A simple and rapid approach for the numerical simulation of non-linear elements and examples of its application

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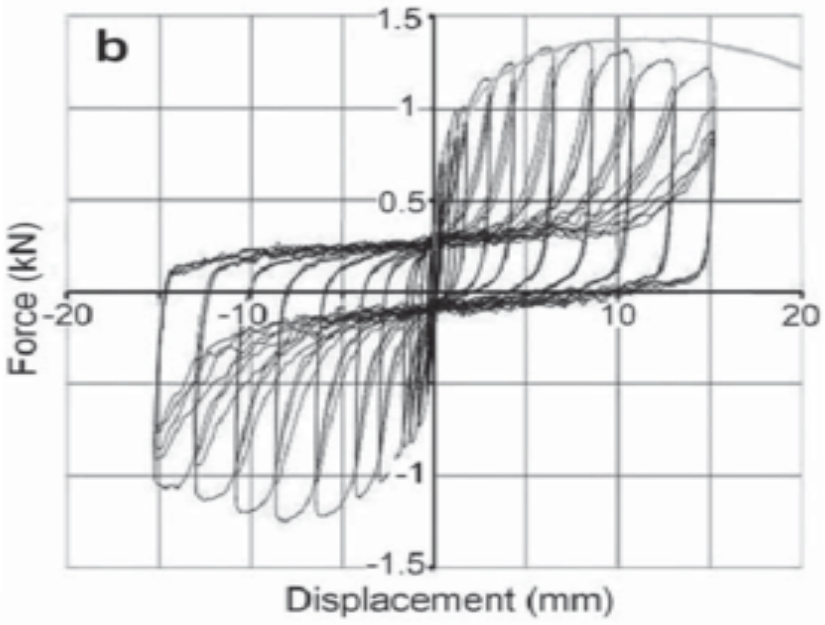
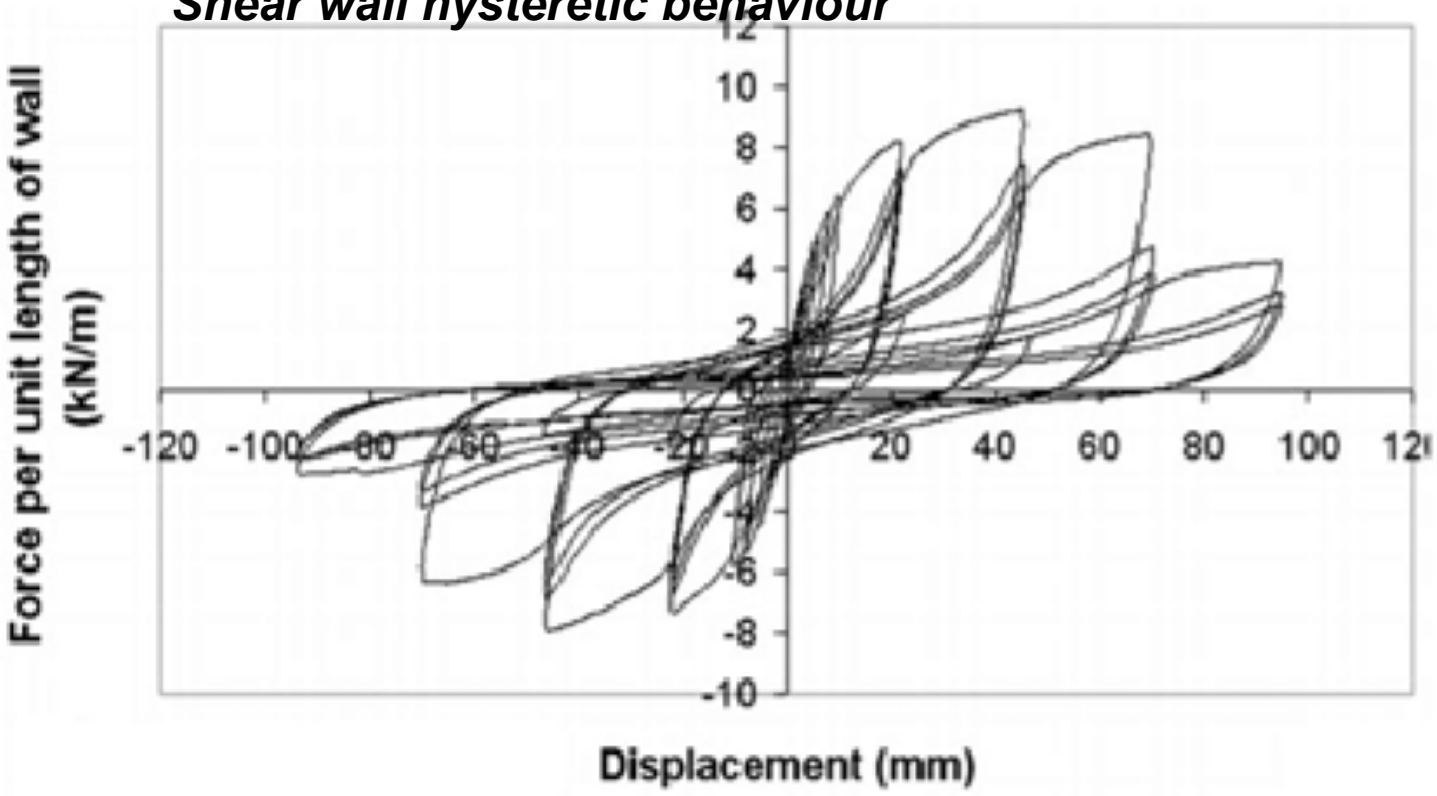
Pinched hysteretic behavior of nails reflected in hysteretic behavior of shear walls

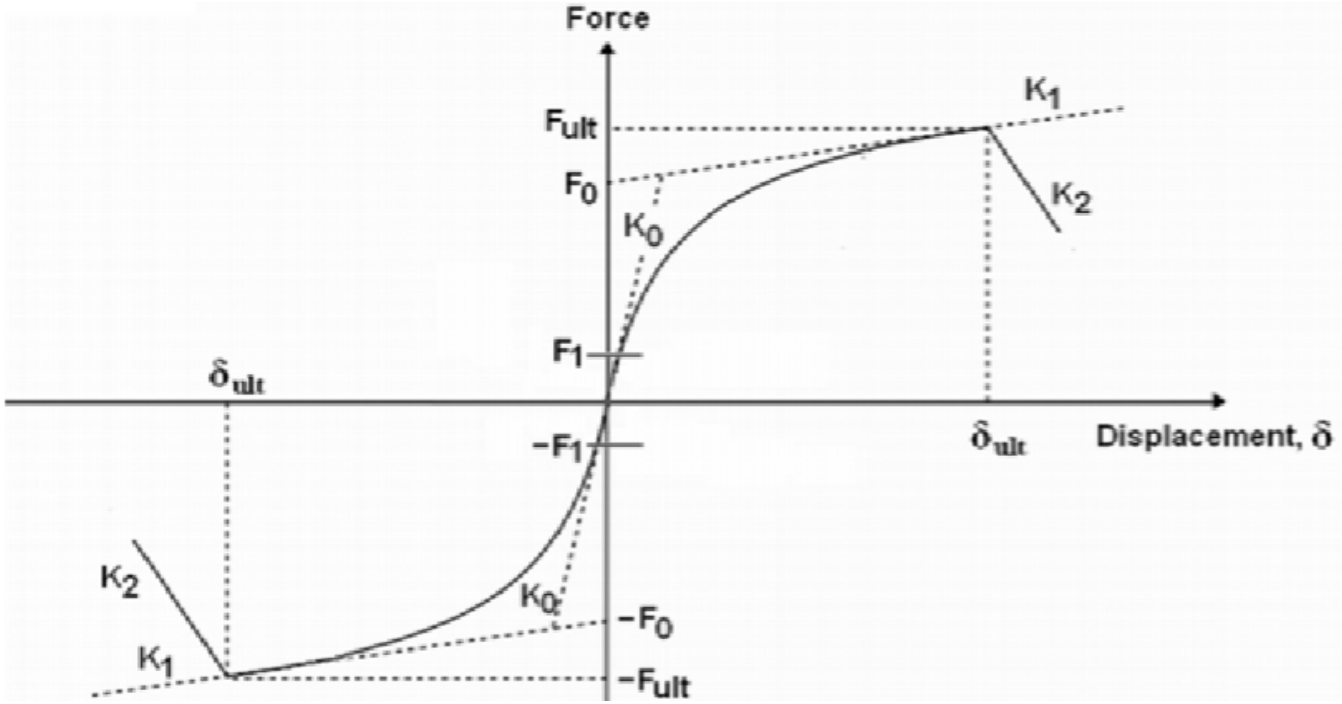
Typical nail hysteretic behaviour



Shear wall hysteretic behaviour



Backbone curve of fastener through wood



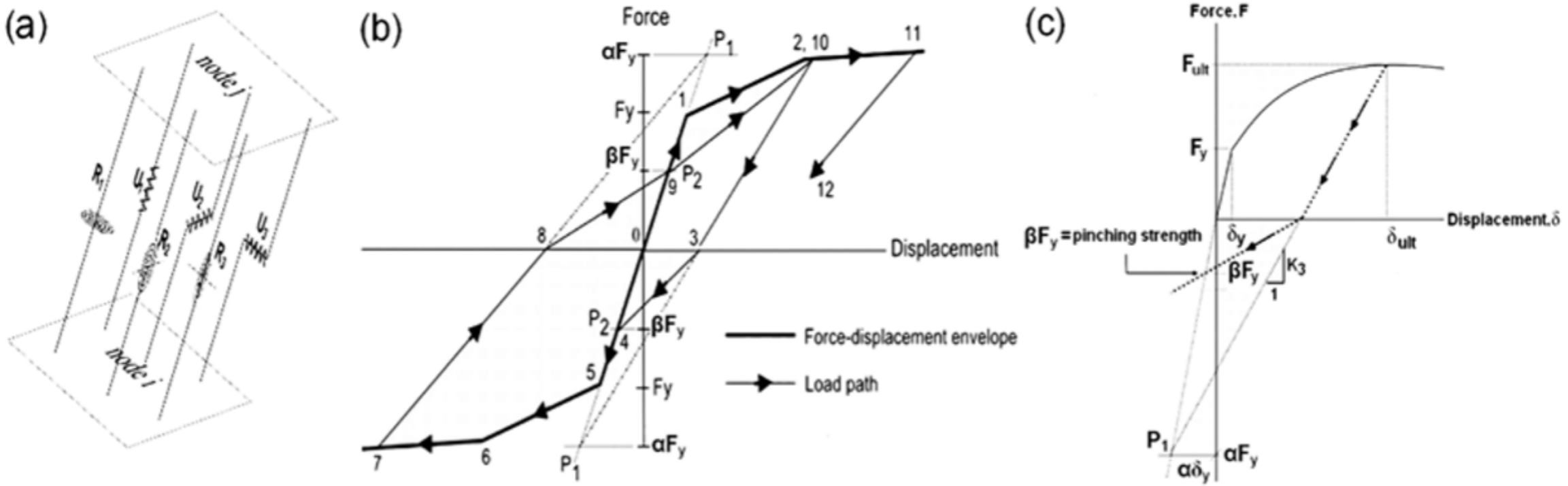
The benchmark force-displacement relationship for modelling nails, will take the form of the well-known Foschi exponential curve (Dolan and Madsen 1992). Eq. (1) describes the curve between zero and ultimate displacement, δ_{ult}

$$Force = (F_0 + K_1\delta)\cdot[1-\exp(-K_0\delta/F_0)] \quad (1)$$

and Eq. (2) describes the relationship for displacements beyond δ_{ult}

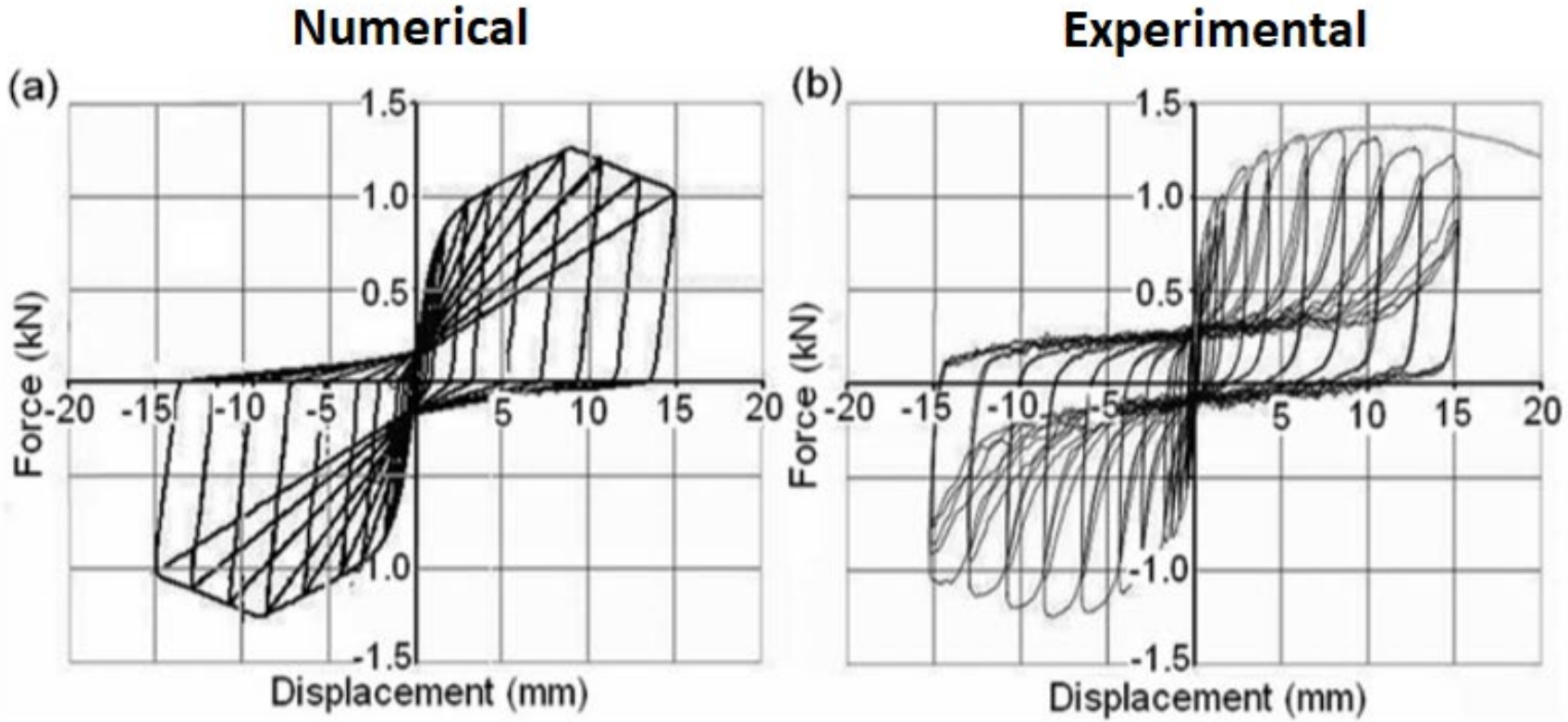
$$Force = K_2\delta + (F_{ult} - K_2\delta_{ult}) \quad (2)$$

Hysteretic behavior modelled by single link element



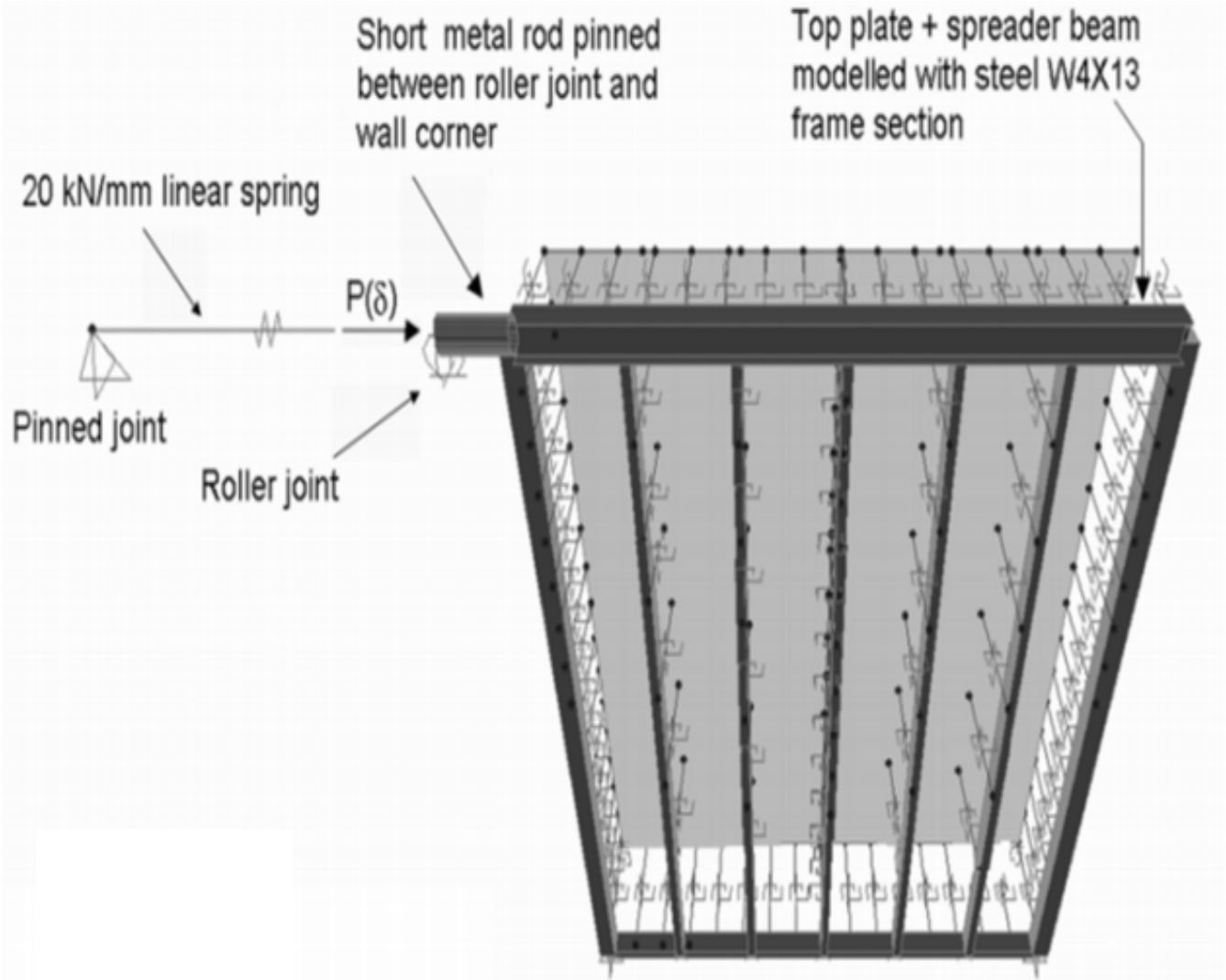
Nail connection (a) multilinear plastic link element adopted consists of translational and rotational springs (b) multi-linear plastic link –'pivot' hysteresis type, and (c) determination of hysteresis parameters α, and β

Hysteretic behavior modelled by single link element

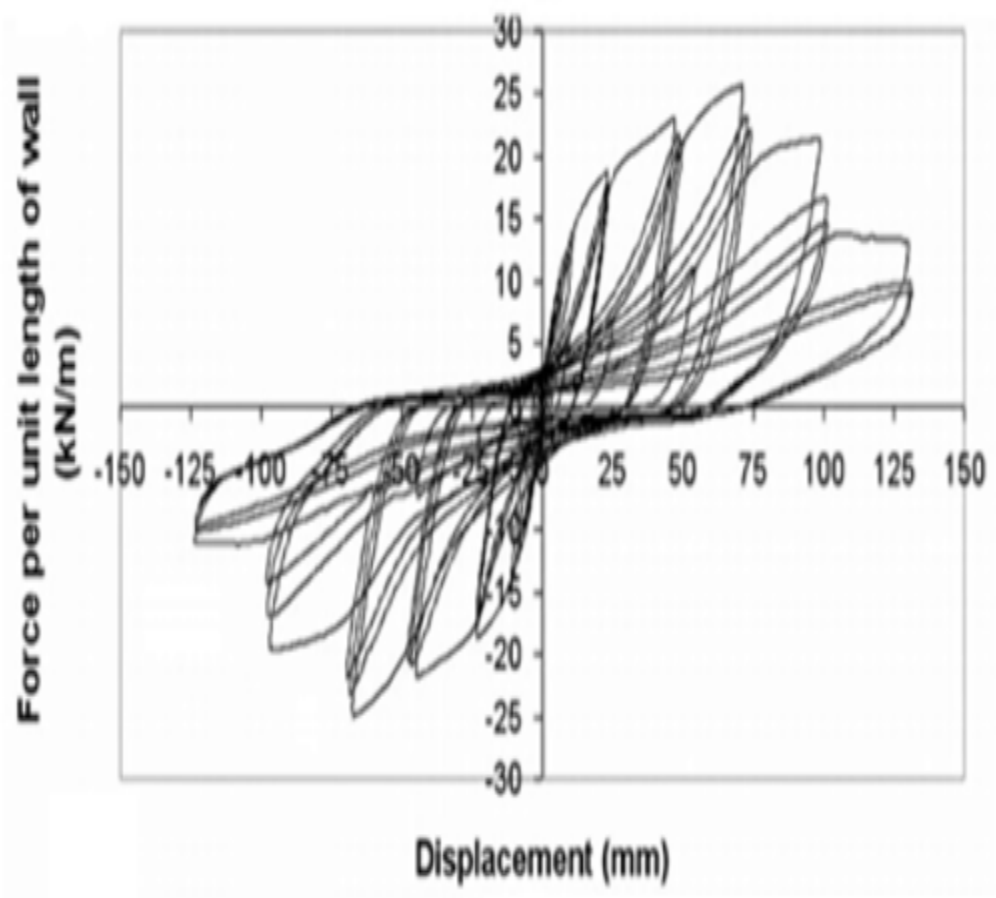


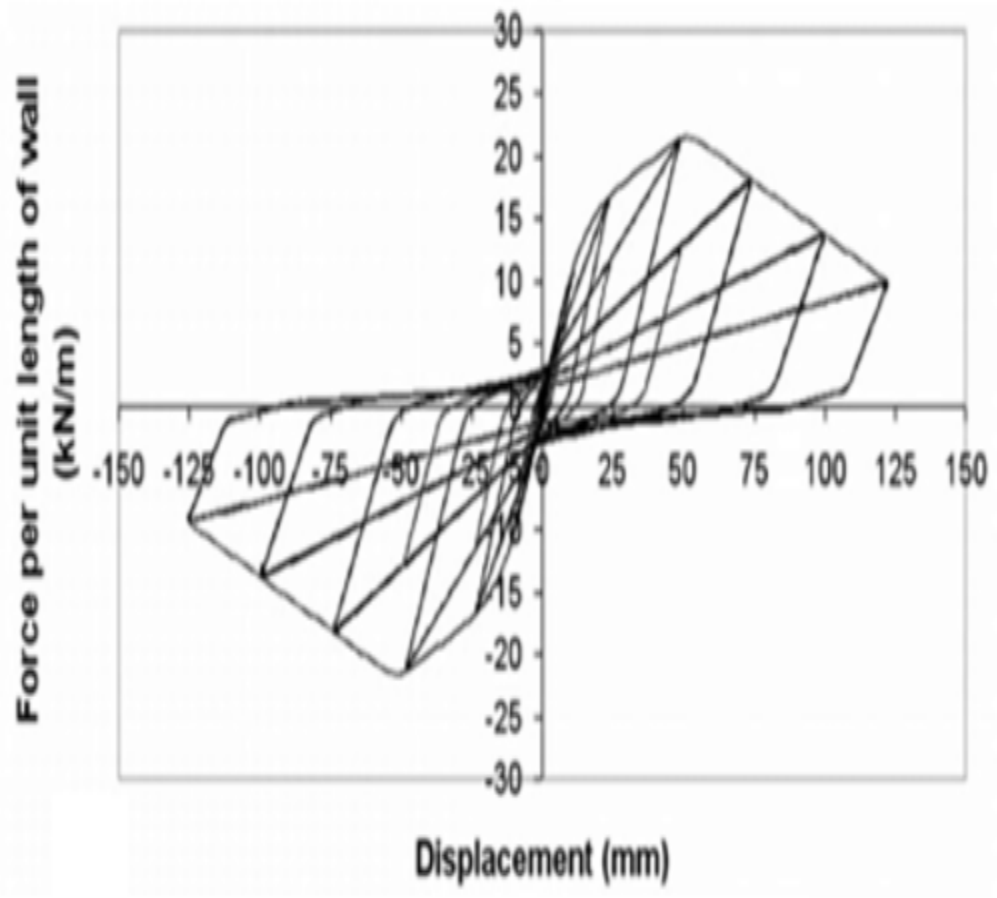
Force-displacement relationship for 3 mm nails attaching 11 mm thick OSB sheathing to SPF framing (a) Numerical simulation and (b) experimental result (courtesy of Dinehart *et al.* (2006))

Elements are implemented in walls

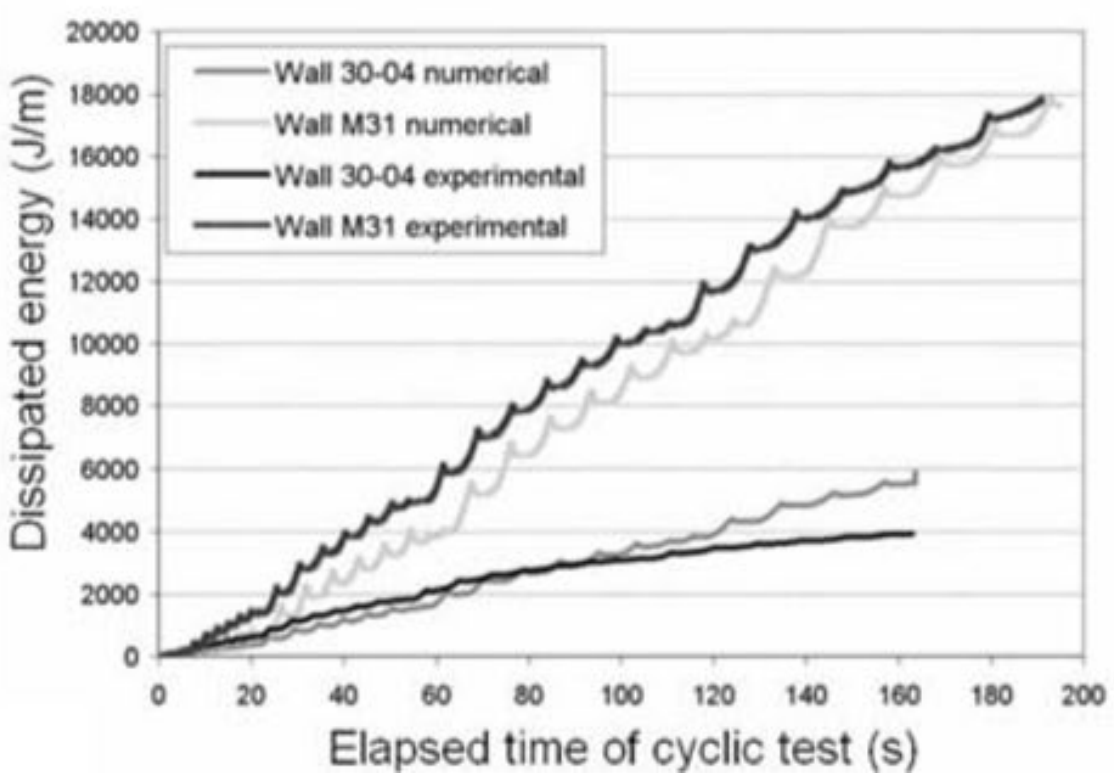


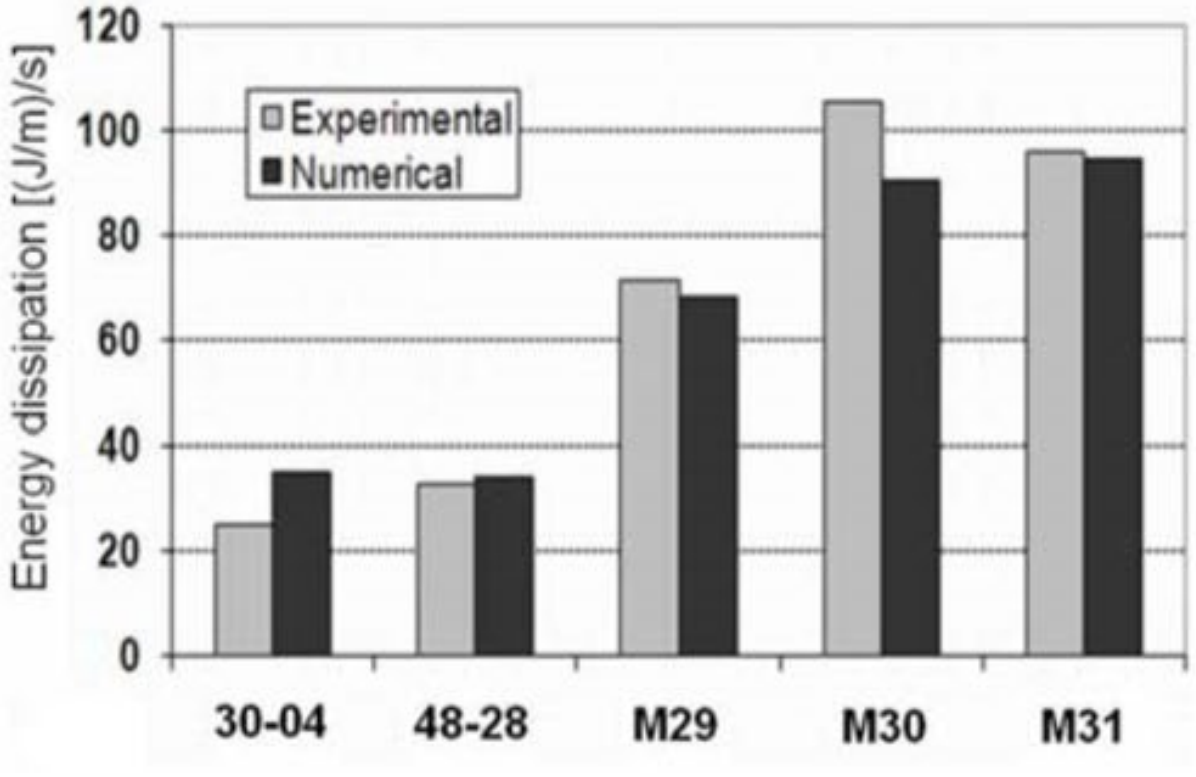
Good match between numerical and experimental



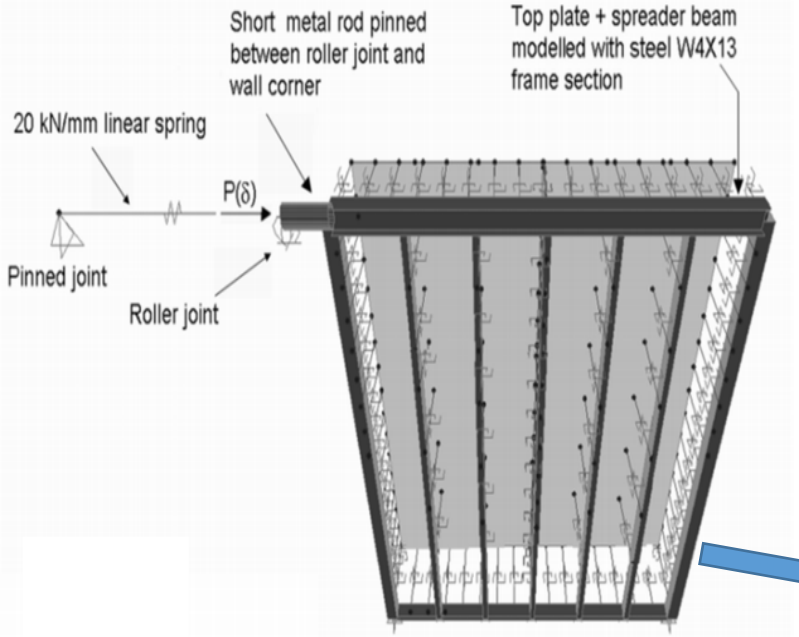


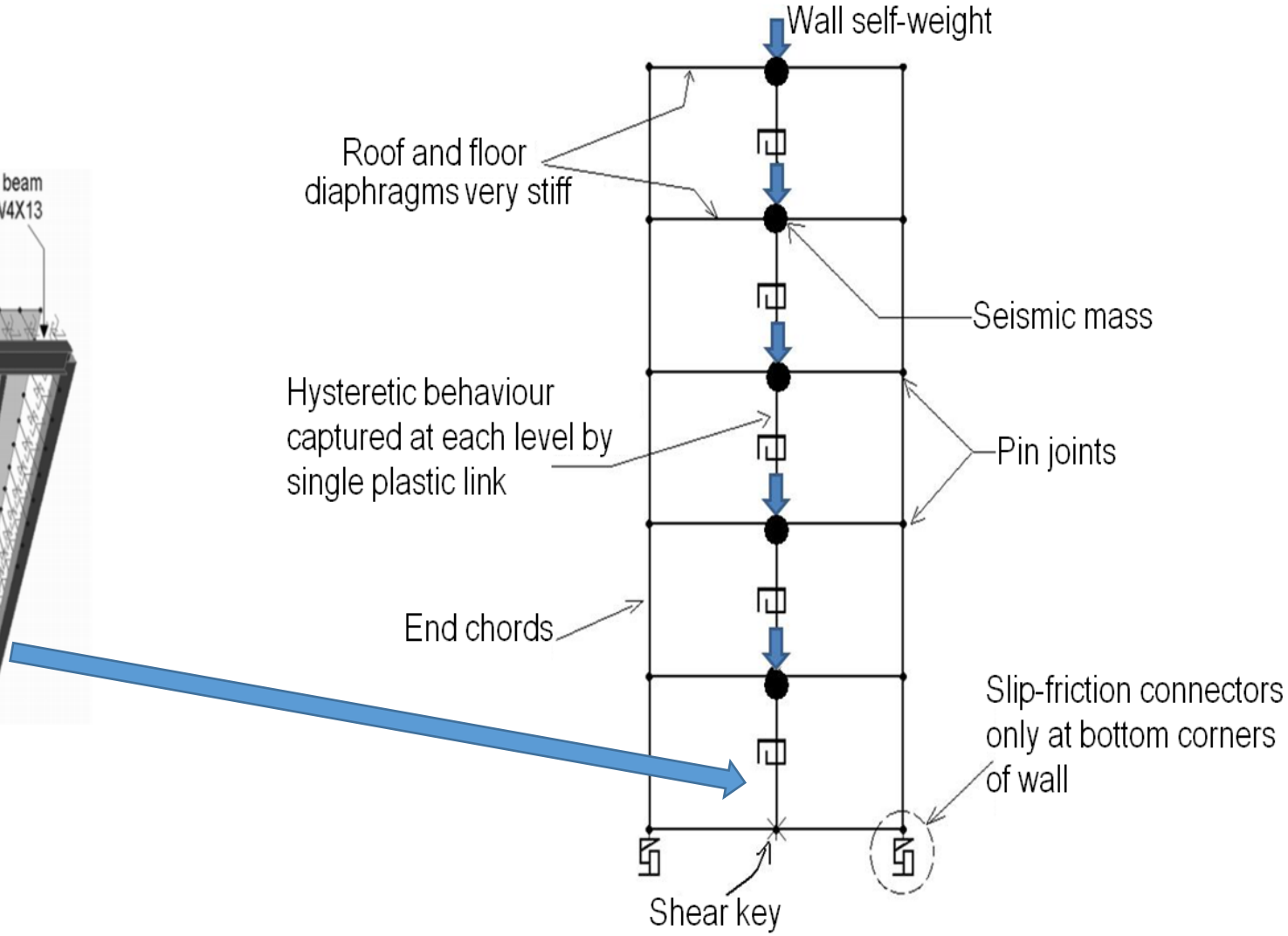
Energy dissipation comparison





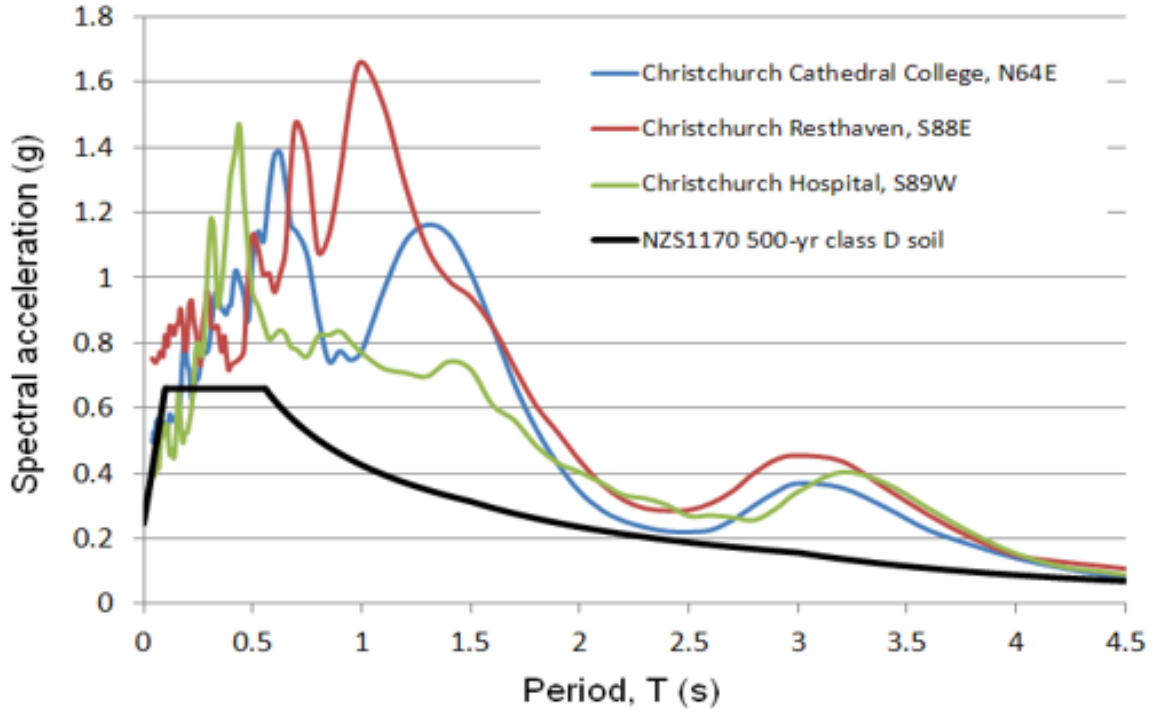
The behavior of a wall with many links can be captured by a single link





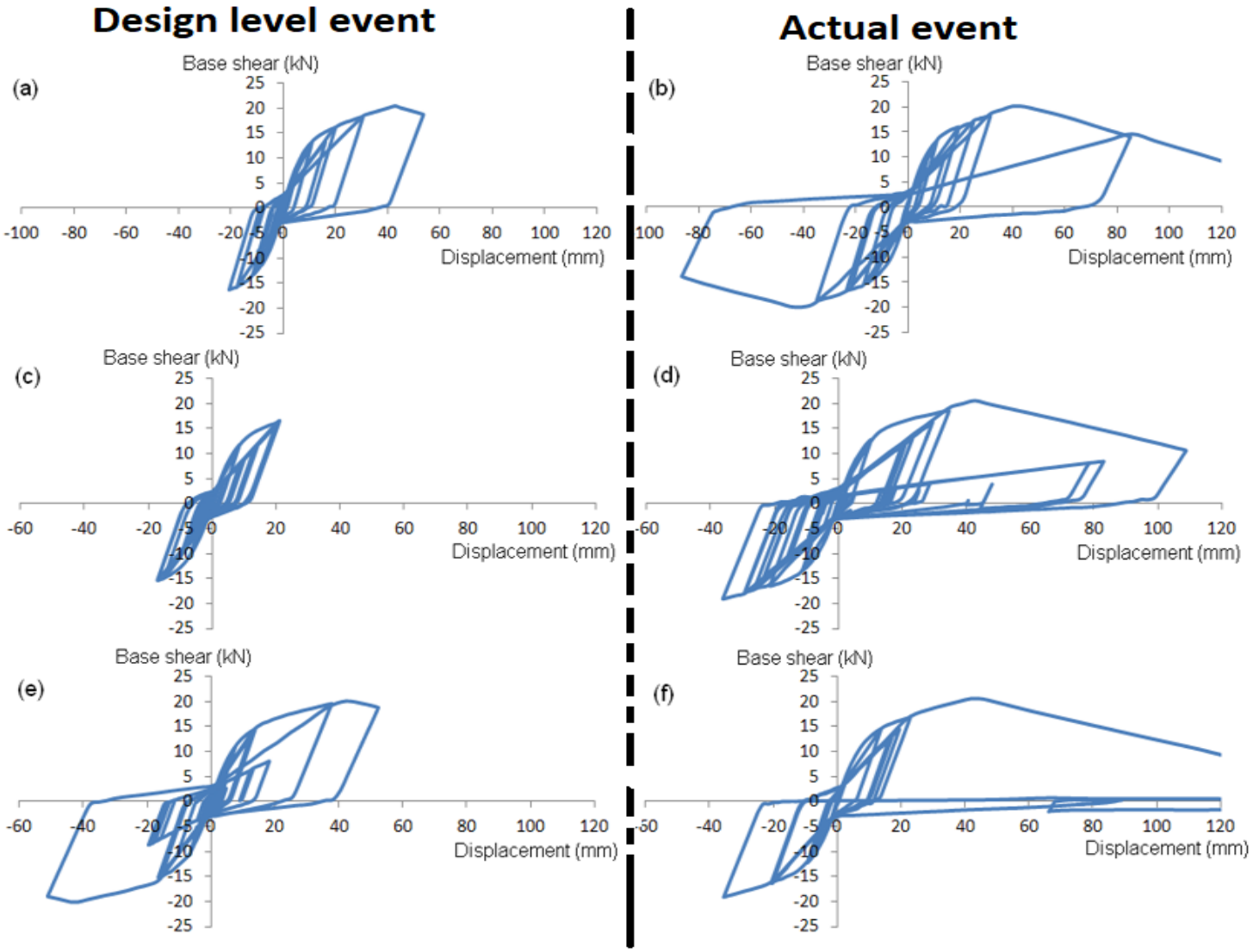
Christchurch, Feb 2011

The authors modelled a shear wall using the methodology of the preceding section and subjected it to a sequence of simulated earthquake loadings. Earthquake motions from the destructive 22nd February 2011 Christchurch earthquake (magnitude 6.3 M_L) were applied. The data used were from three different sites in the Christchurch central business district: Christchurch Cathedral College, Christchurch Hospital, and Christchurch Resthaven (Note Zone factor for Christchurch was 0.22, is now 0.30

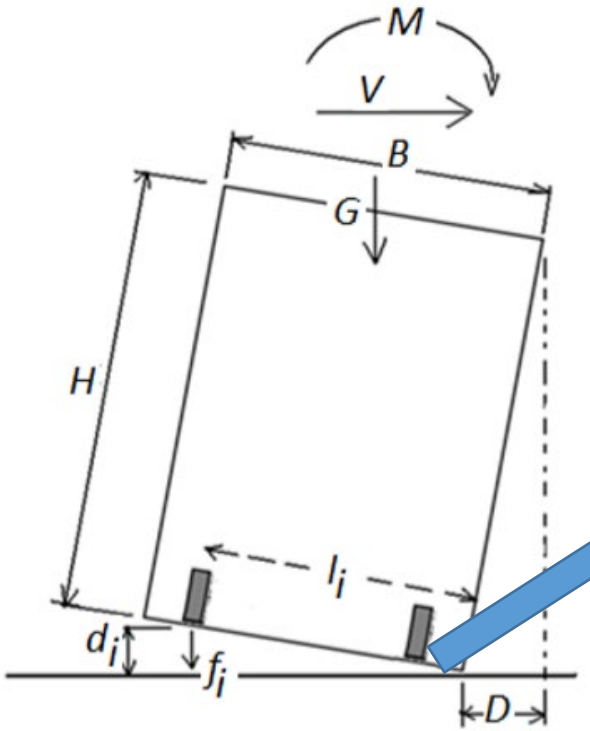


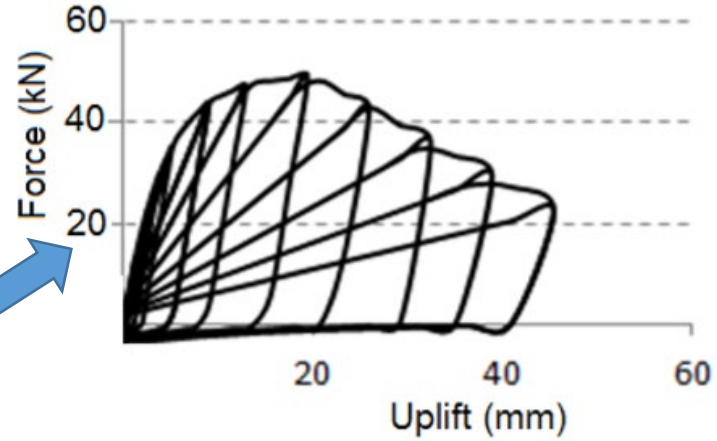
Spectral accelerations for the February 2011 Christchurch earthquake at three sites, and the ULS design spectrum (500 yr return period) for NZS1170.5 [16], Type D (soft) soils (Spectra produced from data provided by GeoNet NZ [17])

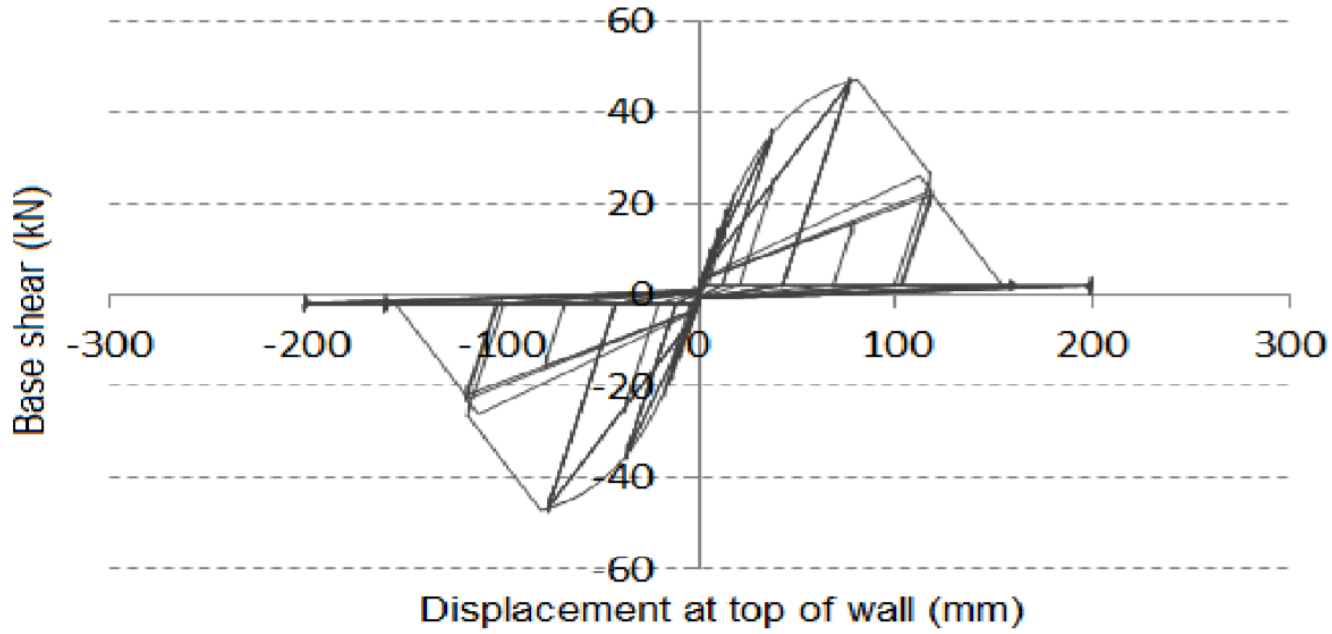
Christchurch: Numerical comparison between actual and Design level (previous) events, single storey wall



Other applications: Modelled *with CLT wall panels*

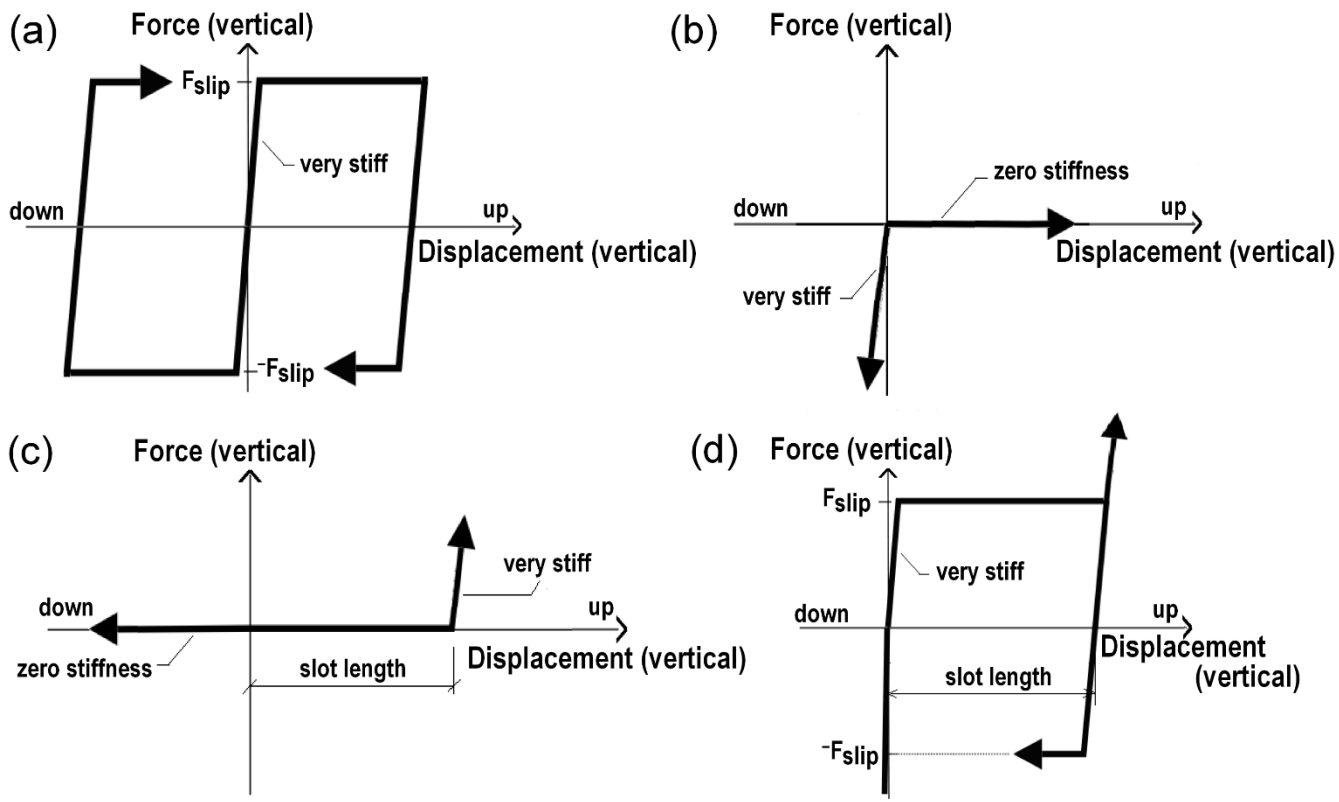






Other applications:

Combined with passive energy friction dissipaters modelled numerically:



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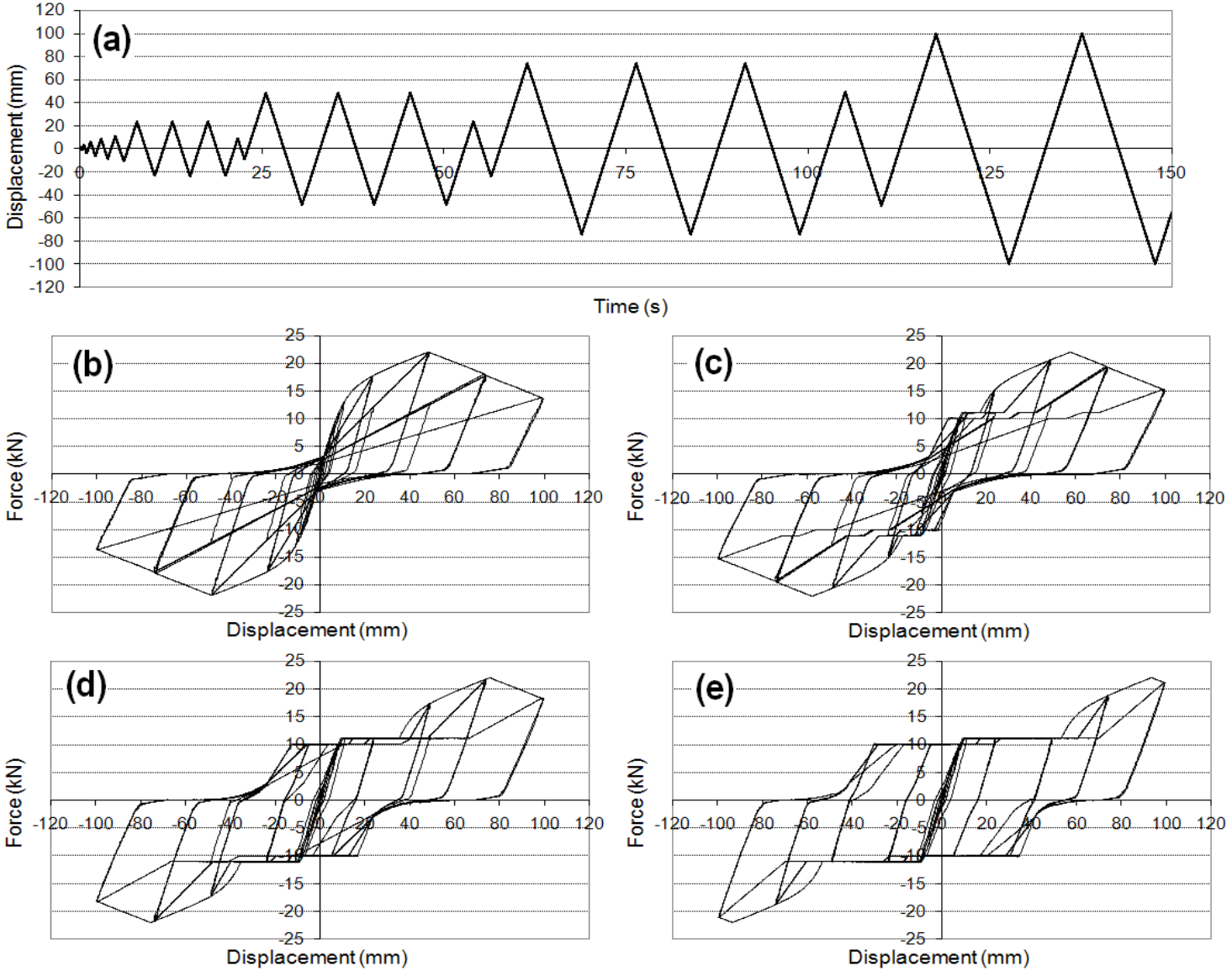
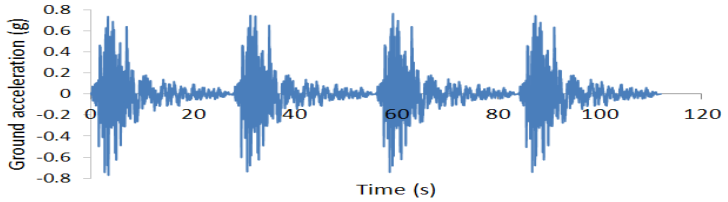
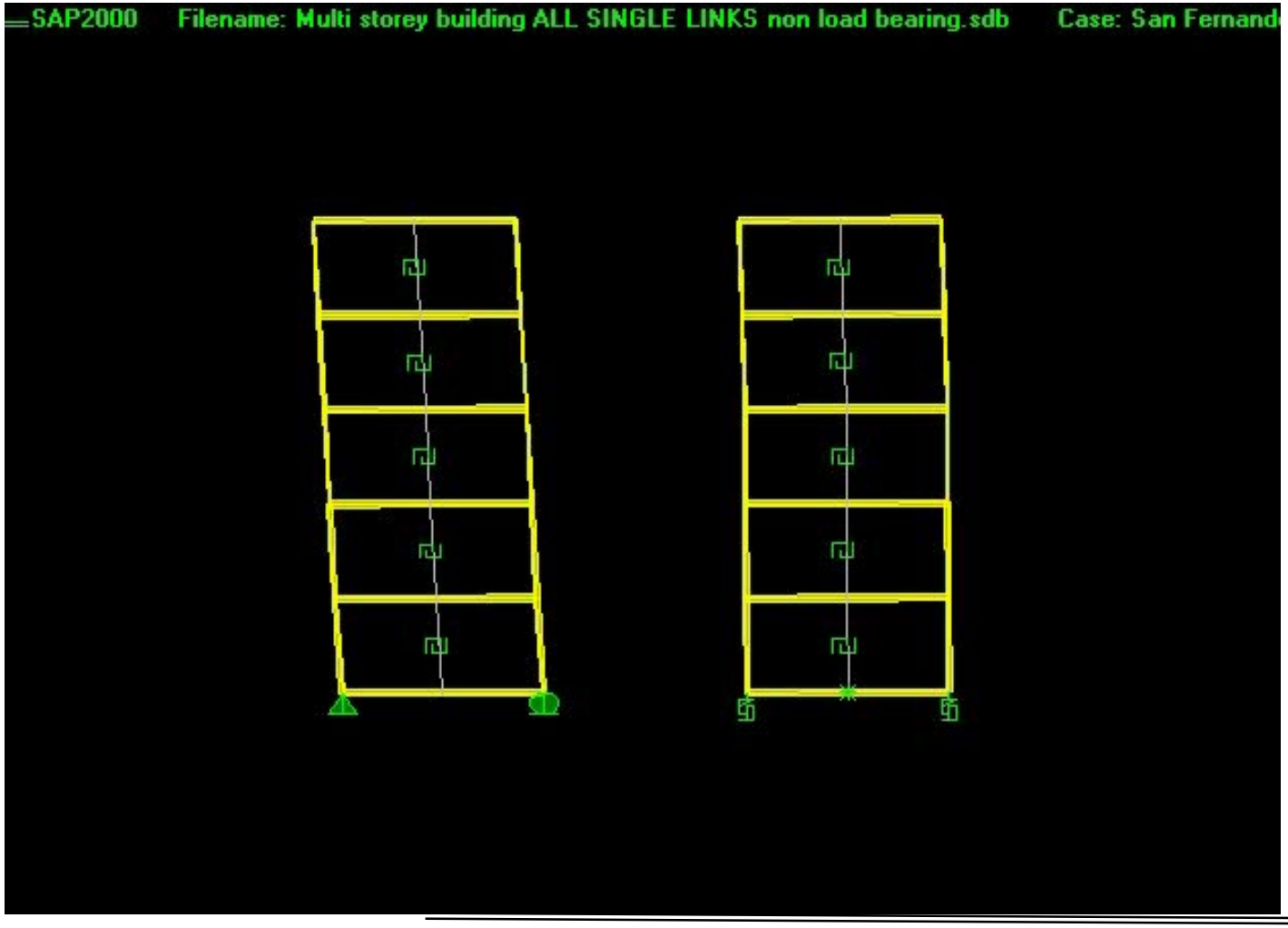




San Fernando scaled events, 4 in succession, scale factor x 5



Conclusion

- Quick and effective way to model non-linear behavior
- Suitable for use by consultants
- Parametric studies can be carried out with automated variation of parameters and running of load cases through the use of VBA programming accessing the API of a finite element software package.