SEISMIC RETROFIT OF SOFT-STORY TIMBER BUILDINGS WITH ENERGY DISSIPATING FLOOR-WALL CONNECTIONS

Asif Iqbal

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ABSTRACT

It has been well known through past earthquakes that building structures with the first story of relatively low stiffness compared to the upper stories has the potential to develop significant deformation and subsequent damage at the first story level. Recent research has also confirmed the necessity to retrofit these buildings for continued occupation and life safety.

A novel retrofit solution with energy dissipating connections between floor diaphragm and first story walls is presented. New walls structurally independent of the building structure will allow relative movements between the floor diaphragm and top of the walls. Mild steel elements within the connections are designed to yield under the relative movements between the diaphragm and the walls during seismic events and will dissipate energy through deformation and yielding of the mild steel (Figure 1). The connections are designed to act in all horizontal directions and are independent of any relative vertical movement between the two ends. Restraining blocks are added to the diaphragms to prevent excessive deformation relative to the walls. The details shown in Figure 1 are for a single wall but it can be modified as necessary for an assembly of walls either in the same plane or in a spatial distribution. The details including number, location and shape of the energy dissipating elements and the restraint blocks have to be modified for such cases. The connections allow the yielding element to be replaced easily after a major earthquake. Other detailing requirements for the scheme are also discussed.

The details can be modified as necessary for an assembly of walls either in the same plane or in a spatial distribution. An example is shown in Figure 2 and Figure 3 for two walls in orthogonal directions. The only modification for this case is the shape of the shared restraint block at the corner. Similar adjustments in locations of the restraint blocks and the dissipating elements can be made to suit particular arrangements of shear walls in a building without compromising the purpose and effectiveness of the underlying concept and energy dissipating mechanism.

Figure 1: Details of the timber shear wall and energy dissipation element for a single wall

1 Asif Iqbal, Senior Engineer, Structural Engineer, BRANZ Ltd., Wellington, New Zealand. Email: asif.iqbal@branz.co.nz
The energy dissipating elements can be used in multi-storied buildings with a shear core made of either individual panels or an assembly of the panels joined together. For the first case the two closely-spaced individual panels can be joined together with a single tapered element and a shared restraint block (Figure 4). When the shear core is formed by a group of shear walls joined together (Figure 5) the energy dissipating elements just connect the core with ceiling above. With the assembly of shear walls the core will have higher strength and stiffness compared the other case and the restraint may not be necessary.

The shear walls have to be independent of the main building structure at the ground level. The floor diaphragm energy dissipators connect to have to be strong enough to transfer the interstory shear forces without damage. The energy dissipators have to be designed to act in distinct ways for different performance levels for the structure. In a minor earthquake, they will remain elastic with no or very little residual reformation. In a moderate earthquake, some of them may yield but displacement limits should be exhausted. In a major earthquake, most or all of the dissipators may yield but any major damage to the walls has to be prevented. The system may not have enough re-centering capacity to bring the structure to the original position after a major earthquake necessary provisions for external re-centering should be kept from before. The steel bars have to be easily replaceable after damage but the fixing plates should not be damaged under any circumstance.

The area of the wall expected to come into contact with the steel connection plate is intended to have some local damage to absorb energy but global damage and potential instability of any wall is unacceptable. The foundations of the shear walls have to be designed to transfer the full forces considering the possibility of rocking at the base.