Experimental investigation of vertically reinforced masonry walls

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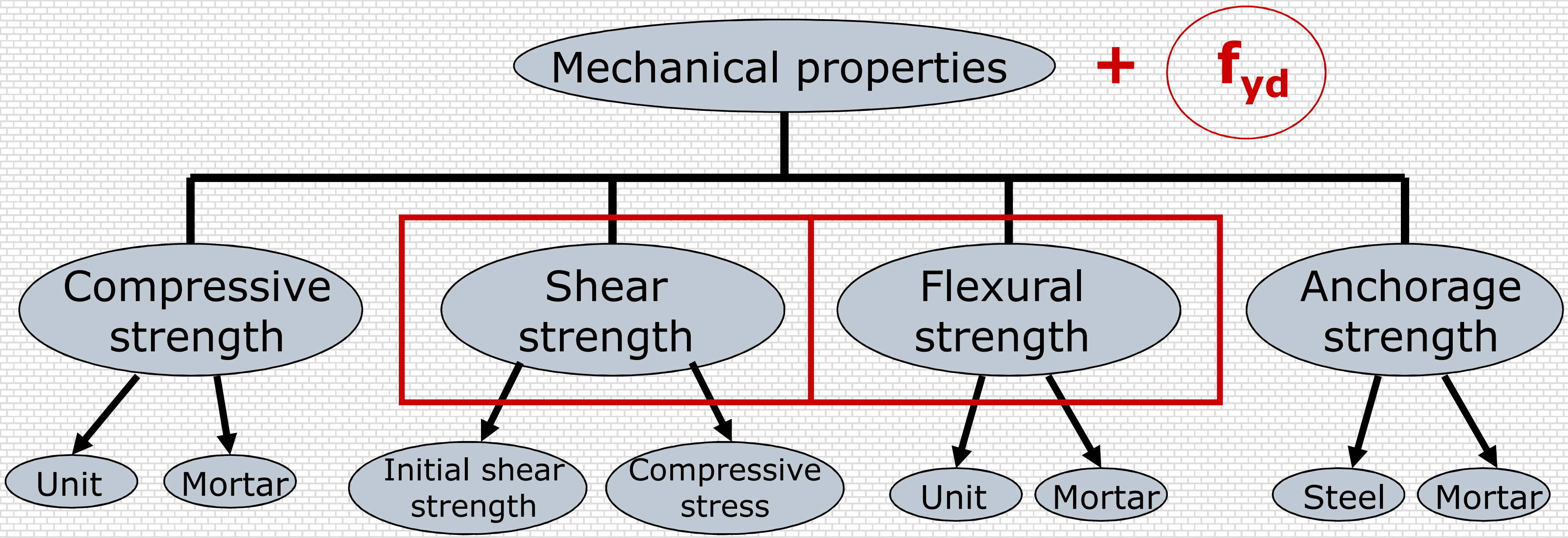
- Short history of reinforced masonry
- Why exactly shear investigation?
- Common failure of masonry
- The possible type of bond
- Summary and further plans

History of reinforced masonry

- 1825 Marc Isambard Brunel:
Blackwall Tunnel under the Thames

- 1900-1910 flower stands of the Park Güell

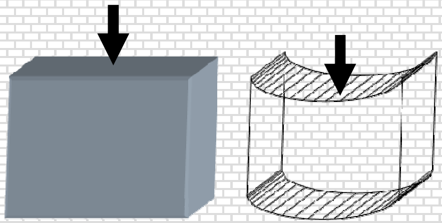
The Eurocode 6 in Hungary



$f_k = K \cdot f_b^{\alpha} \cdot f_m^{\beta}$ $f_{vk} = f_{vk0} + 0{,}4\ \sigma_d$ $f_{xk1};\ f_{xk2}$ f_{b0k}

Acting loads and failure modes

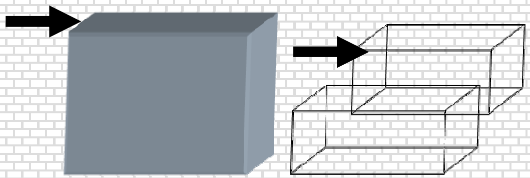
Vertical



$N_{Ed} \leq N_{Rd} = \Phi \cdot t \cdot f_d$

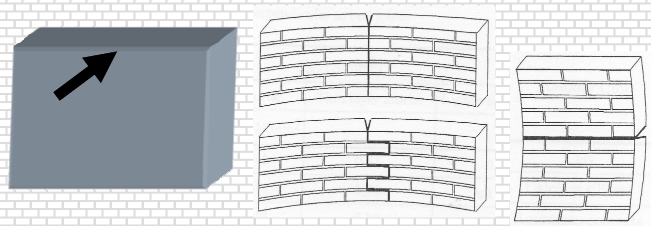
$N_{Edc} \leq N_{Rdc} = \beta \cdot A_b \cdot f_d$

Horizontal



$V_{Ed} \leq V_{Rd} = f_{vd} \cdot t \cdot l_c$

Lateral



$M_{Ed} = \alpha \cdot W_{Ed} \cdot l^2$

$M_{Ed} \leq M_{Rd} = f_{xd} \cdot Z$

UNREINFORCED

Bending, axial loading or both:

$M_{Ed} \leq M_{Rd} = A_s \cdot f_{yd} \cdot z \leq 0{,}4 \cdot f_d \cdot b \cdot d^2$

Shear: 1.) Horizontal load:

$V_{Ed} \leq V_{Rd1} + V_{Rd2}$

$f_{vd} = \min(\text{inf.};\text{mas.})$

VERTICAL REINFORCEMENT

$V_{Rd1} = f_{vd} \cdot t \cdot l$

$\boxed{V_{Rd2} = 0{,}9 \cdot A_{sw} \cdot f_{yd}}$

$(V_{Rd1} + V_{Rd2})/(t \cdot l) \leq 2\ \text{N/mm}^2$

2.) Shear load:

$V_{Ed} \leq V_{Rd1} + V_{Rd2}$

$f_{vd} = \min(\text{inf.};\text{mas.})$

$V_{Rd1} = f_{vd} \cdot b \cdot d$

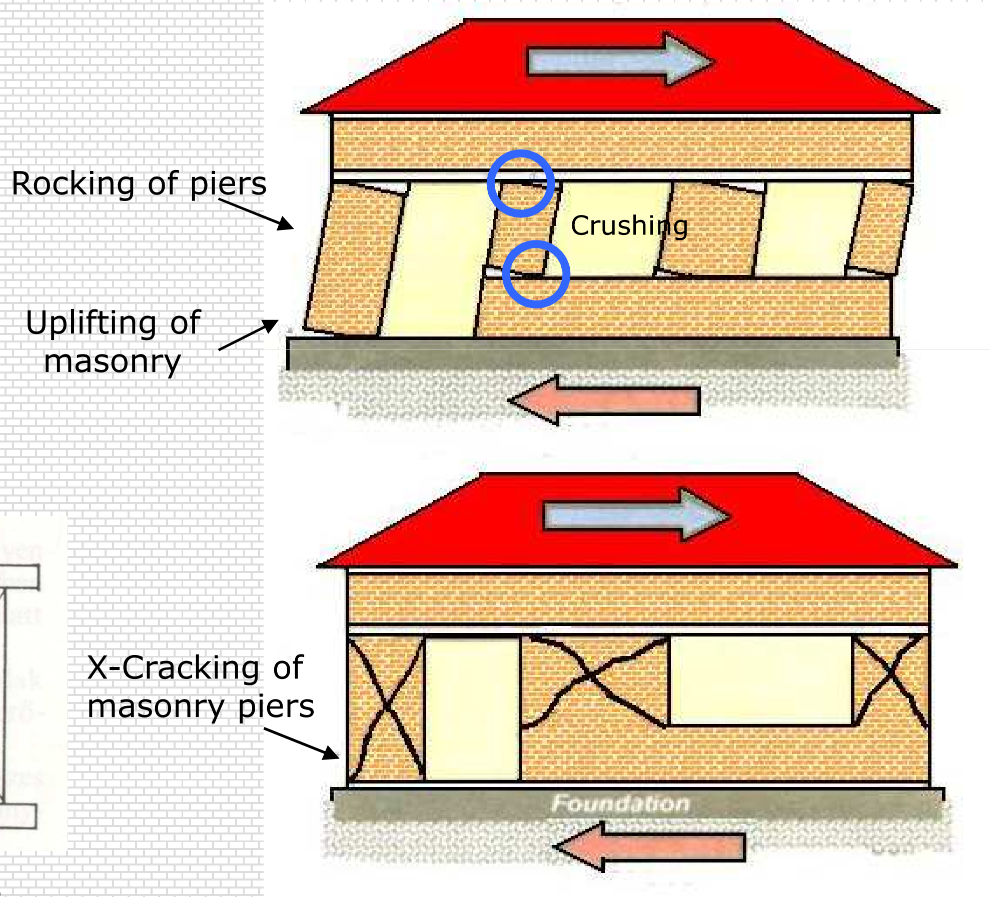
$V_{Rd2} = 0{,}9 d \cdot A_{sw} \cdot f_{yd} / s$

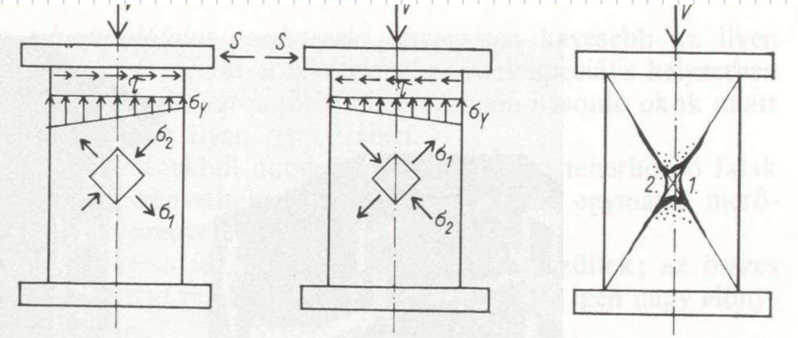
$V_{Rd1} + V_{Rd2} \leq 0{,}25\ f_d \cdot b \cdot d$

REINFORCED

Common failure of masonry

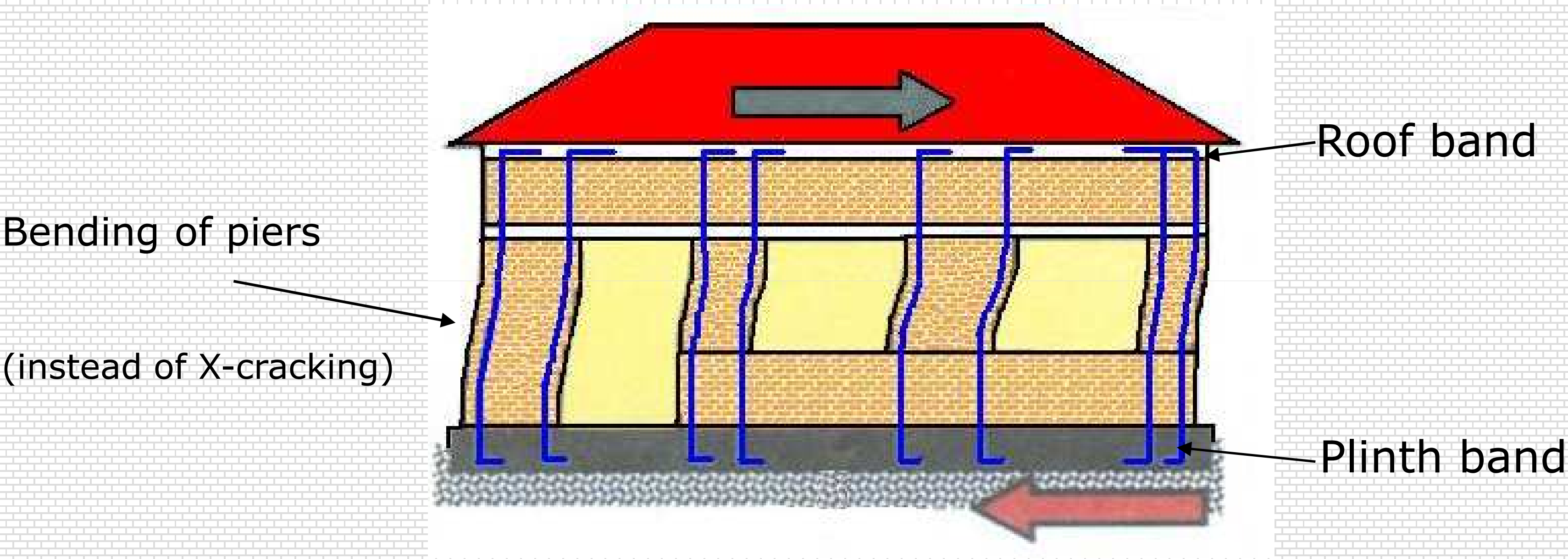
Failure owning to earthquake





X-cracking due to main stresses

The resolution



Vertical steel bars anchored in foundation and roof band

Shear mechanism

$V_n = V_m + V_s$

Cracking

V_n: nominal shear strength

V_s: horizontal reinforcement

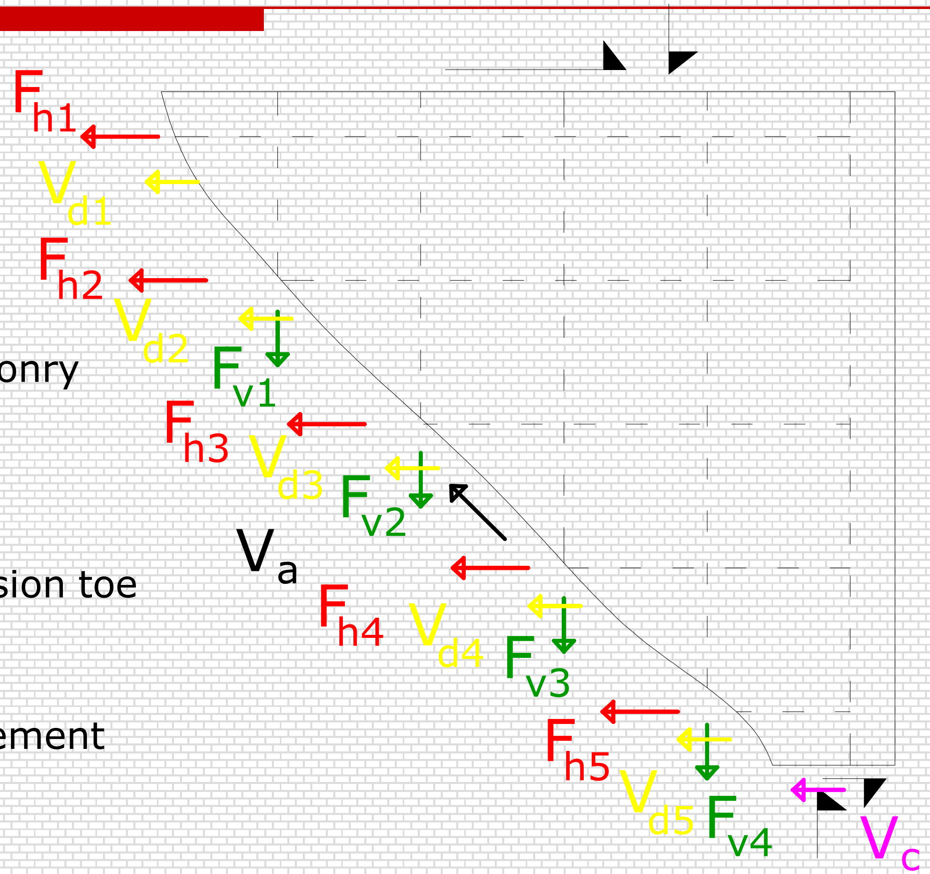
V_m: residual strength of masonry

$V_m = V_c + V_a + V_d$

V_c: shear resistance in the compression toe

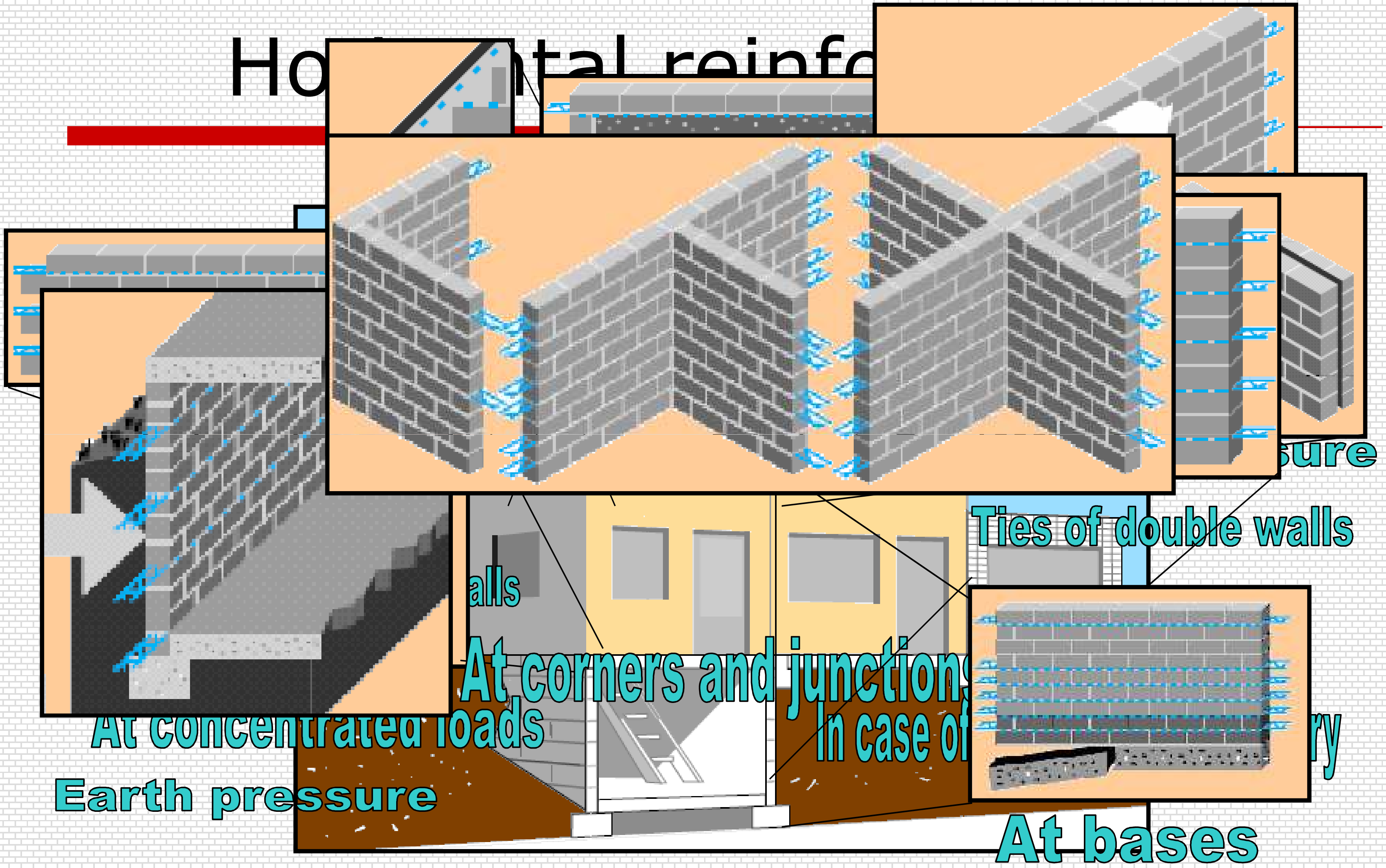
V_a: aggregate interlock force

V_d: dowel forces of flexural reinforcement



Horizontal and vertical reinforcement are needed for the adequate shear capacity!

Ho ntal reinfo

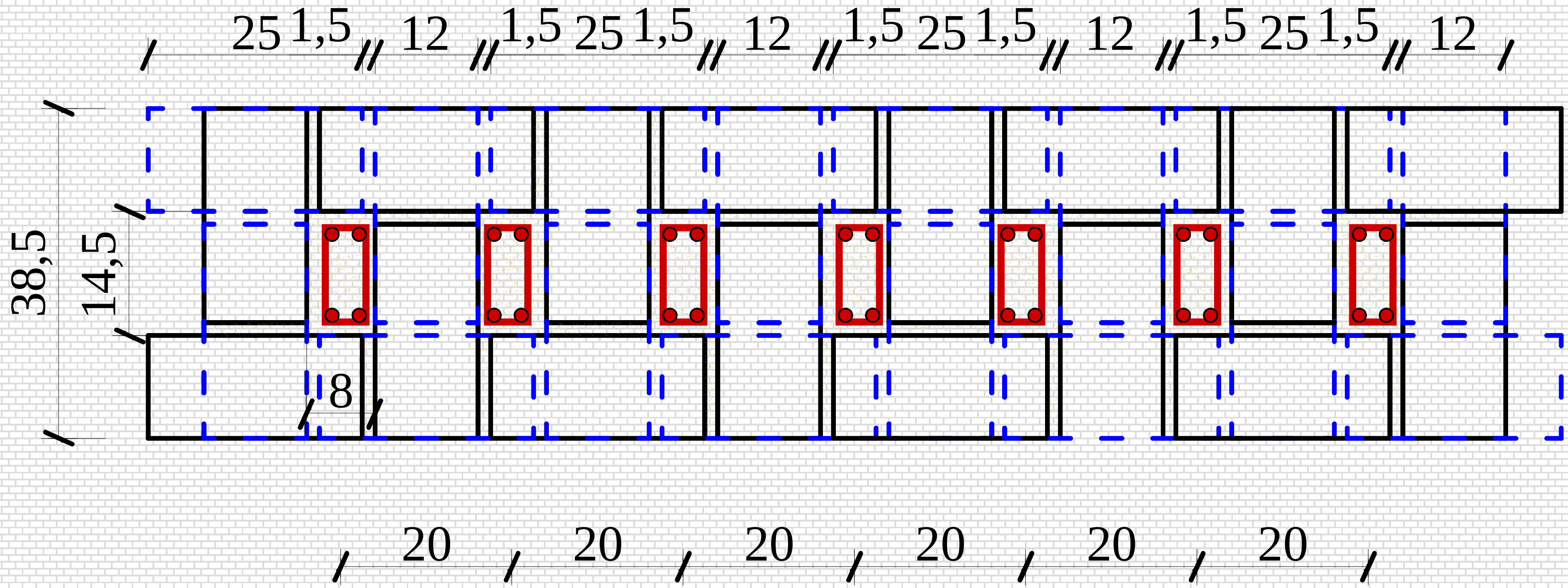


Questions in connection with shear:

- EC6 adjudges that the effect of shear deformations on the stiffness can be neglected only if the wall is higher then twice its length
- **EC6 deals only with concrete infill**
- EC6 applies mostly to horizontal reinforcement
- **EC6 doesn't contain: what happens if vertical reinforce-ment is placed in mortar pockets (not in hollow blocks)**
- Shear strength of mortar
- Adhesion between steel-mortar-brick
- Problem of ductility

Not conventional bonding of bricks

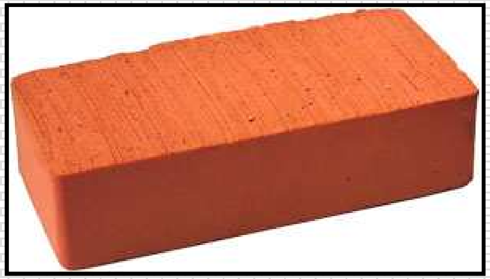
Reinforced pocket type wall

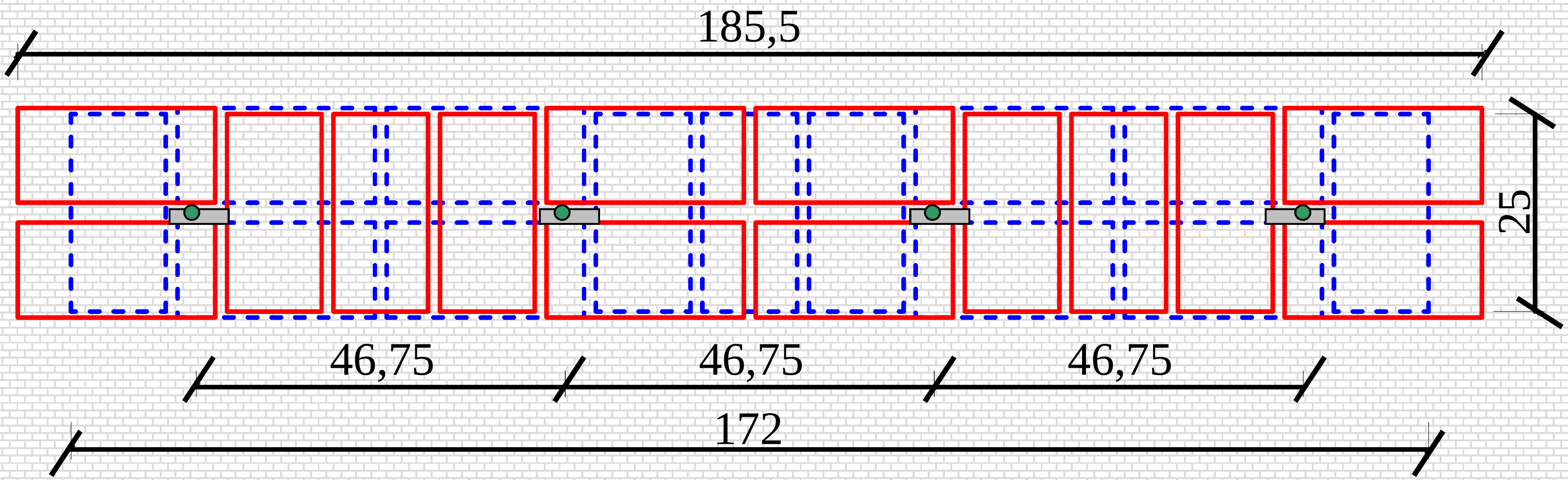


Reinforced solid wall

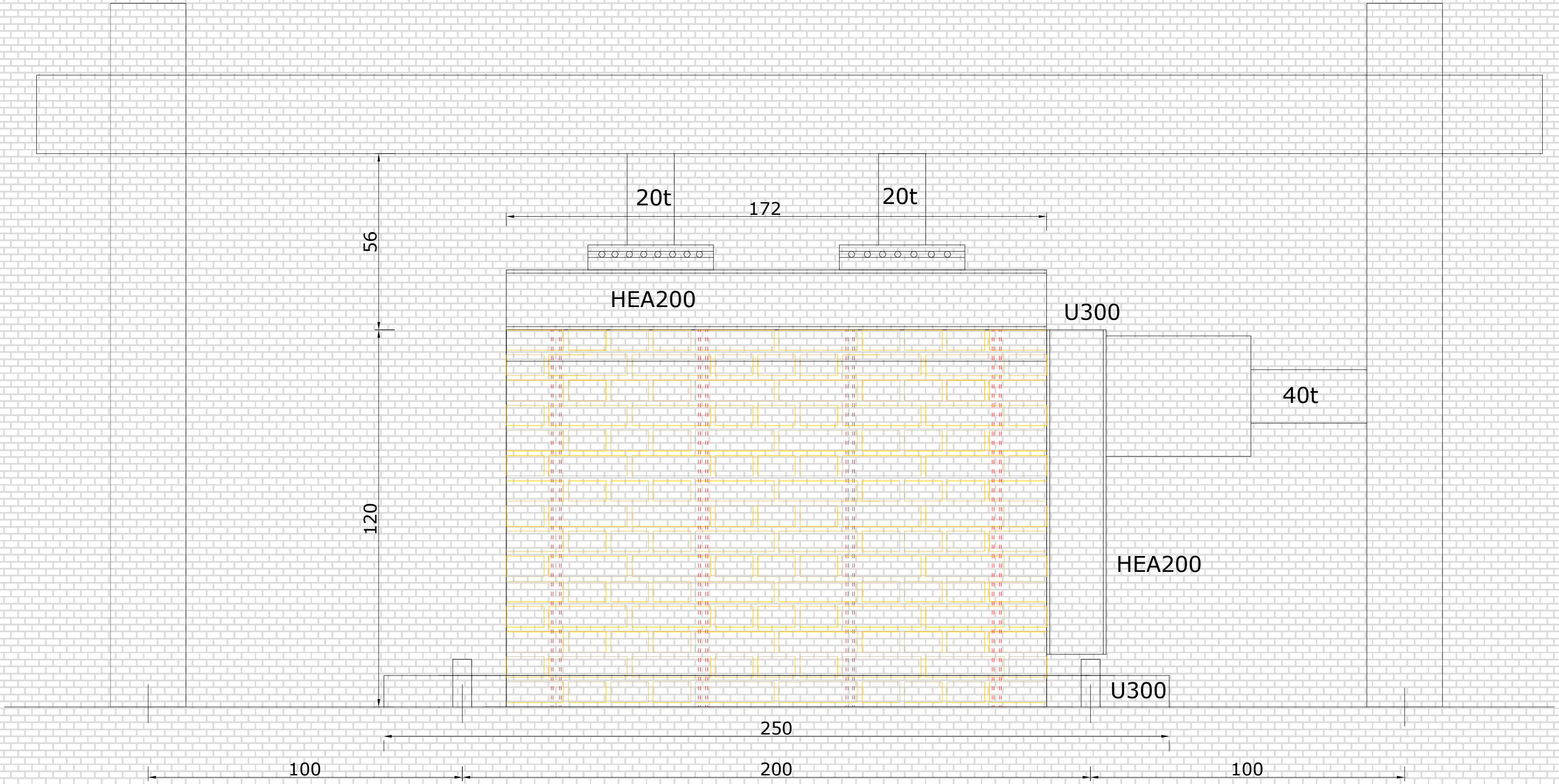
Conventional Hungarian solid brick

250x120x65



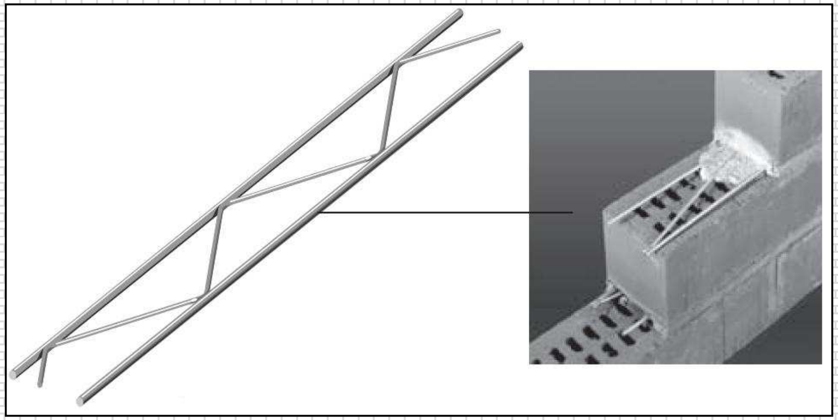


The schematic of the test setup



Further plans

- Wall without reinforcement
- Wall with vertical reinforcement
- Wall with horizontal reinforcement
- Wall with horizontal and vertical reinforcement



Summary and conclusions

In the literature

- Experiments that use concrete hollow masonry bricks

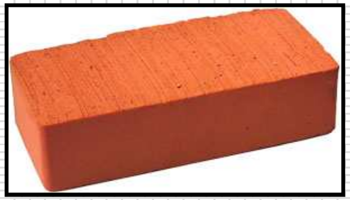
- Tests that possess of concrete grouting
- EC6 doesn't contain direction for: the size of pockets
- EC6 doesnt contain direction for: the amount of vertical steel that can be taken into account during shear

$V_{Ed} \leq V_{Rd1} + V_{Rd2}$ $\quad f_{vd} = \min(\text{inf.};\text{mas.})$

$V_{Rd1} = f_{vd} \cdot t \cdot l$ $\quad \boxed{V_{Rd2} = 0{,}9 \cdot A_{sw} \cdot f_{yd}}$

Current research

- Consist of clay solid bricks



- Are built with mortar grouting
- Can investigate the size of the pocket
- Would investigate the effect of vertical reinforcement

?????

Thank you for your kind attention!