

### Structural Design For Reuse Of Sawn Cast-In-Place Reinforced Concrete Components

#### Case study of a residential building structure and comparison to conventional construction method

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#### Introduction

The construction with reinforced concrete (RC) holds several challenges in terms of sustainability. In particular, the production of cement causes 8% of global CO<sub>2</sub>-emissions<sup>2</sup>. Moreover, concrete and mixed demolition account for approximately 50% of construction waste in Switzerland<sup>3</sup>. One approach to handle both these issues is the reuse of RC, where structural components are deconstructed at the end-of-life of a building and reassembled in a new structure. In this way, the production of new cement can be avoided and the quantity of construction waste is significantly reduced.

This thesis aims to show the feasibility of a building constructed from reclaimed cast-in-place RC elements and compare it to an equivalent conventional construction. For this purpose, the load-bearing system of a hypothetical target building is developed, considering two in-situ RC buildings as source buildings to extract the elements to be reused.

#### Design process

##### 1. Analyze the source buildings

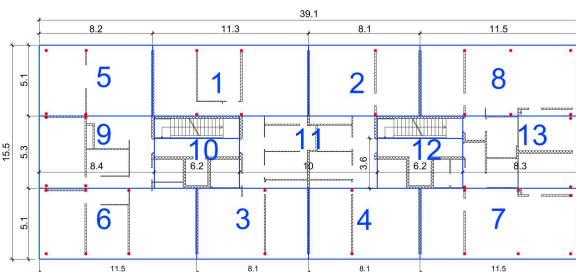
Material properties, dimensions, reinforcement layout, etc.

##### 2. Define a preliminary floor plan of the target building

Room layout, loads, limit states, etc.

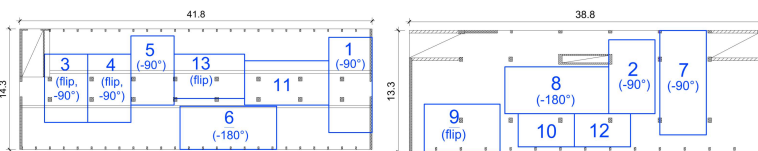
##### 3. Divide the target floor slab into elements, which are sought to be built in one piece

Consider the position of joints in the target building, limitations of maximum dimensions due to transportation and lifting capacity of cranes.



##### 4. Allocation of source slab elements to target slab

Find the best position to cut every target element on the source slabs minimizing the amount of required bending moment strengthening.



##### 5. Check deflections of the reassembled slab

Consider creep and cracking of the concrete. If the expected deflections are too large, either provide strengthening or modify the static system.

##### 6. Allocation of vertical load-bearing elements

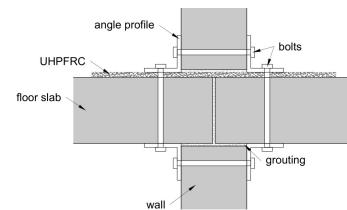
Allocate walls and columns based on structural and geometrical considerations.

##### 7. Check columns for second order effects

##### 8. Check punching resistance of reassembled floor slab

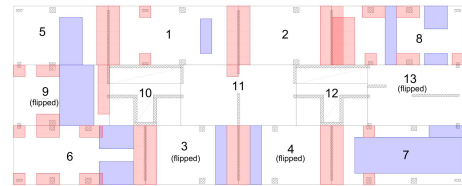
##### 9. Design connections for gravity loads

In this thesis, the sought force transmission mechanism is equivalent to the case where the slab is continuous, i.e. a negative bending moment is transferred from one slab element to the other. The chosen connection detail consists of angle profiles bolted along the interface to avoid the relative displacement of the walls. A layer of UHPFRC<sup>(\*)</sup> on the upper surface serves to transfer tension forces across the support.



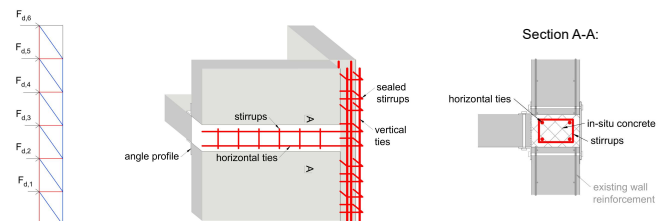
##### 10. Design strengthening measures

In the context of this thesis, the required structural strengthening is provided using (R-)UHPFRC<sup>(\*)</sup> as it allows strengthening the floor slab in two directions simultaneously. The target slab might need strengthening on the bottom (blue) or the top (red) surface.

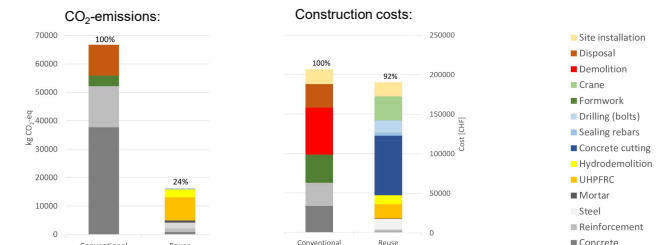


##### 11. Seismic verifications

If the elements of the lateral bracing system are built from reclaimed elements, the cross-sectional resistance of the core is not sufficient. Therefore, each core wall is built as a truss system over the height of the building, where ties are introduced at every floor level by casting an in-situ beam in between the walls.



##### 12. Assessment and comparison to conventional construction method



#### Discussion and conclusion

The thesis shows the potential of reuse to reduce the ecological footprint of RC construction without causing significant additional costs (if demolition and disposal of obsolete materials are included). However, some questions remain open as to the applicability of current design standards to reused structural elements or the influence of long-term effects on the reclaimed concrete.

<sup>(\*)</sup> (Reinforced) Ultra-High Performance Fiber Reinforced Cementitious Composites

#### References

- J. Lehne and F. Preston, Making Concrete Change: Innovation in Low-carbon Cement and Concrete, Jun. 2018. [Online]. Available: <https://www.chathamhouse.org/2018/06/making-concrete-change-innovation-low-carbon-cement-and-concrete> (visited on 12/22/2021).
- Wüst&Partner, "Bauabfälle in der Schweiz - Hochbau Studie 2015", Zürich, Schlussbericht, Sep. 2015.