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Horizontal stiffness of multi-storey timber buildings

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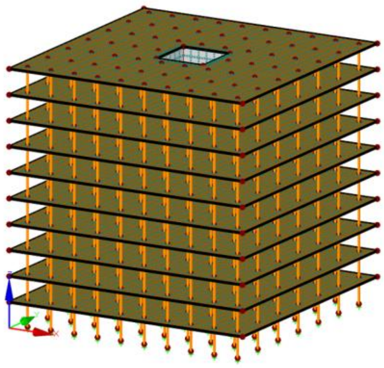
Abstract This thesis evaluates the effects of the position of the concrete core and its stiffness on the horizontal deformation of a multi-storey timber-concrete hybrid building. As part of the evaluation a calculation method with polynomial functions was derived to estimate the deformations of the highest slab due to a continuous horizontal surface load. The polynomial functions calculate the deformation in x- and y-direction on each point of the slab and depend on the position of the concrete core, its stiffness and the amount of horizontal loading. This allows to estimate the deformations efficiently when designing a building.

The effects of different concrete cores and positions were evaluated with the calculation method derived before. It was found that the position of the core further from the line of the resultant force yields higher deformations than a position on the line of the core. It was also found that the stiffness of the core has a significant effect on the deformation of the highest slab. The stiffness of the core was varied by different sizes of the core and different wall thicknesses. The result of the influences of these parameters were shown in maps, where the limits of the horizontal surface loads for each core position and stiffness are shown.

Parameters

Variable

- Position of the core
- Equivalent stiffness of the concrete core
- Amount of loading
- Floor plan: 30m x 30m; 20m x 45m



Fixed

- Height: 30 m
- Columns: 20/24 GL28h
- Raster: 3m x 4.5m
- CLT-slabs: 280 mm
- Line hinges on the concrete core
- No plate elements
- Horizontal surface load in y-direction
- FE grid: 99 x 99

Polynomial fitting

The polynomial fitting is done for the deformation of the highest slab due to a constant horizontal surface load.

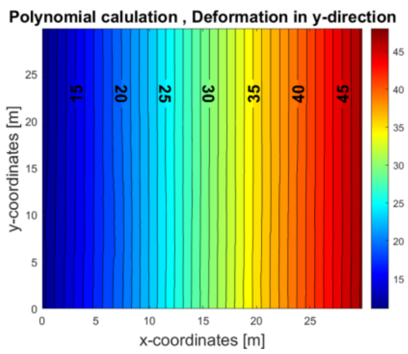
The steps of the fitting:

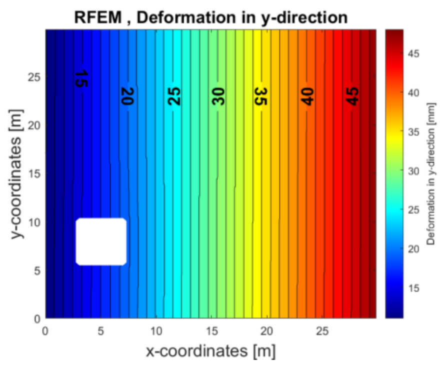
1. Fitting of the polynomial functions with constant loading and concrete core
2. Adjusting the function to the amount of loading
3. Adjusting the equivalent stiffness of the concrete core.

The base values used are:

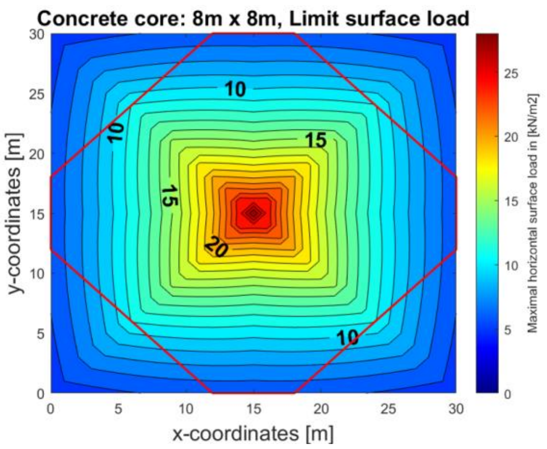
$EI_{ers,base}$ = 675'000 MNm^2 (core of 6m x 6m)

q_{base} = 3 kN/m^2





$$DEF_{x,y} = \frac{EI_{ers}}{EI_{ers,base}} \cdot \frac{q}{q_{base}} \cdot (a_{x,y} + b_{x,y} \cdot x + c_{x,y} \cdot y + d_{x,y} \cdot x^2 + e_{x,y} \cdot x \cdot y + f_{x,y} \cdot y^2 + g_{x,y} \cdot x^3 + h_{x,y} \cdot x^2 \cdot y + i_{x,y} \cdot x \cdot y^2)$$



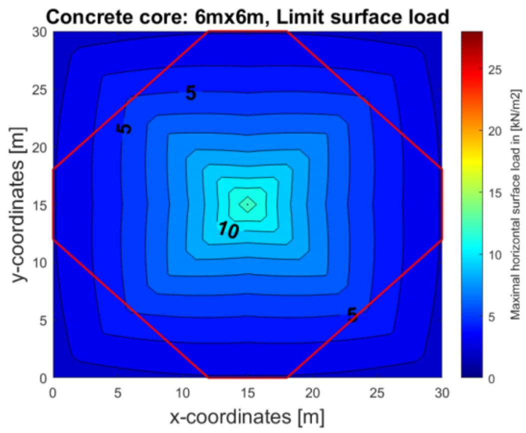
Results

Use of the polynomial function:

1. Quick evaluation of the deformation of the highest slab to check the limits
2. Determination of the maximal deformations
3. The creation of maps with the horizontal surface load limits according to the limit of deformation of:

   H/300 = 100 mm

4. Fire escape limit of 35 m shown with the red line



Limitations

Limitations regarding the use of the polynomial function:

1. The geometry of the building
2. The concrete core regarding openings and connections
3. The horizontal surface load
4. The slab parameters
5. The plate elements in the slab
6. The floor plan