A modifiable and optimized structural system for circular use of buildings made of precast concrete

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A modifiable and optimized structural system for circular use of buildings made of precast concrete

PROJECT

Industrial PhD

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Concrete is a widely used material in the building industry. In Denmark, precast concrete elements are commonly used for building structures. The tradition of precast concrete structures started in the 1950s, when industrialization and standardization of production methods were prominent. Since then, the production and construction of precast concrete structures for buildings has developed into an efficient industry with a skilled labor force and a wealth of accumulated knowledge. Furthermore, concrete has some beneficial material properties and performs well within technical requirements like durability, acoustic insulation, fire safety, and heat accumulation. For those reasons, concrete is often chosen as a material for structures in the tradition-driven construction industry.

However, concrete is also known as a material with high environmental impact, primarily due to the content of cement. With an urgent need to reduce greenhouse gas emissions, the building industry needs to rethink its construction methods to limit the use of concrete and implement a circular construction philosophy.

Precast concrete structures often consist of concrete walls, which serve multiple functions, from load-bearing, to room separations, sound isolation, and fire protection. Traditional concrete walls are often designed in a structurally inefficient manner, and they are not very flexible with respect to future building modifications.

In this project, we will delve into the limitations of a tradition-driven industry and rethink structural design to fit current well-known construction methods with the hope of developing a new and scalable approach that reduces material usage in the present and supports adaptable use of buildings in the future.

To this end, we have developed a new concept – precast modifiable concrete walls. The modifiable concrete walls are prepared for multiple future modification scenarios, such as merging adjacent apartments, transformation from housing to office space, or many other types of alterations or renovations which require new holes or door openings in existing concrete walls.

The modifiable concrete walls are designed with two zones: a stronger frame zone, and a flexible zone that can be removed in the future with no or little need to strengthen the structure. Furthermore, the structural design of the wall is optimized by use of computational methods to minimize the CO2 footprint.

Figure 1:

Illustration of the concept.

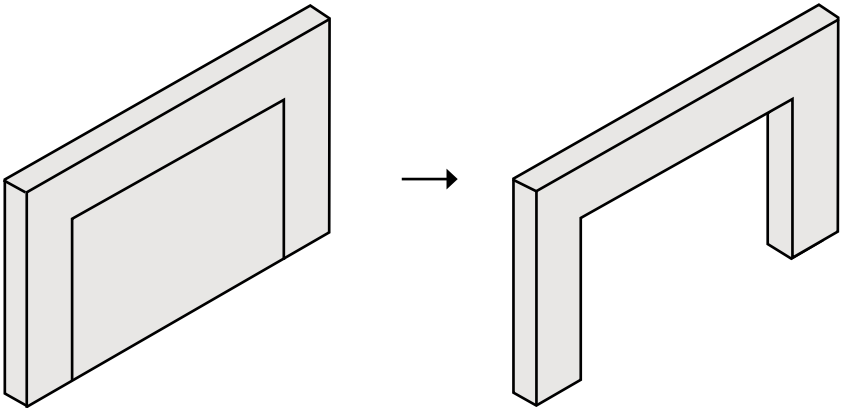

Figure 2:

A full scale modifiable wall element that is ready for testing.

Current analyses indicates, that there are potential CO2 savings in the range of 25 - 50% compared to a standard concrete wall, depending on specific conditions. A large part of the savings comes from using a very low strength concrete in the flexible zone, which reduces the amount of cement in the concrete mixture. However, the designs need to undergo further analysis throughout the project before practical application.

To develop solutions that can be produced with the quality required for practical application and commercialization, the production is tested at a concrete element factory. Furthermore, experimental tests of the wall elements are conducted to verify the analytical results.