Wall-to-floor connection behavior in a low-damage concrete wall building

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Abstract

Following the 2010/2011 Canterbury earthquakes, approximately 60% of multi-story buildings with reinforced concrete walls required demolition. Both practitioners and researchers have increasingly realized that low-damage structural systems could be an alternative to improve the seismic behavior of concrete buildings and to reduce the economic and social impact of structural damage in future earthquakes. To verify the seismic response of a low-damage concrete wall building representing state-of-art design practice, a shake table test on a two-story concrete building was recently conducted as part of an ILEE-QuakeCoRE collaborative research program. The building utilized flexible wall-to-floor connections in the long span direction and isolating wall-to-floor devices in the short span direction to provide a comparison of their respective behavior. Additionally, the wall-to-floor interaction such as effects of wall uplift on the link slab, quantification of gap in the tongue connection, and acceleration transfer mechanism from floor to the wall are discussed.

Wall-to-floor connection

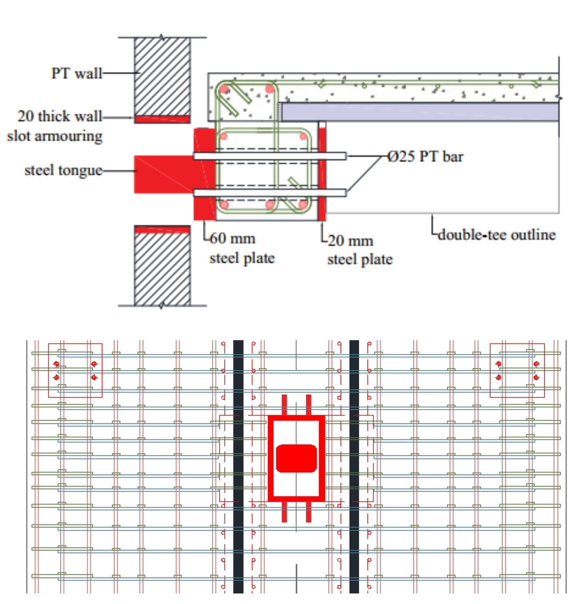

Figure 1. Isolated connection

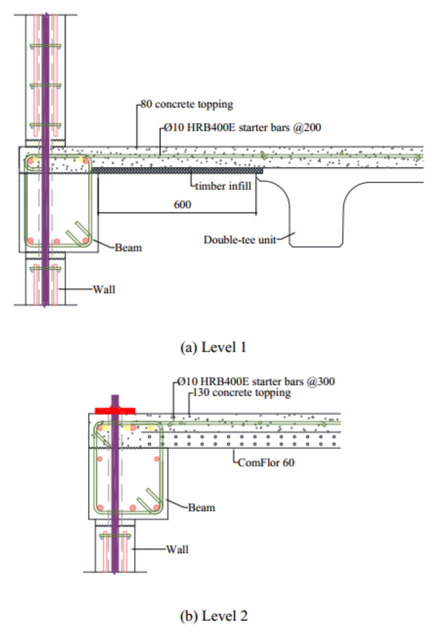

Figure 2. Flexible connection

Two alternative wall-to-floor connections were implemented to accommodate the potential displacement incompatibility as the wall uplifts. Isolated wall-to-floor connections were used for the Grid A and C walls in the transverse direction. A steel tongue that was embedded in the beam extended out into an armoured slot that was cast in the wall panels. The tongue allowed for lateral force transfer to the PT wall but was free to slide vertically with sufficient travel. An initial 10 mm gap was designed into the steel tongue connection for tolerance that was later filled with high density plastic shims. Flexible wall-to-floor connection was used for the Grid 1 and 3 walls in the longitudinal direction that were designed to be stiff enough to transfer in-plane diaphragm loads while being flexible in the out-of-plane direction to accommodate wall uplift and rotation. On Level 1, a 600 mm wide and 80 mm thick link slab was located between the wall and the first double tee unit, and on level 2 the composite floor provided sufficient flexibility when spanning perpendicular to the wall.

Floor crack map

For the Level 1 floor the cracking was almost concentrated within the flexible link slabs. The distributed cracking in the link slab occurred as it accommodated the vertical deformations while the double tees remained stiff and undamaged. On the Level 2, the cracking extended from in the region adjacent to Walls 1 and 3 to the center of the floor. Although the cracking looks significant in the crack maps, the crack widths were typically narrow.

Table 1. Summary of width of floor cracks

		D1a-25%	D1a-100%	D2-100%	D2-180%	D3-150%
Floor cracks	Max	0.2 mm	0.4 mm	0.5 mm	1.0 mm	1.2 mm
	Typical	<0.1 mm	<0.2 mm	0.2 mm	0.2 mm	0.2 mm

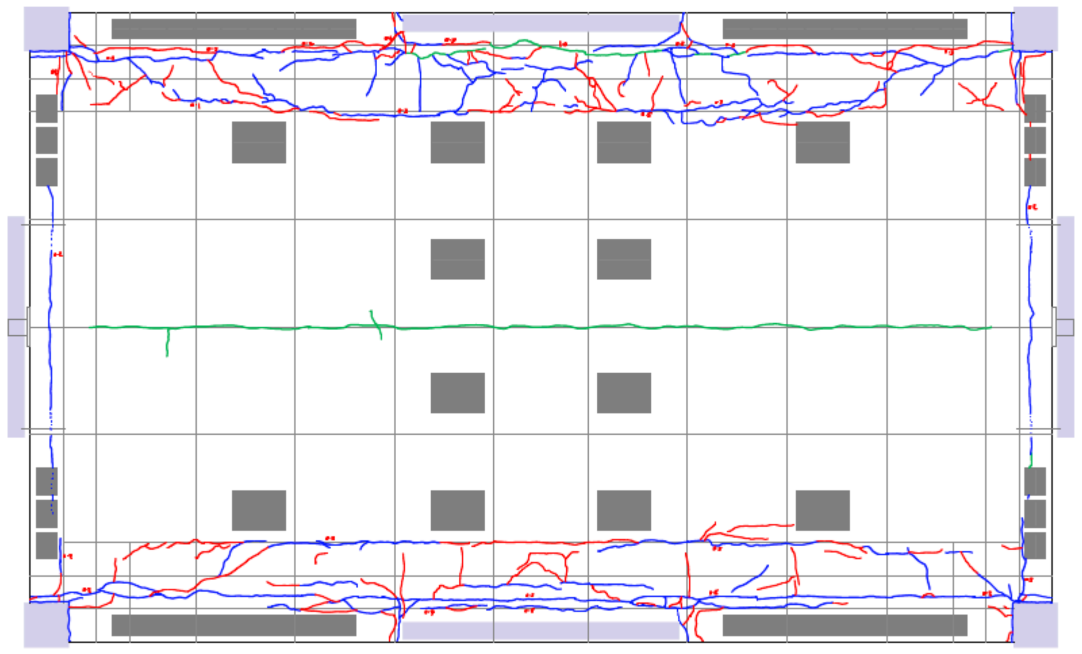

Figure 3. L1 crack map

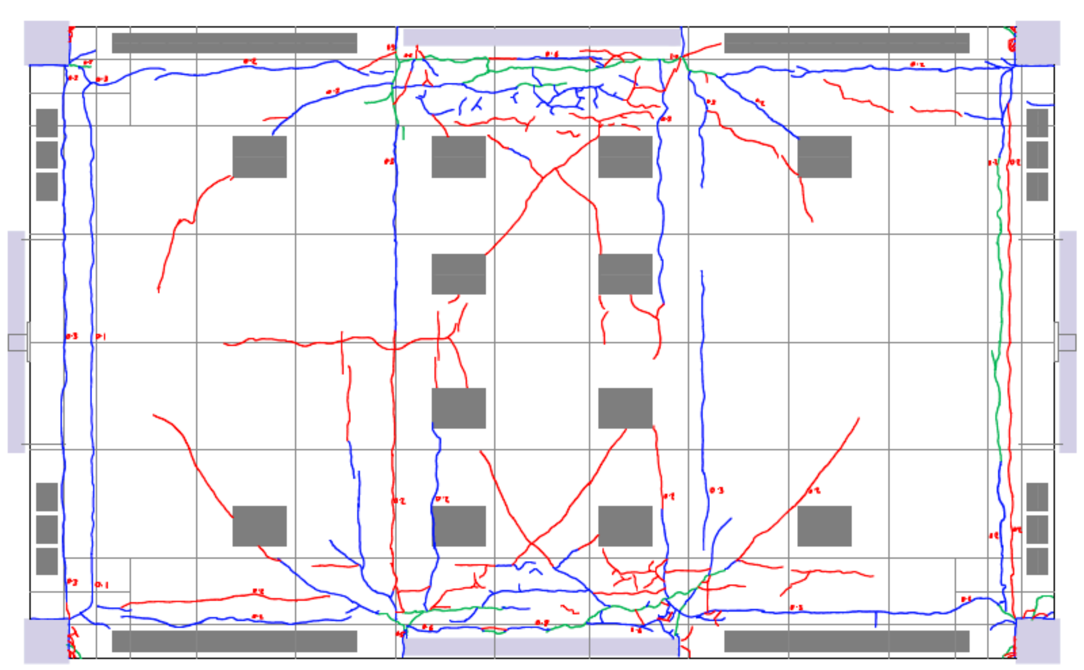

Figure 4. L2 crack map

Wall uplift accommodated by link slab

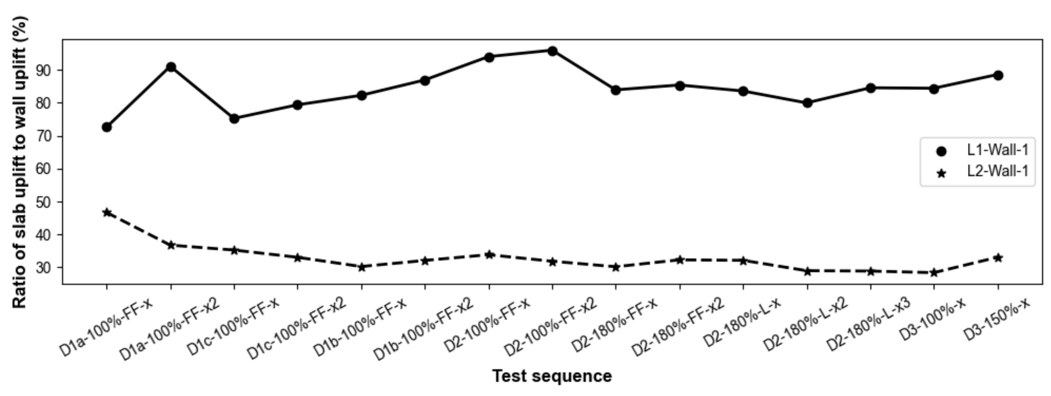

Figure 5. Ratio of slab uplift to wall uplift for x-directional tests

Link slab on level 1 averagely accommodated 85% of wall uplift while level 2 only averagely accommodated 35 % of wall uplift, which confirms that cracks extend to the floor center on level 2 while cracks almost concentrated within the link slab on level 1.

Tongue gap

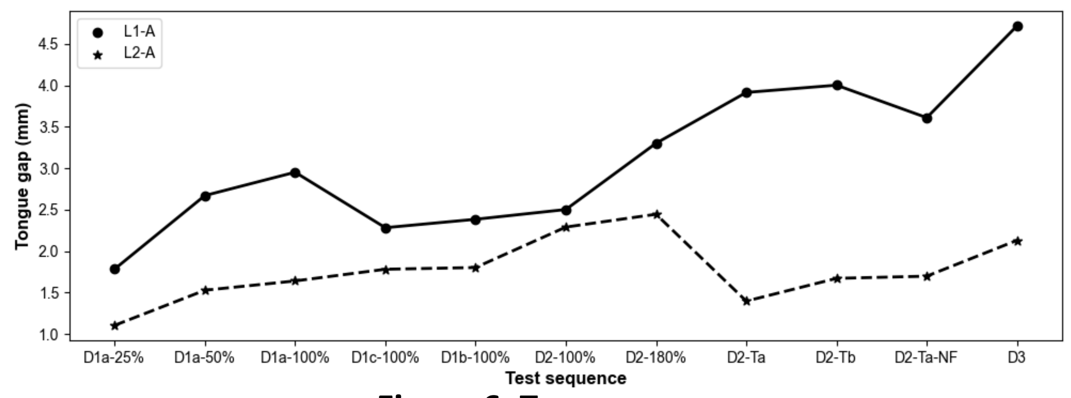

Figure 6. Tongue gap

The actual gap fluctuated throughout the test series. As test series progress, shims became squashed and bent, resulting in an increase in the gap. When shims were replaced, the gap reduced.

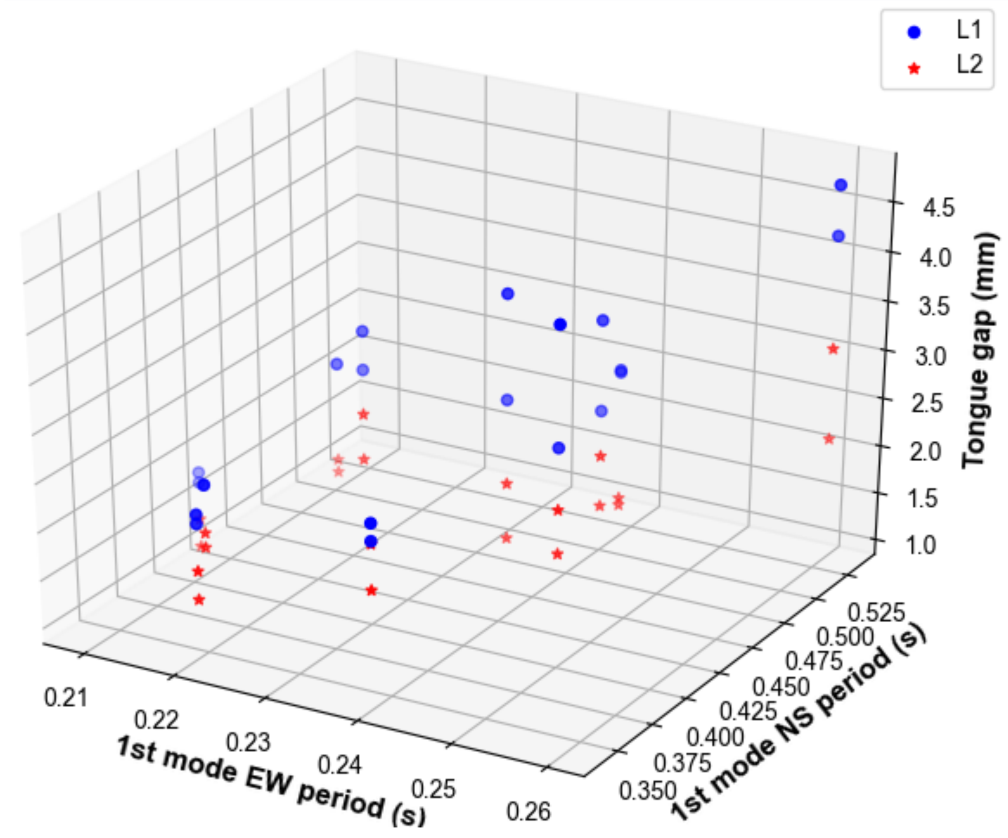

Figure 7. Relationship between tongue gap and building 1st mode period

- The 1st mode EW and NS periods increased with the increase of the gap.
- The increase of gap had less effect on the EW period than the NS period.

Acceleration transfer

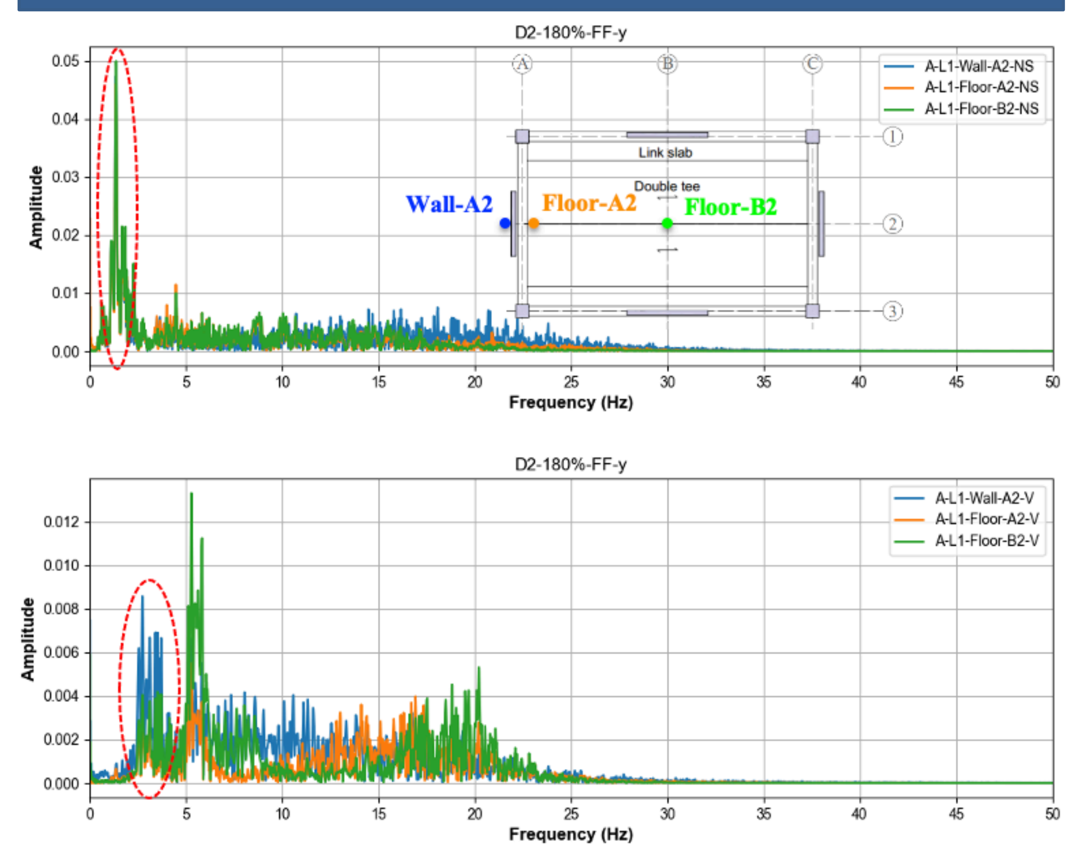

Figure 8. Fourier spectrum for y-directional accelerations from wall to floor in the isolated connection

For MCE y-directional test, the Fourier spectrum for y-directional accelerations reflects effect of tongue impact on the floor horizontal acceleration transfer. The Fourier spectrum also shows a similar pattern from wall to floor center, so the isolated connection can also transfer acceleration like the flexible connection but the amplitude is magnified due to the impact. The wall rocking frequency components significantly decayed due to free vertical sliding of the tongue.

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