ReCast Floors

Seismic Assessment and Retrofit Development of Precast Floors

Mostafa M[1], Bueker F[1], Parr M[2], Jenkins M[1], Sarkis Fernandez A[2], Hogan L[1], Elwood K[1], Bull D[3], Brooke N[4], Henry R[1], Sullivan T[2], Liu A[5]

[1] University of Auckland, [2] University of Canterbury, [3] Holmes Consulting, [4] Compusoft Engineering, [5] BRANZ

1. Motivation

Precast floors are the dominant flooring system in New Zealand's multi-storey buildings stock, where hollow-core floors are the most ubiquitous flooring system. Following the 2016 Kaikoura Earthquake, significant damage was observed in multiple buildings that incorporated hollow-core floors. Hollow-core flooring systems vulnerability in regions of high seismicity was reinforced, and concerns regarding the performance of these floors in future seismic events were confirmed.

As a response to those concerns the 'ReCast Floors' research group was formed with the objectives of improving the current understanding of the seismic performance of precast floors and develop suitable, tested retrofit techniques. Results of the experimental investigations undertaken by the 'ReCast Floors' project so far are presented herein.

2. Project Overview

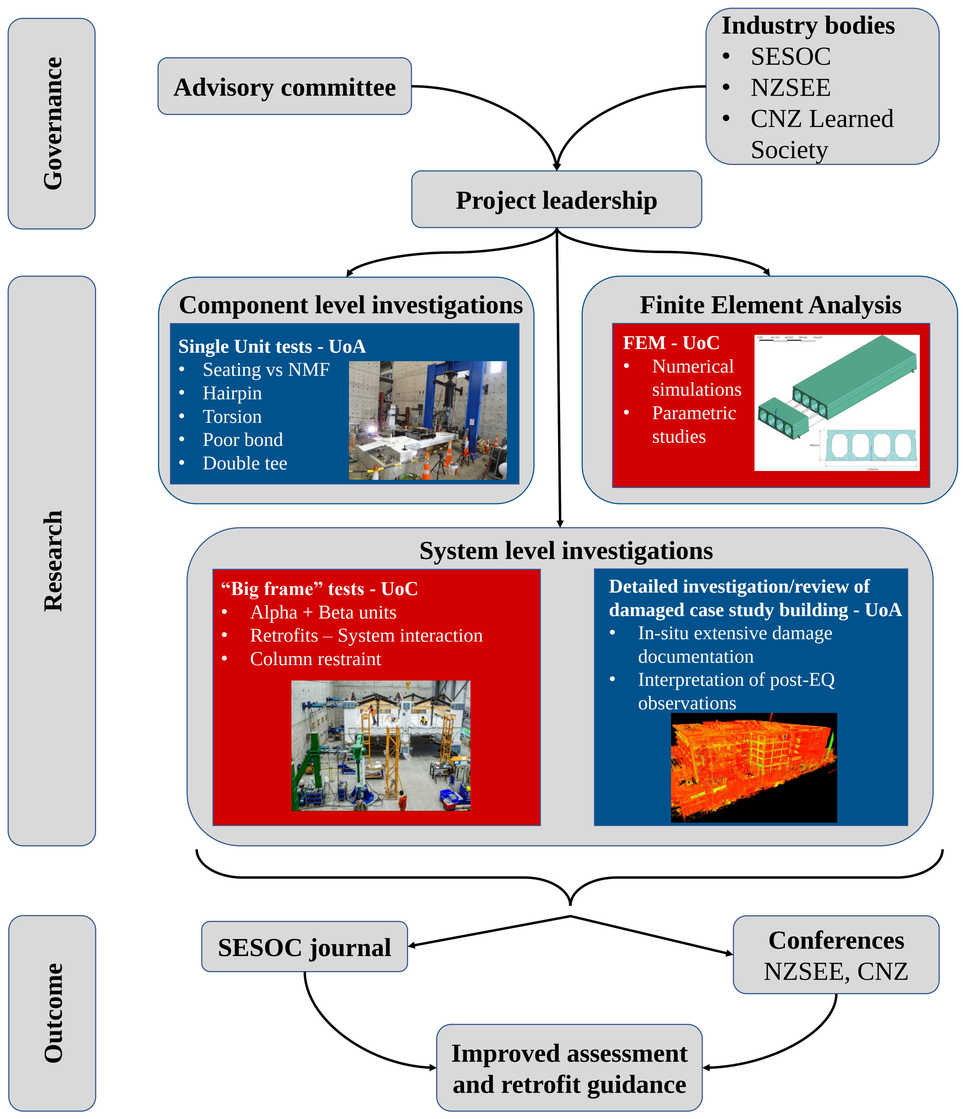


Fig.1 Schematic illustration of project organization

3. System Level Testing

- Two full scale specimens "*Big frame*" tests representing part of the floor and support structure of a typical frame building (Fig. 2a,b) have been planned to take part of this project.
- The first "Big frame" test had the key objective of experimentally validating some of the commonly used hollow-core floor retrofit solutions that have been already incorporated in existing buildings and some suggested retrofit solutions from previous research (Fig. 3a).

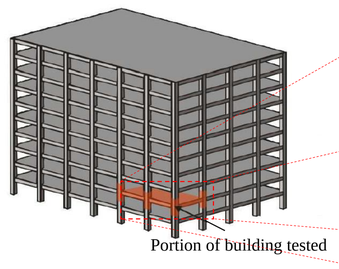


Fig. 2a Prototype building used to replicate floor portion (Woods, 2008)

Fig. 2b Specimen "Big frame test 1" while preparation

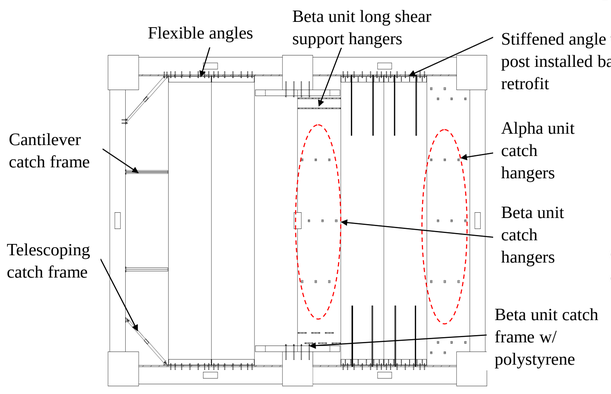


Fig. 3a Plan view of first "Big Frame" retrofits tested

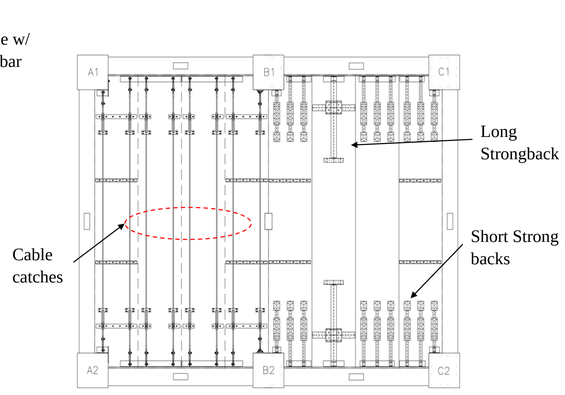


Fig. 3b Plan view of second "Big Frame" retrofits tested

- Second Big Frame test is currently being prepared and scheduled for January 2021.
- Key objective of the second test is to experimentally validate new hollow-core floor retrofit solutions that have been developed by the ReCast team.
- Cable catch retrofit (Fig. 4a) [Catch the floor in case it drops during an earthquake]
- Strong backs (Fig. 4b) [I-beams under the flooring units and seated on a steel angle]

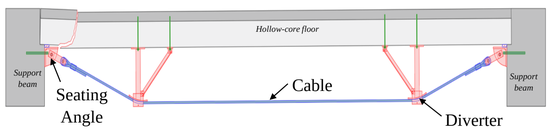


Fig. 4a Cable Catch Retrofit (Side view)

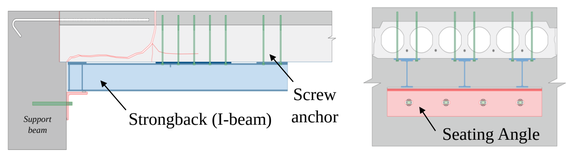


Fig. 4b Strongback Retrofit (Side and section view)

4. Field Investigation

- Detailed review of a case study building that was damaged during the Kaikoura earthquake is currently taking place.
- Extensive damage documentation of the entire bare structure of the case study building has been conducted.
- Severity and distribution of the damage sustained in the building was captured by utilizing some of the available technologies as shown in Fig.5 and 6 respectively (laser scanning and structure from motion techniques).
- This investigation will allow better understanding of the observed performance of buildings with precast floors.

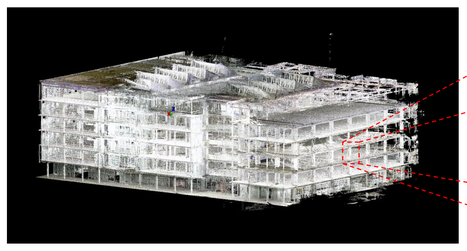


Fig. 5 Registered point cloud of the case study building (Mostafa et. al 2020)

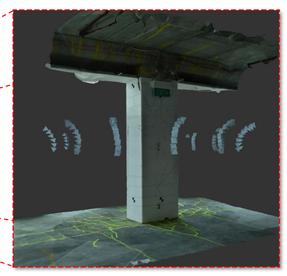


Fig. 6 Structure from motion result for a region of interest

5. Double-Tee Floors

- The collapse of precast double-tee units in Statistics House (Wellington) during the Kaikoura Earthquake in 2016 reinforced concerns about floor to support connection. These units included the "loop bar" support detail (Fig. 7), which had rising concern due to the unfavourable tension load path the loop bars generated across the topping interface (Fig. 8).

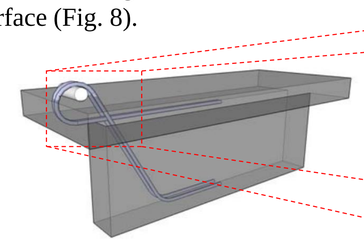


Fig. 7 Loop bar detail (Hare et. al 2009)

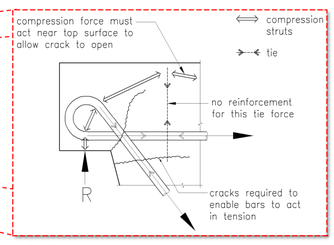
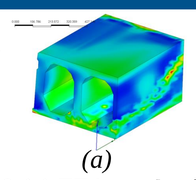


Fig. 8 Load path through the loop bars generated across the topping interface (Hare et. al 2009)

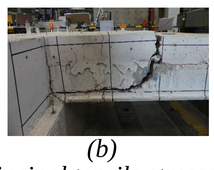
- Experiments on "loop bar" double tees to improve our understanding of the potential seismic support spalling and the effect of delamination on the gravity capacity of the precast units.
- These tests will be conducted in conjunction with retrofit testing.
- The investigation is expected to conclude midway through 2021.

6. FEM and Component Level Testing

- Detailed nonlinear finite element (FE) analyses, validated against experimental data are currently taking place.
- Component testing is underway to investigate various failure modes and retrofits to address them.



(a)



(b)

Fig.9 (a) FEA result of principal tensile stresses (b) NMF component test

7. Conclusion

Output from the ReCast floors project have direct impact on the precast concrete industry with key objectives of:

- Providing properly validated retrofit solutions for precast floors to the construction industry.
- Provide a new State-Of-The-Art precast floors retrofit design guideline.
- Provide better understanding of the seismic behavior of precast floors to inform the current precast floors assessment guidelines with the purpose of amending as necessary.

References

Woods, L. J. (2008). The Significance of Negative Bending Moments In The Seismic Performance of Hollow-core Flooring [Master of Engineering]. University of Canterbury.

Mostafa, M., Hogan, L. S., Stephens, M., Olsen, M. J., & Elwood, K. (2020, September). *Evaluating State-Of-The-Art Methodologies For Post- Earthquake Structural Reconnaissance*. 17 World Conference on Earthquake Engineering, Japan.

Hare, J., Fenwick, R., Bull, D., Built, R., & Fulford, R. (2009). Precast Double Tee Support systems. *Structural Engineering Society New Zealand*, *2*(3), 16.

Acknowledgement

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