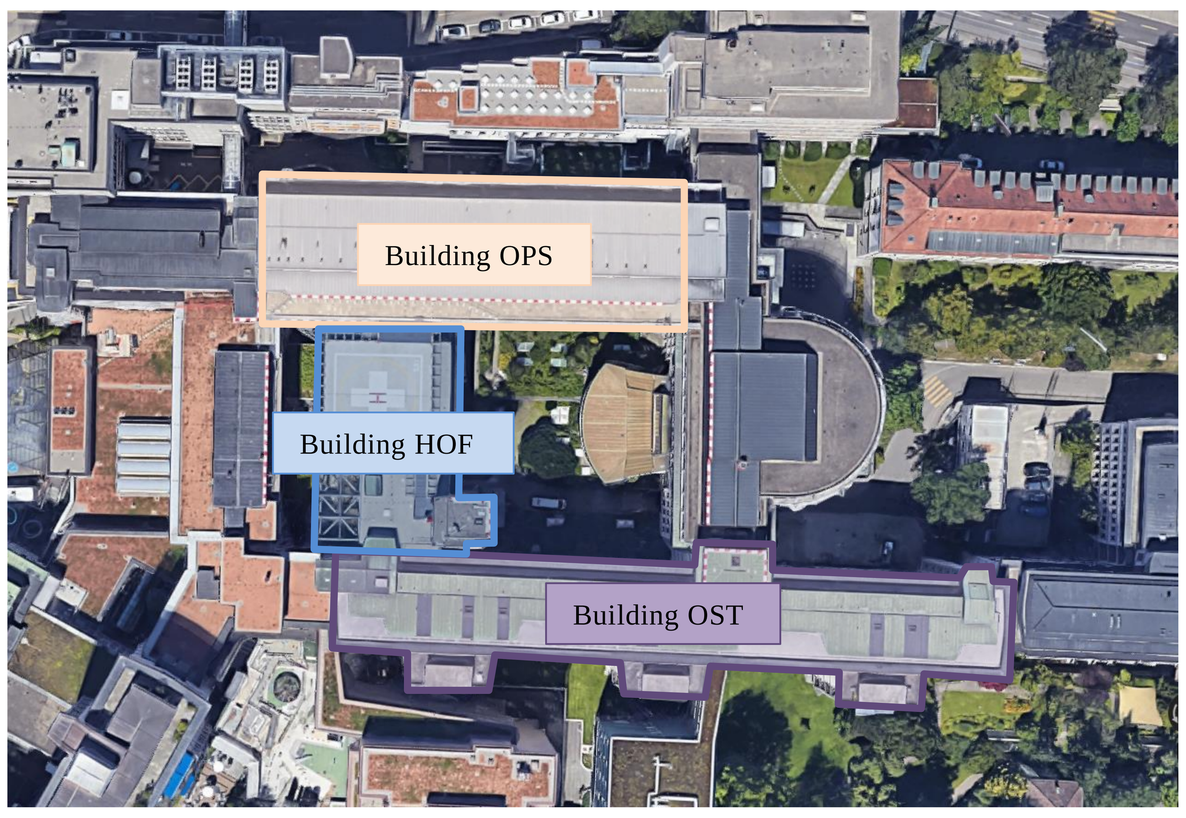
HSLU Hochschule Luzern

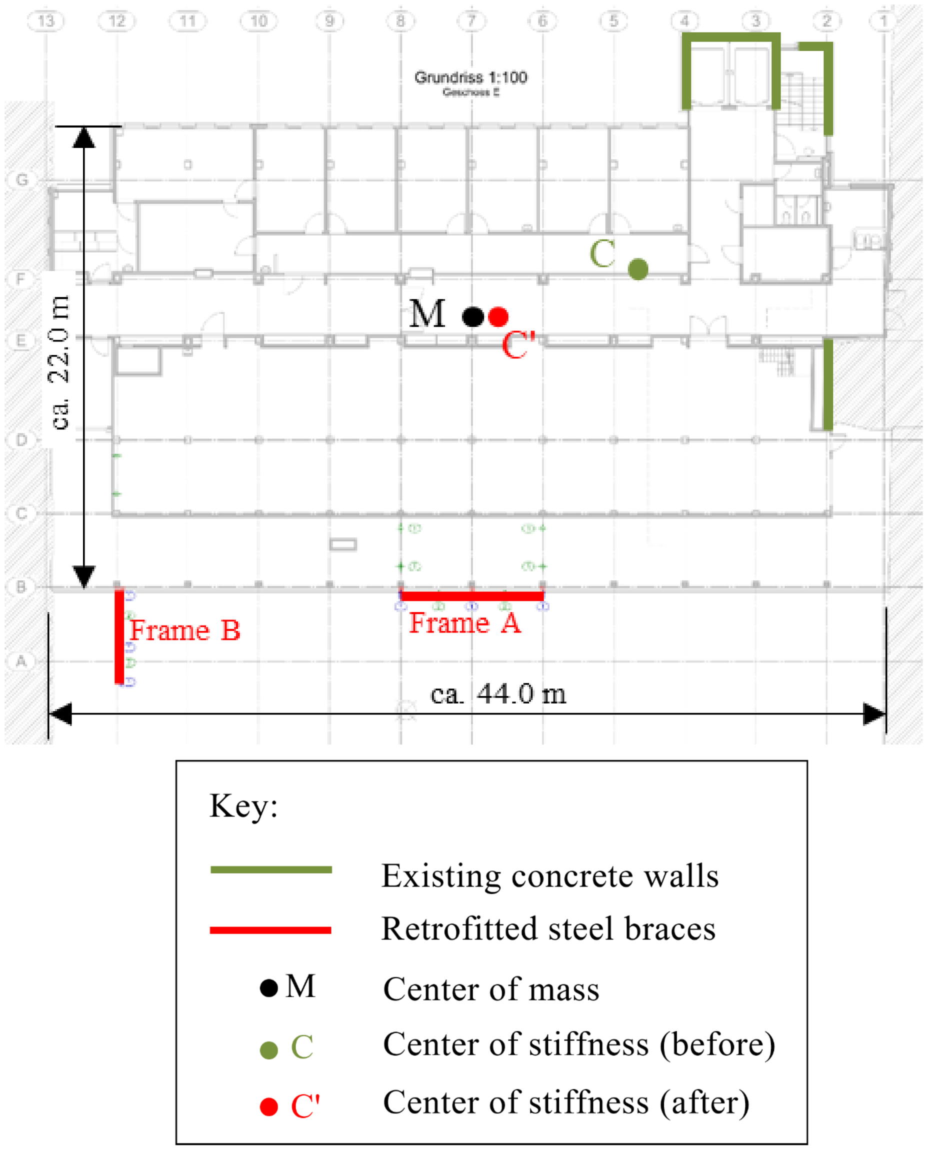
Technik & Architektur
Konstruktion und Tragwerk
Master-Thesis

Master of science in engineering

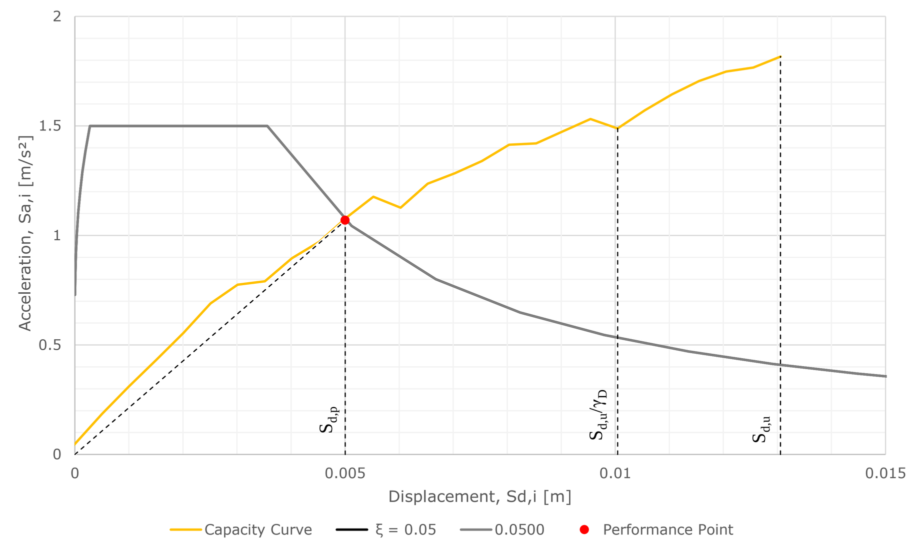
Seismic retrofitting of existing buildings with steel frames and their anchoring



Overview of the University Hospital Zurich



Floor plan with lateral resisting elements



Building capacity in the ADRS format (X-direction), damping=5%, Zone: Z1a, BGK: A, BWK III (γD=1.3) SIA (2020)

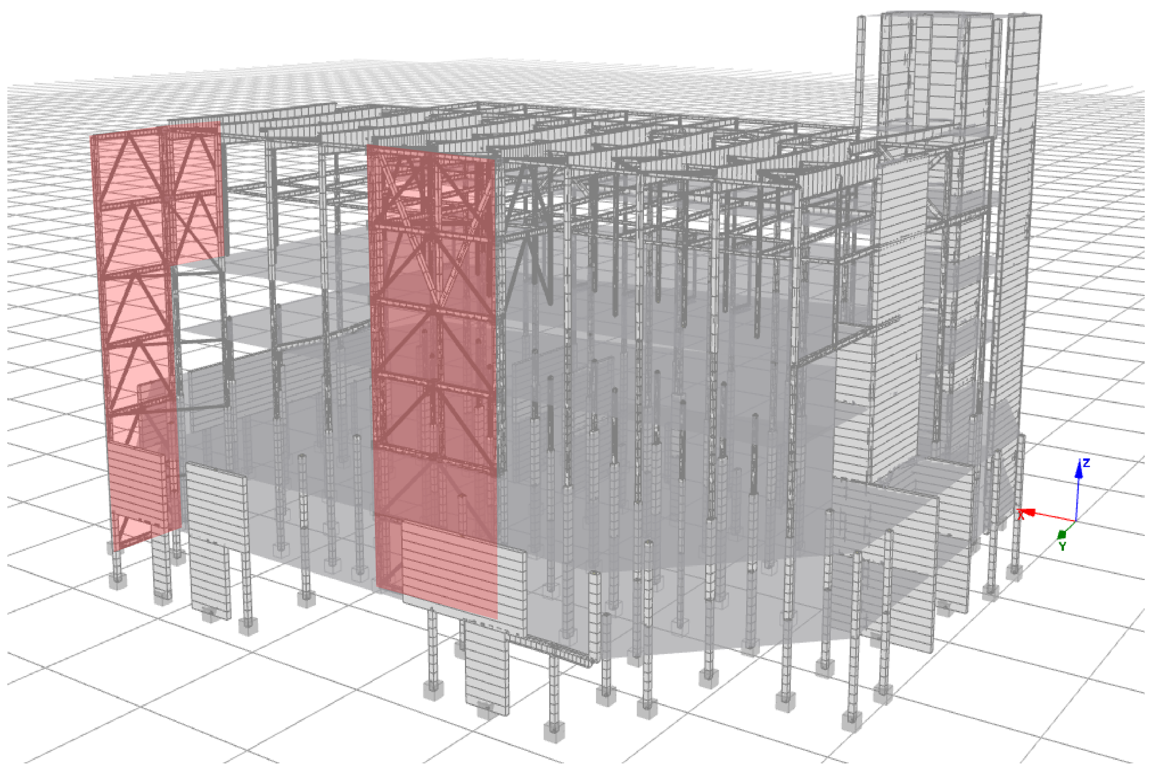
Before retrofitting (dominated by torsion vibration)

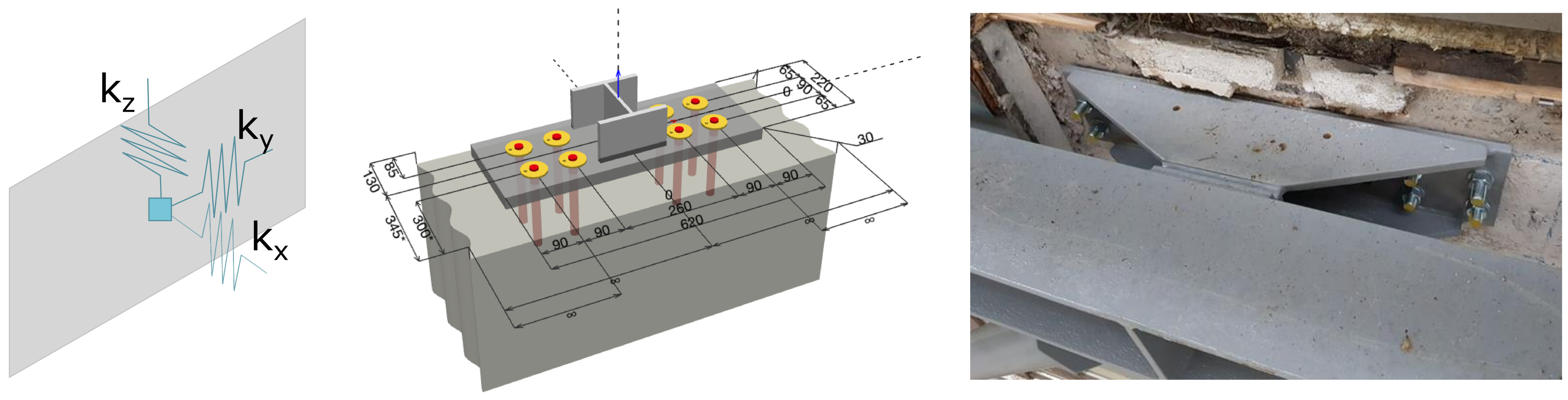
Mode	Period [s]	[eff. mod. mass in x]	[eff. mod. mass in y]
1	2,264	17,08%	21,70%
2	1,751	39,15%	13,13%

After retrofitting (dominated by vibrations in x- and y-direction)

Mode	Period [s]	[eff. mod. mass in x]	[eff. mod. mass in y]
1	1,407	48,49%	3,28%
3	1,071	2,94%	54,70%

Effective modal mass in percentage before and after retrofitting (main modes in X- and Y-direction)


3D model of the building with the retrofitting steel frames in red in SeismoStruct



Post-installed steel-concrete connection of the hospital building HOF, spring stiffness (axial and shear) in x,y,z direction (left), calculation tool (middle), execution (right)

Context

The construction industry undergoes continuous evolution. Emerging concerns such as sustainability and resource-efficient construction are gaining significant importance. Due to that, there is a growing emphasis on maximizing the lifespan of existing buildings, whenever feasible. However, many existing buildings do not meet the current design criteria for seismic design.
The correct modelling of the existing structure is central to efficient retrofitting. As a result, non-linear and deformation-based calculation methods are often used to analyze existing buildings compared to new buildings. In addition to modelling, the chosen retrofit strategy also plays a central role (e.g. strengthening, seismic damping, etc.) in the design.

Objective

The thesis will cover theoretical fundamentals such as analysis methods, reinforcement strategies, and subsequent anchoring. Additionally, the structural behavior of existing buildings will be illustrated through various examples.
The focus lies on the seismic strengthening strategy with external steel braces. Using the University Hospital of Zurich as an example, the accumulated knowledge was combined and implemented. This is a courtyard extension (HOF) of the hospital, which could not guarantee earthquake resistance due to its highly eccentric ground plan. Therefore, it was reinforced in 2020 with the help of external steel braces. This example was modelled in FE programs and recalculated with deformation-based calculation methods (pushover analysis). In addition, the influence of the connection stiffness between the existing building and the steel frame was investigated using this example.

Conclusion

Retrofitting with external steel trusses turned out to be a very effective strengthening measure that eliminated the strong eccentricity of the floor plan and thus made the building earthquake resistant. External steel trusses also brought some other advantages. The intervention in the structure could be kept to a minimum and the operation of the hospital was only slightly disturbed. In addition, the measures could be implemented quickly. In addition, it could be determined that the connection stiffness can certainly have an influence on the behavior of the overall structure and the connection forces.

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