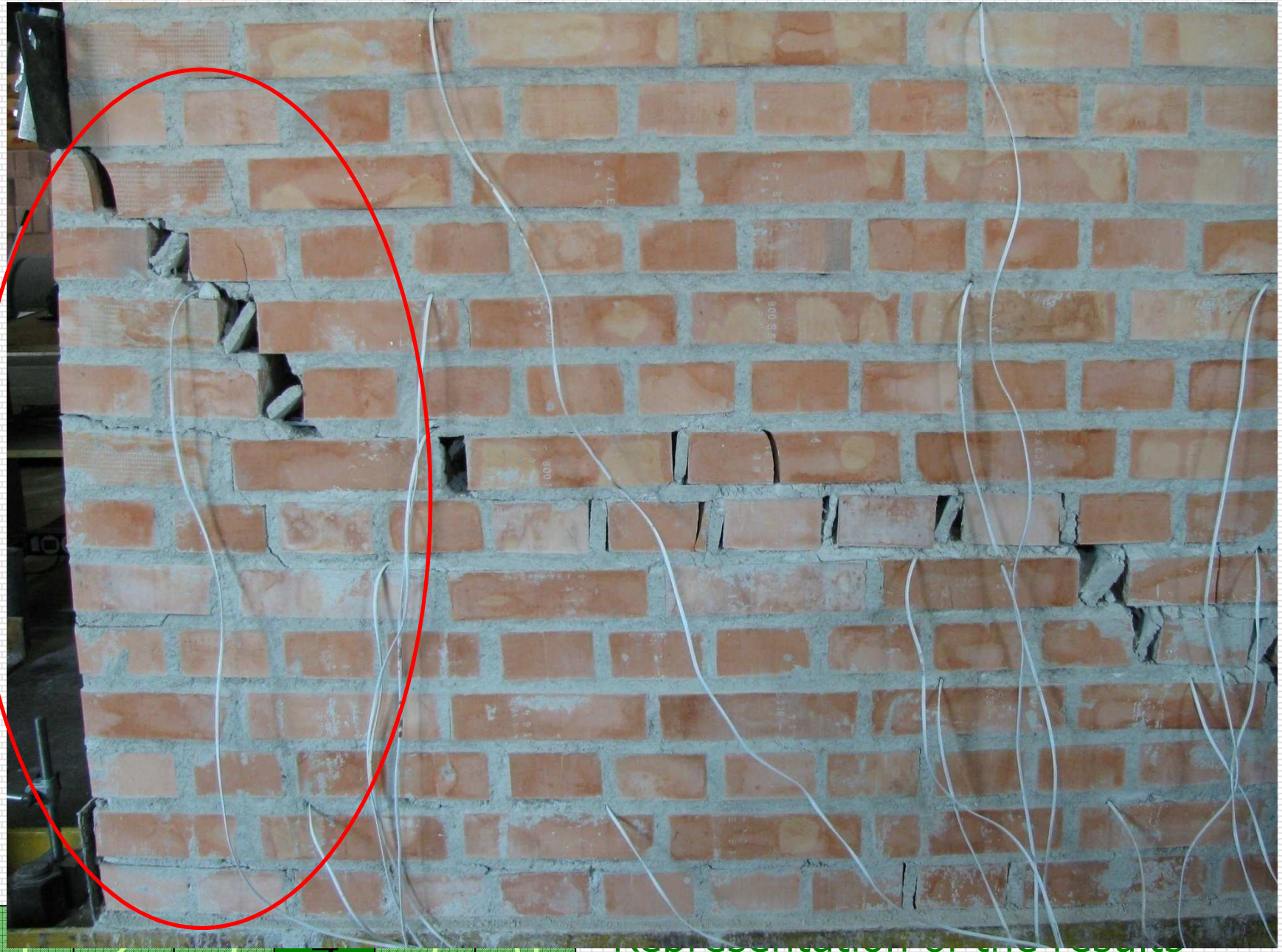
Crack pattern – horizontally reinforced masonry, M30

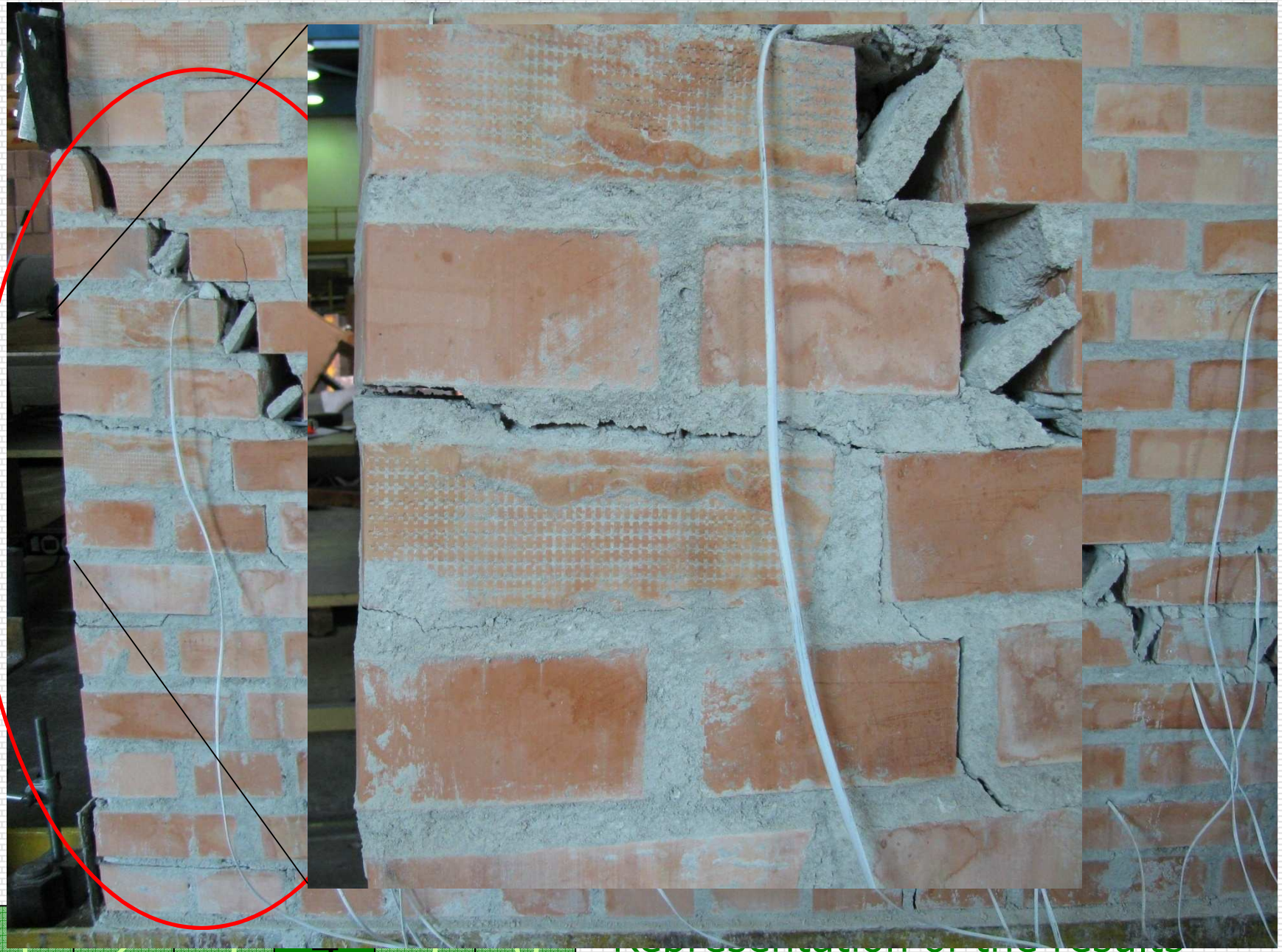
First crack: 173 kN
(6.5 mm)

Shape of the crack pattern changes, the way of the failure alters partly.

Maximal force: 180 kN
(16.9 mm)

Residual force: 163 kN





Crack pattern – vertically and horizontally reinforced masonry wall, M30

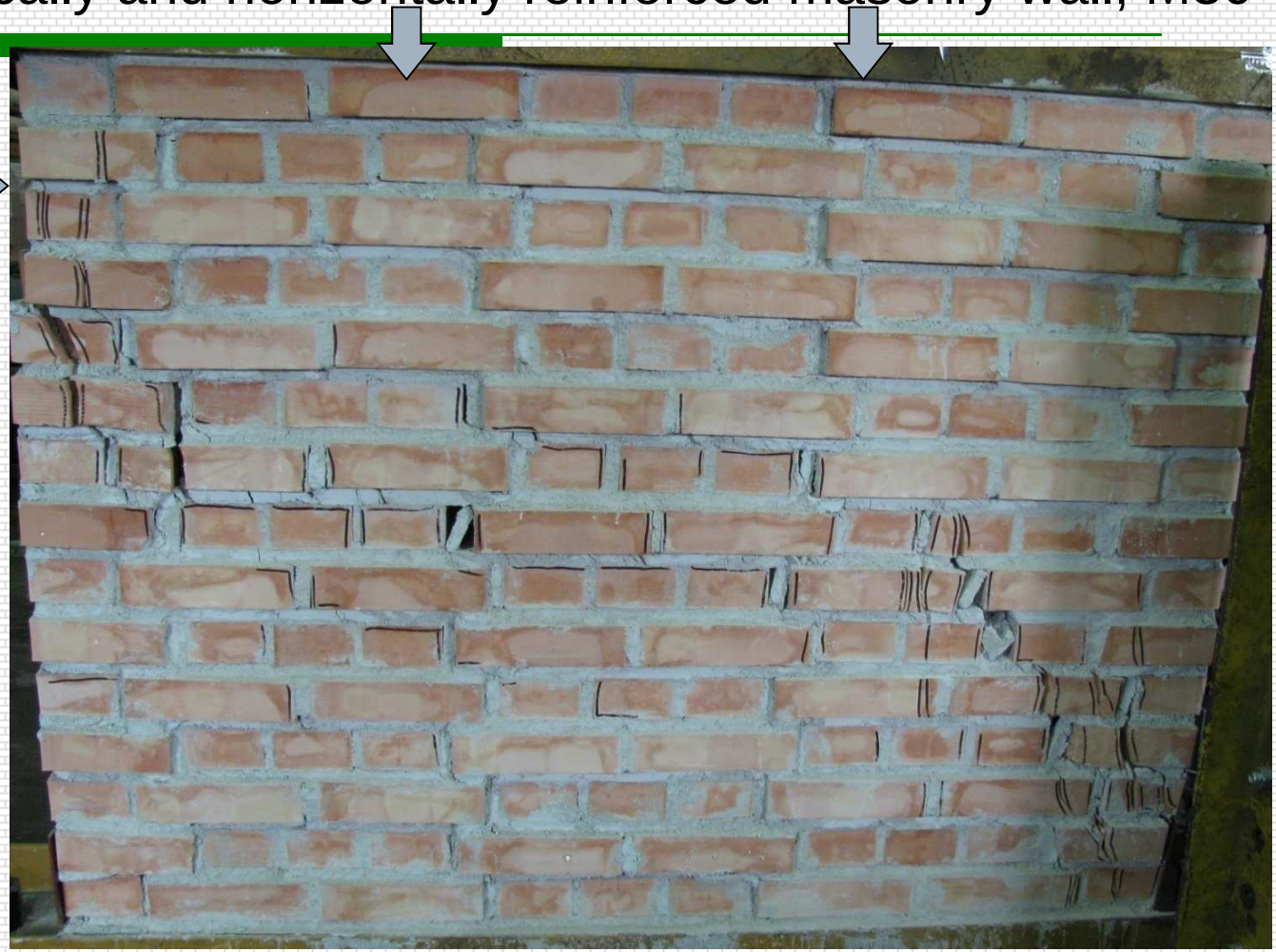
First crack: 176 kN
(6.5 mm)

Maximal force: 252 kN
(60.8 mm)

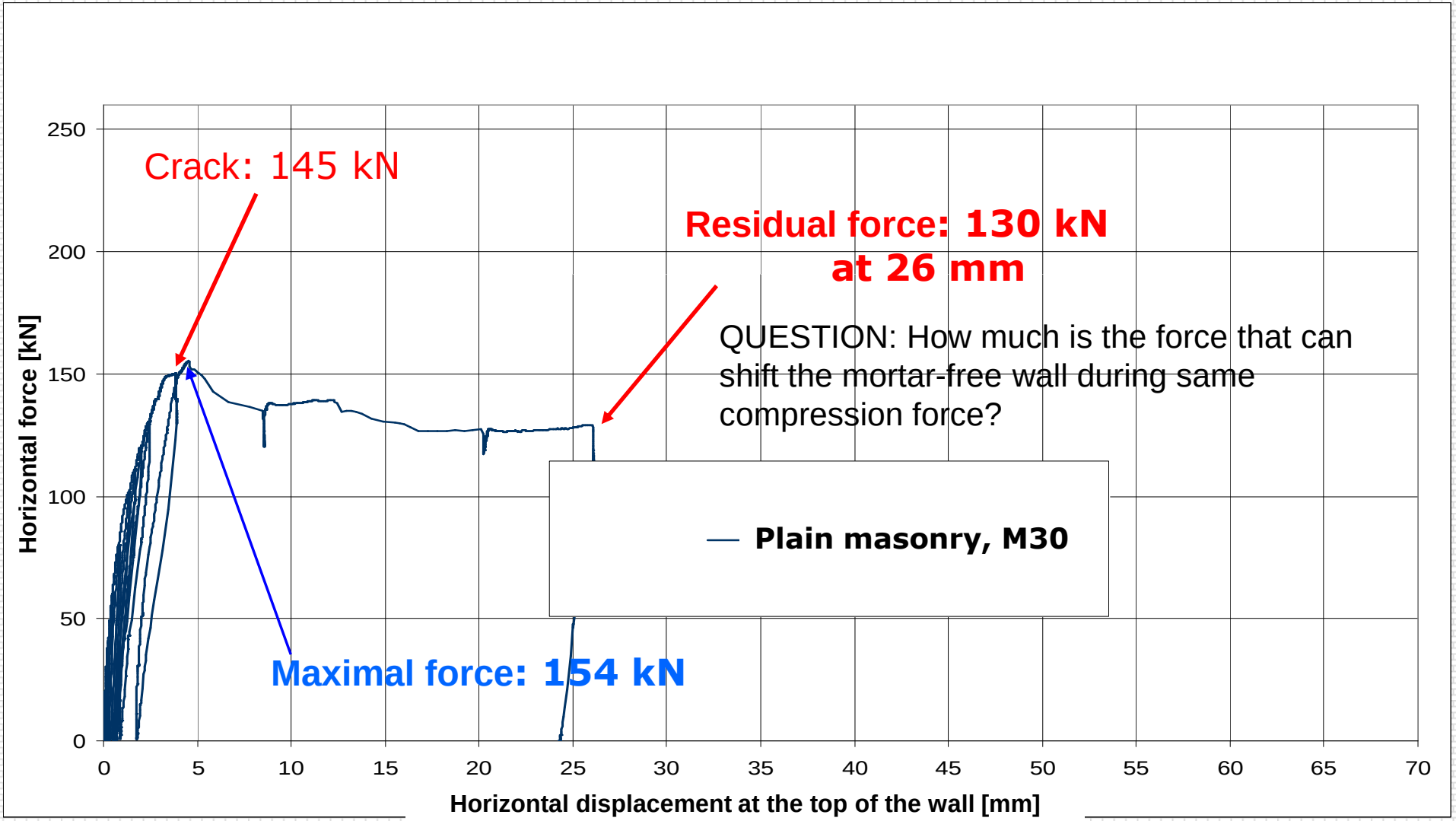
Maximal displacement:
60.8 mm

The run of the crack pattern changes, the cracked zone is bigger.

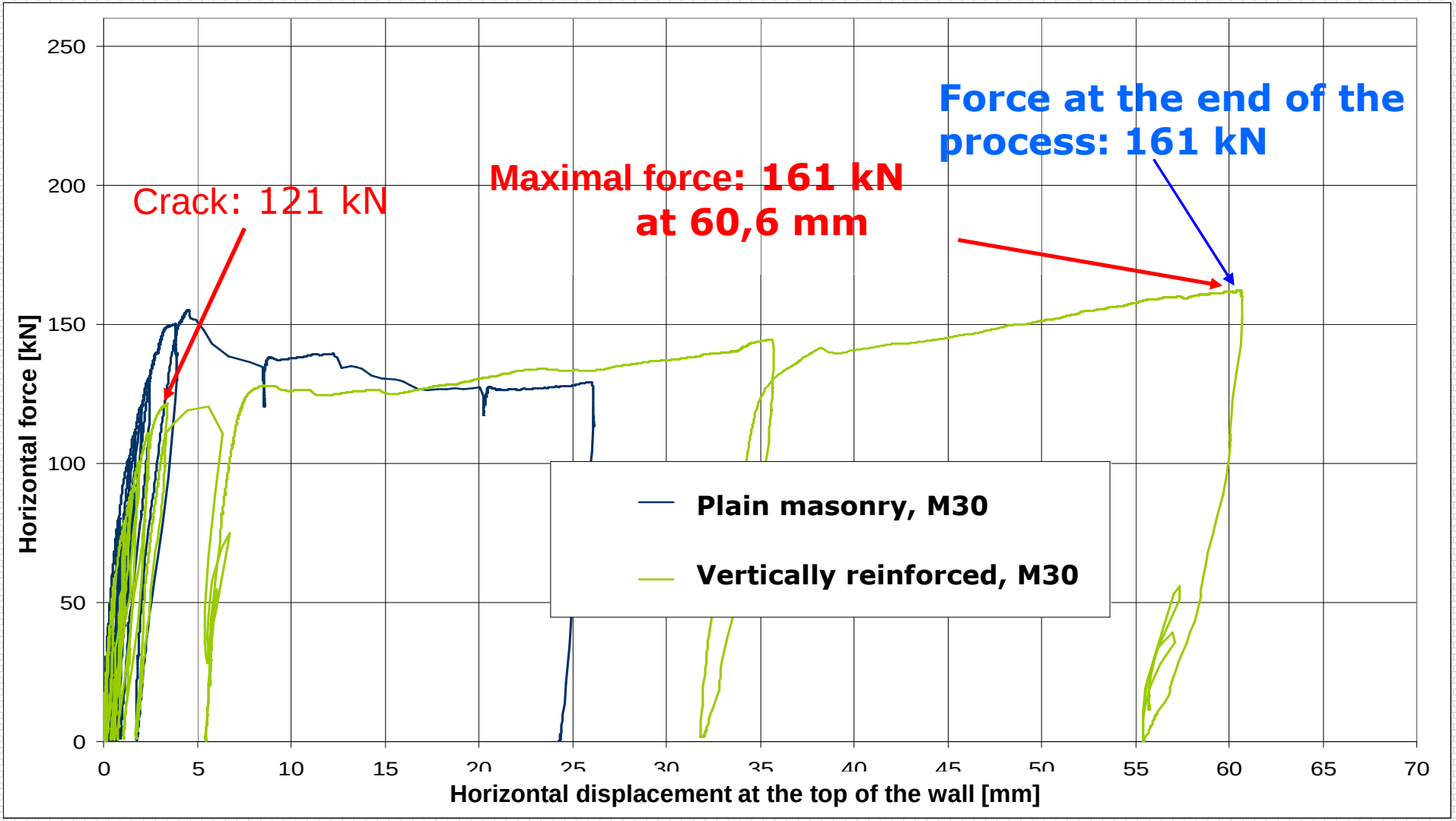
The width of the cracks is smaller.



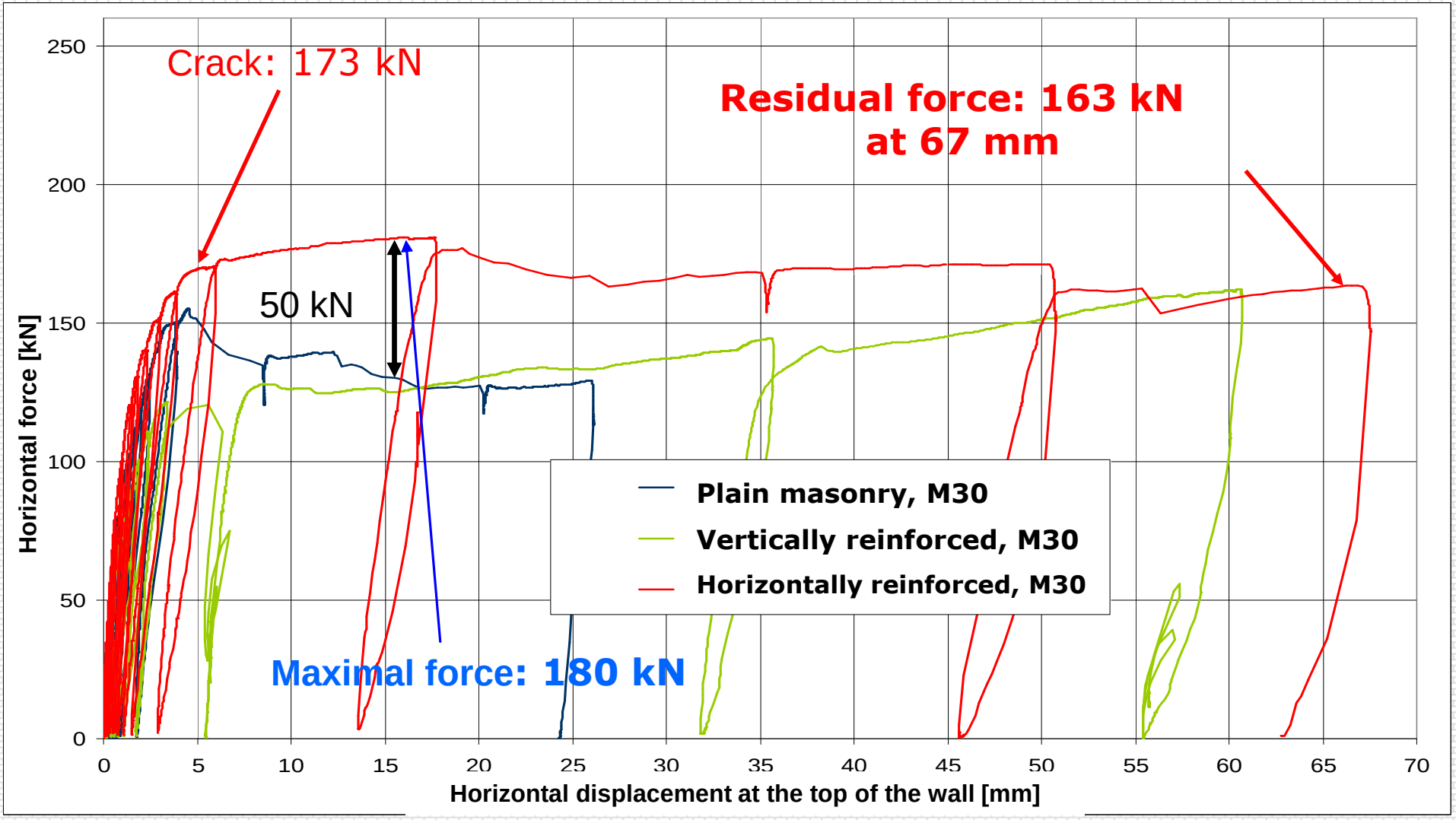
Force vs. displacement of the plain masonry wall, M30



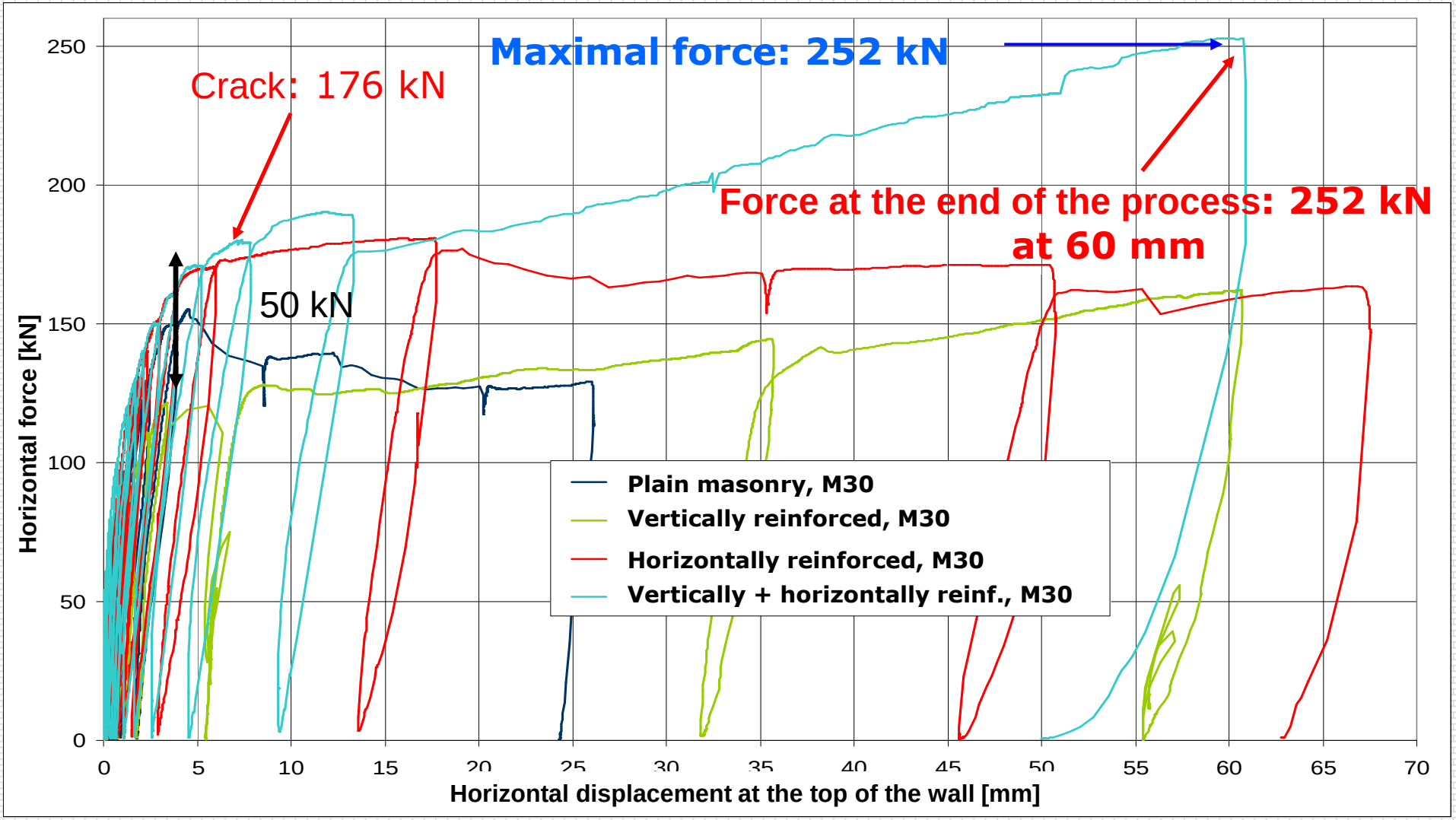
Force vs. displacement diagram of a vertically reinforced wall, M30



Force vs. displacement diagram of a horizontally reinforced wall, M30



Force vs. displacement diagram of a wall reinforced in both directions, M30



Crack pattern– plain wall, M100

Maximal force: 193 kN (4.8 mm)

Crack pattern changes: run of the cracks begins lower: under the fifth course.

Residual force: 143 kN, Maximal displacement at the top: 31 mm

First crack: 180 kN (2.3 mm)

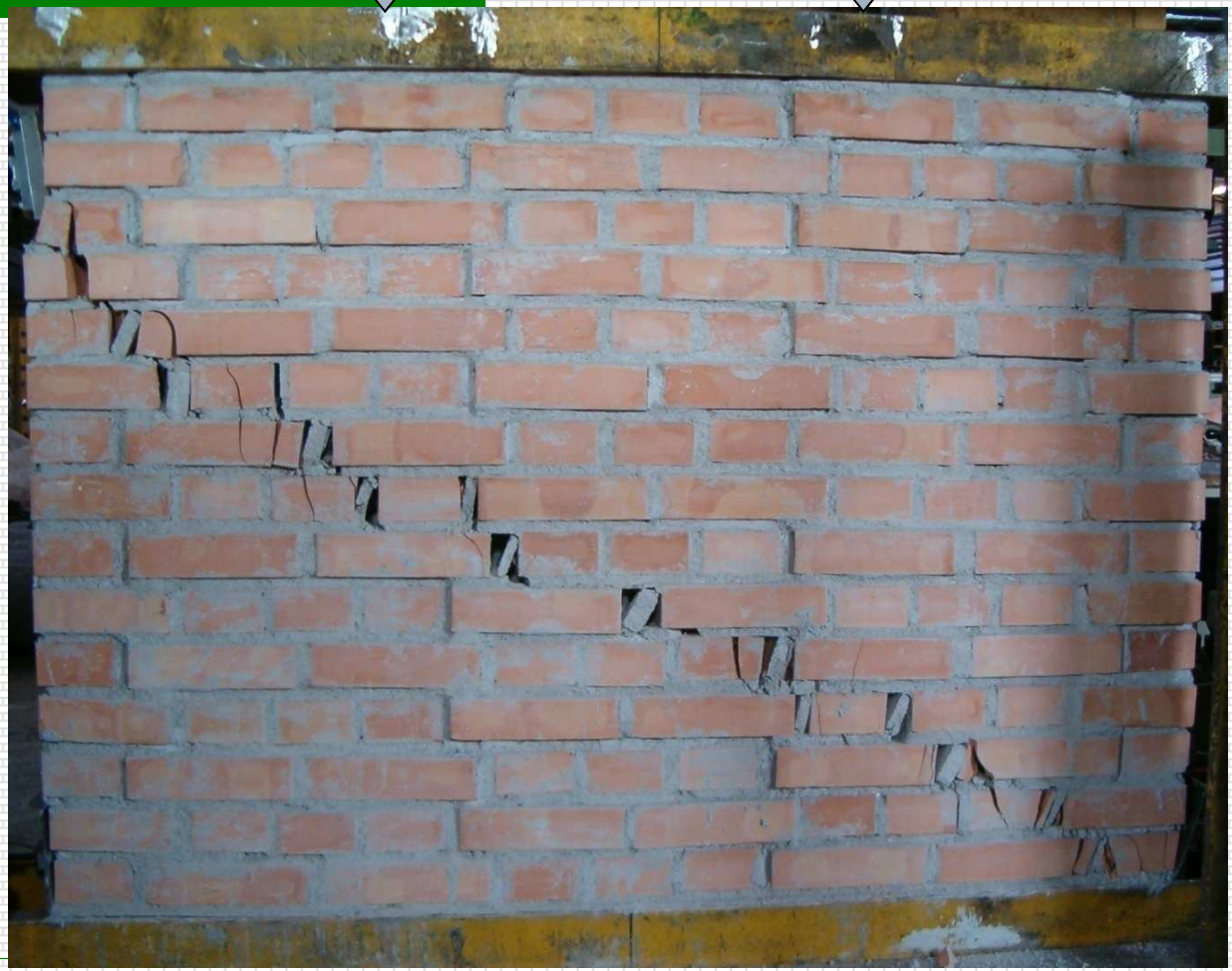
Crack pattern – vertically reinforced wall, M100

First crack: 176 kN (5.3 mm)

Maximal force: 231 kN (39 mm)

Maximal displacement: 42 mm

Crack pattern changes: cracks run through the bricks.



Crack pattern – horizontally reinforced wall, M100

First crack: 190 kN
(4.4 mm)

Crack pattern changes: run of the cracks begins lower: under the twelfth course.

Maximal force: 193 kN,

Residual force: 171 kN, maximal displacement at the top: 38 mm

Crack pattern – horizontally and vertically reinforced, M100

<u>200 kN compression:</u>
Maximal load: 331 kN

Max. displacement: 32 mm

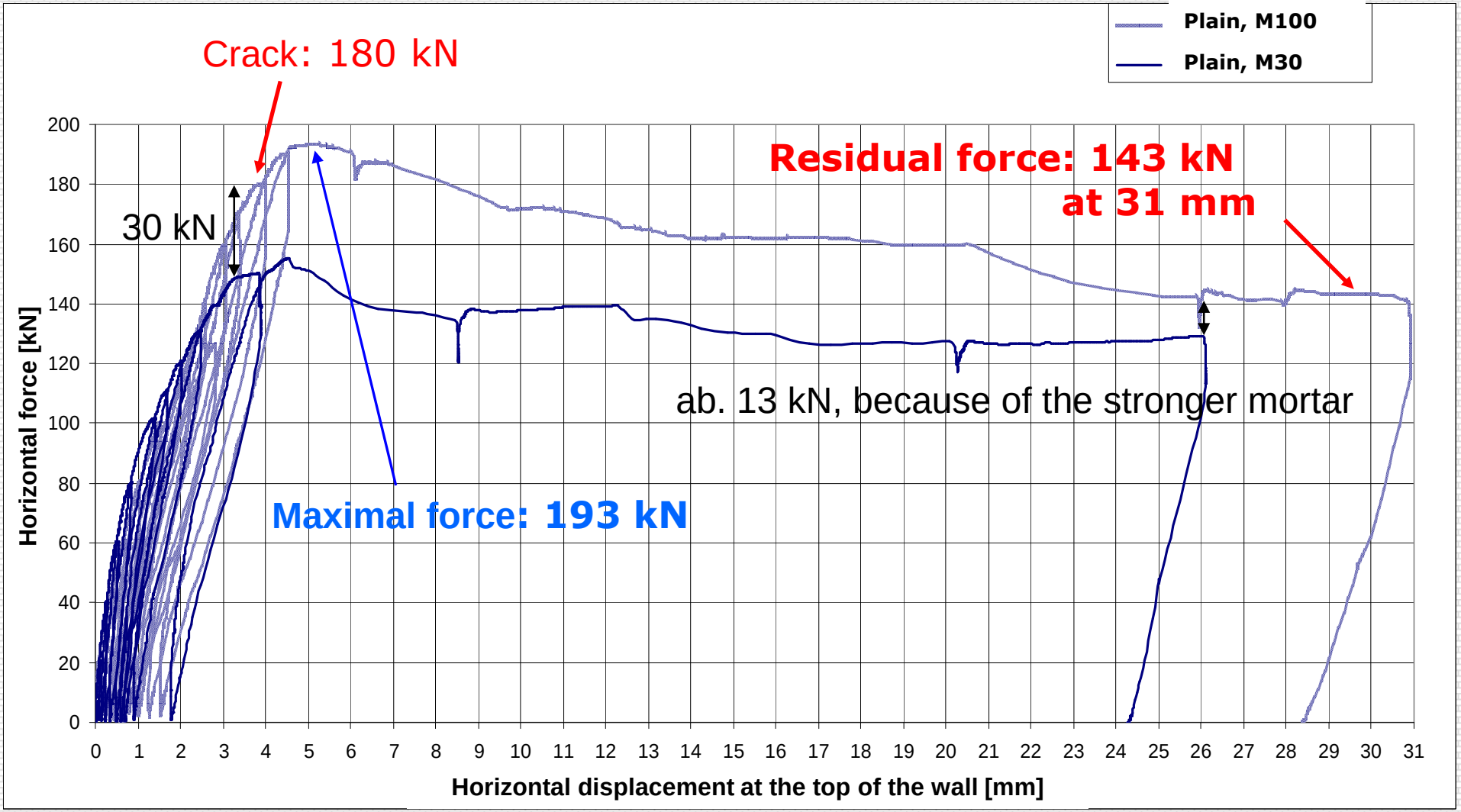
<u>240 kN compression:</u>
Maximal load: 378 kN

Max. displacement: 38 mm

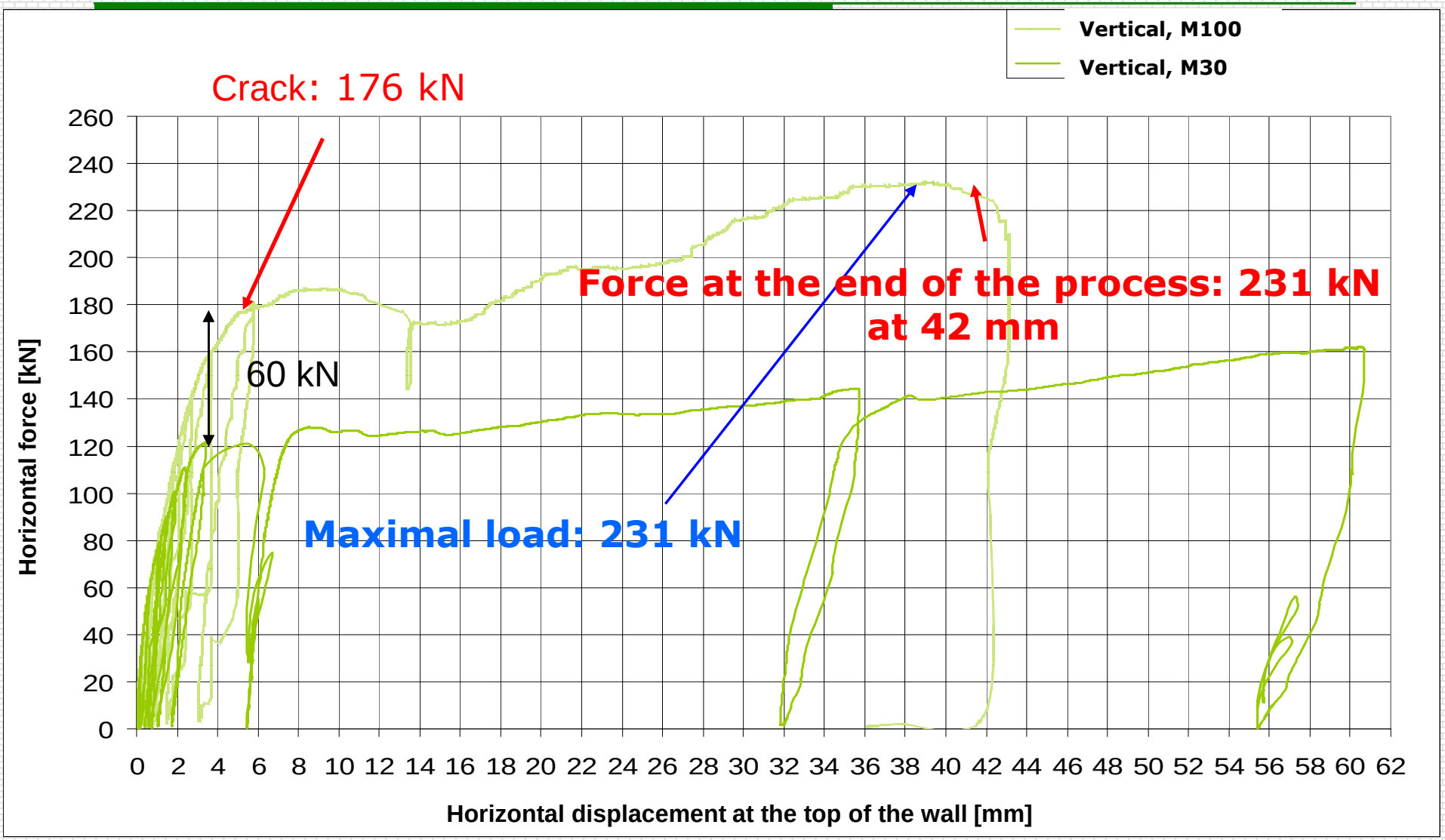
Failure can be caused by bending definitely.

First crack: 200 kN

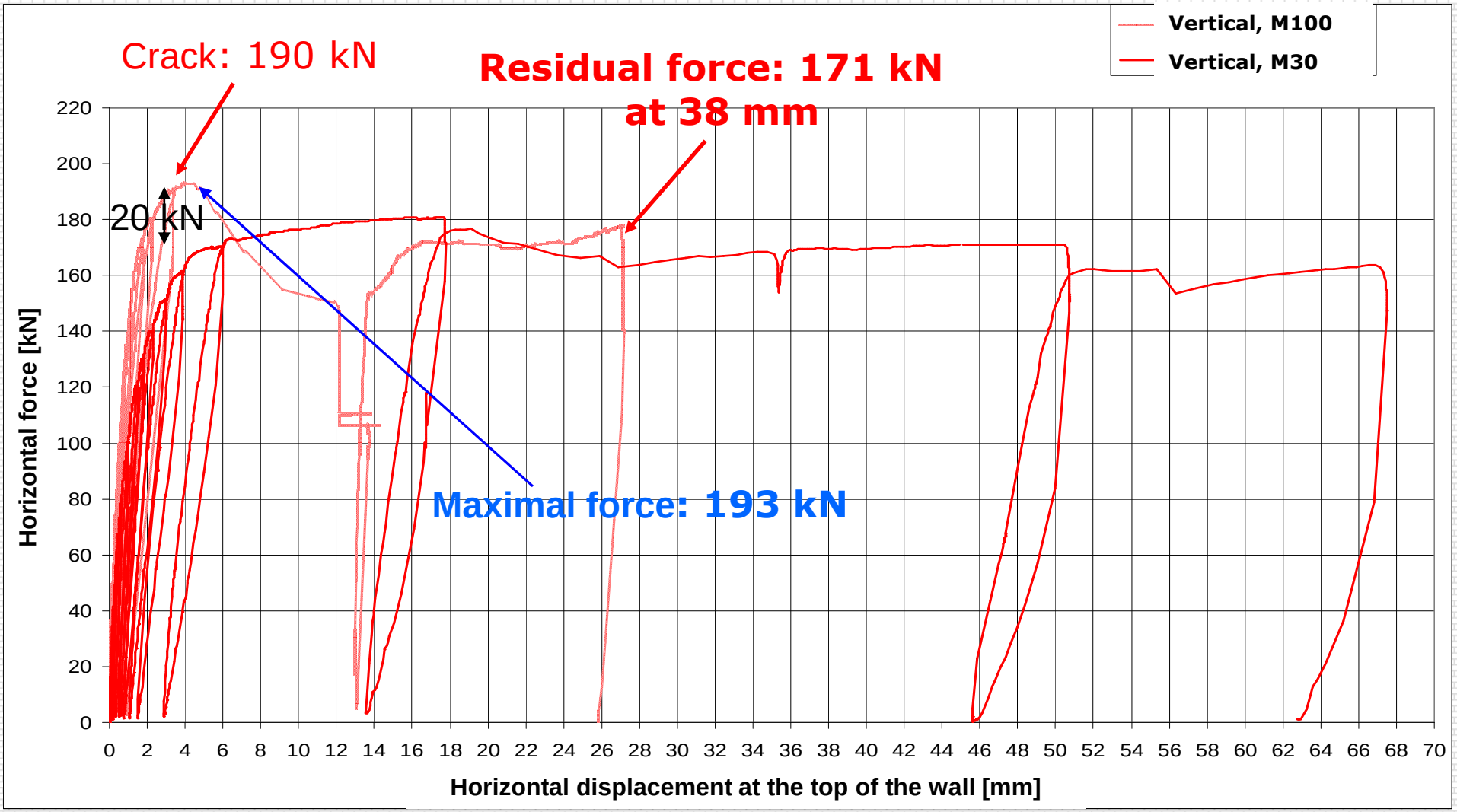
Force vs. displacement diagrams for plain masonry



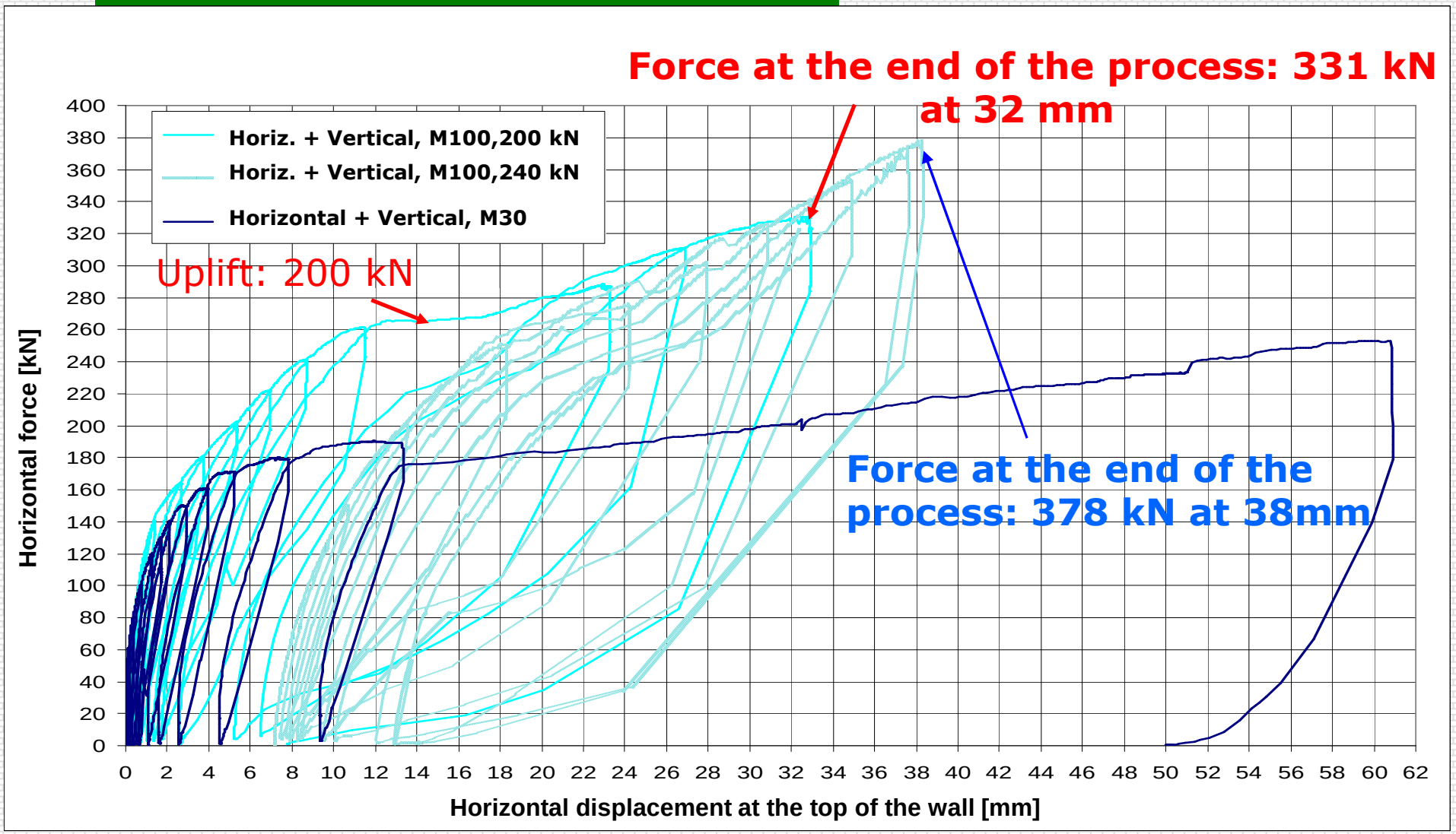
Force vs. displacement diagrams for vertically reinforced masonry



Force vs. displacement diagrams for horizontally reinforced masonry



Force vs. displacement diagrams for masonry reinforced in both directions



Summary of walls M30

Type of the wall	Appearing first crack		Maximal load		Maximal displacement (residual force)	Forces belonging to 25 mm displacement
Plain masonry without mortar			89 kN	12,6 mm	41 mm (76 kN)	80 kN
Plain masonry	145 kN	3.2 mm	154 kN	4,6 mm	26 mm (129 kN)	128 kN
Vertically reinforced	121 kN	3.4 mm	161 kN	60,7 mm	60 mm (161 kN)	133 kN
Horizontally reinforced	173 kN	6.6 mm	180 kN	16,9 mm	67 mm (163 kN)	166 kN
Vertically and horizontally reinforced	176 kN	6.5 mm	252 kN	60,8 mm	60 mm (252 kN)	189 kN

Summary of walls M100

Type of the wall	Appearing first crack		Maximal load		Maximal displacement (residual force)
Plain masonry	180-192 kN	3.7 mm	193 kN	4.8 mm	31 mm (143 kN)
Vertically reinforced	176 kN	5.3 mm	231 kN	39 mm	42 mm (231 kN)
Horizontally reinforced	192 kN	4.4 mm	193 kN	4.4 mm	38 mm (171 kN)
Vertically and horizontally reinforced	200 kN	5.0 mm	331 kN (378 kN)	32 mm	32 (38) mm 331 kN (378 kN)

Conclusions I.

According to the experiments carried out the following conclusions are drawn:

- Horizontal reinforcement increases the shear capacity of masonry wall and delays appearing cracks in case of the weaker mortar. It modifies the crack pattern and decreases the width of the cracks.
- In case of stronger mortar the horizontal reinforcement does not provide an extra shear capacity compared to the plain masonry, the attention is attracted to an other failure mode that can be prevented by applying vertical reinforcement.
- By applying weaker mortar, horizontal and vertical reinforcement the extension of the cracked zone is bigger, cracks appear less closely and the width of the cracks is smaller than in case of the plain masonry, at the same load.

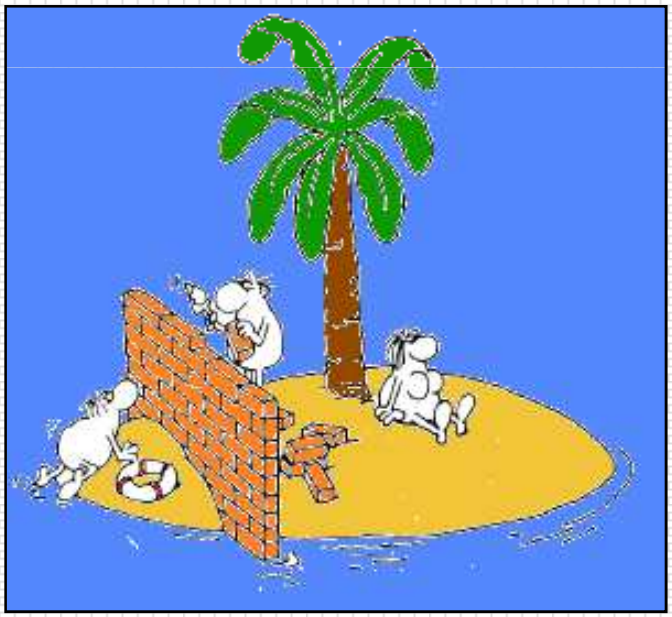
Conclusions II.

- The new bonded vertically reinforced wall cracks almost at the same load as the conventional wall independently of the type of the mortar. However, the masonry does not decay after cracking immediately, it is able to carry load in an amount that is provided by the reinforcement.
- The vertical reinforcement does not alter the run of the cracks. Although using stronger mortar causes a crack pattern running through the bricks.
- The stronger mortar, the horizontal and vertical reinforcement presented a masonry that modified the type of the failure. It can not be damaged with the test setup.

Further plans

- Experimental investigation of masonry wall bulit by other special technologies
- Developing of a numerical model

Thank you for your kind attention!



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