Using the Macroelement Method to Seismically Assess Complex URM Buildings

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Flagship 3

THE UNIVERSITY OF AUCKLAND
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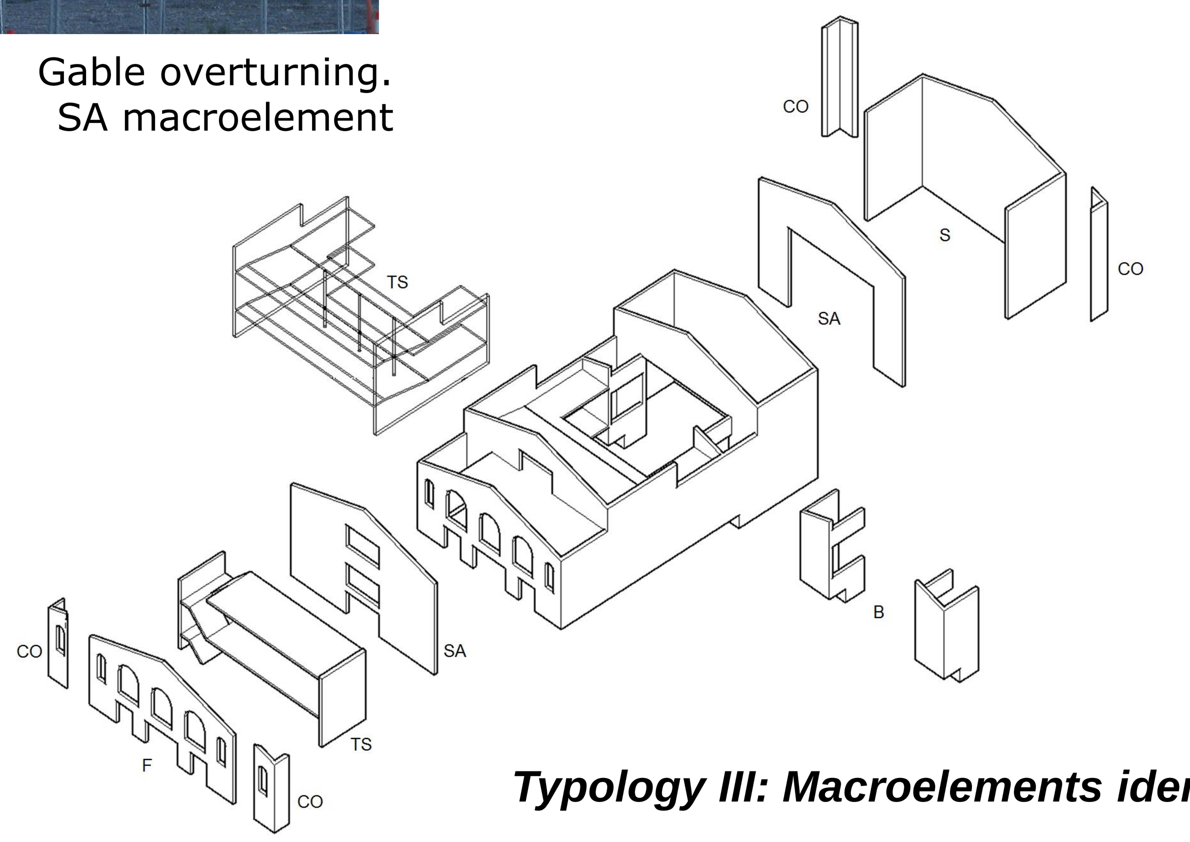
Te Whare Wānanga o Tāmaki Makaurau

Gable overturning.
SA macroelement

Gable overturning.
SA macroelement

Gable overturning.
S macroelement.



Back wall overturning.
S macroelement.

Typology III: Macroelements identification

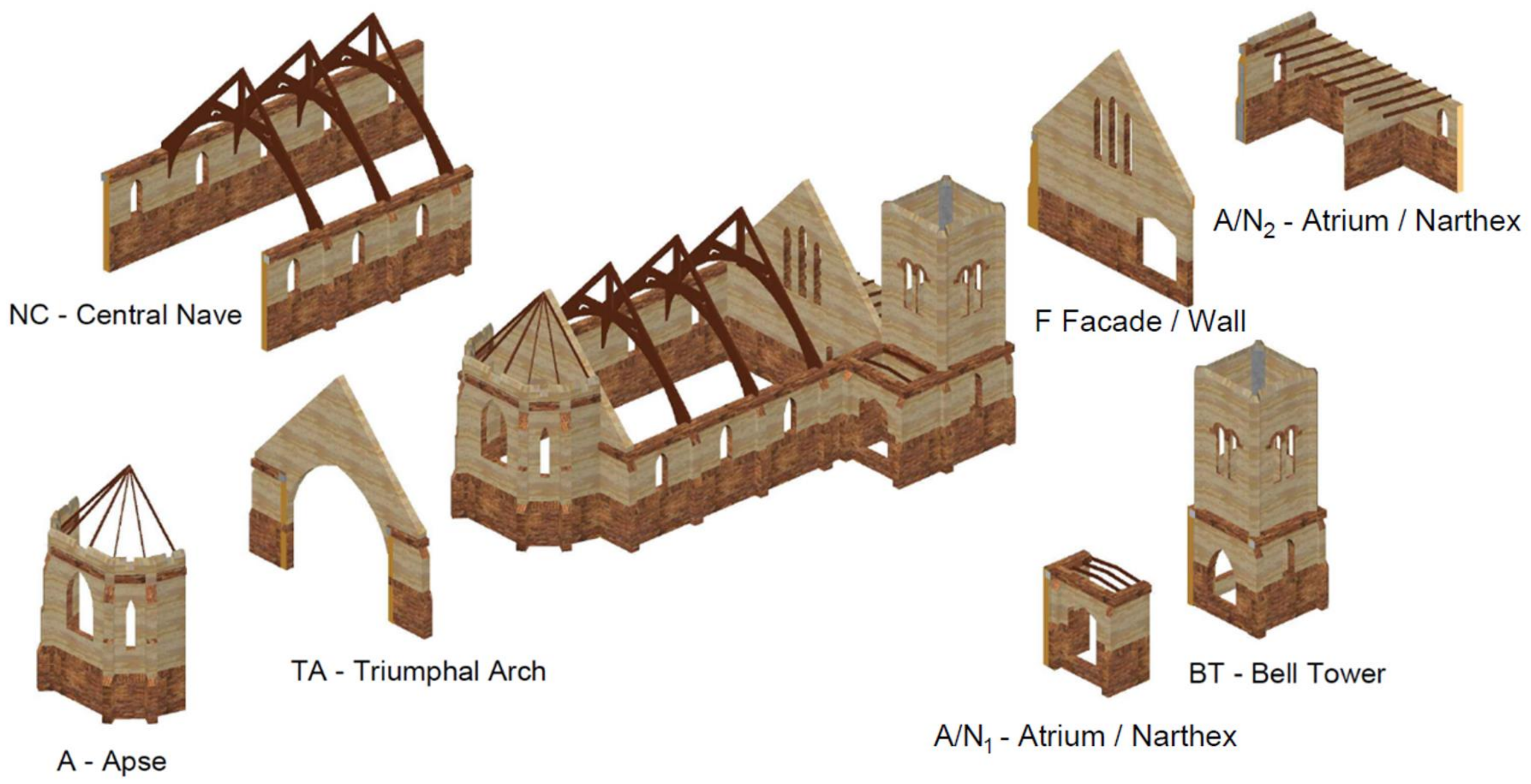
Top of the façade overturning.
F macroelement.

Mixed overturning.
F and CO macroelements.

Corner overturning.
CO macroelement.

Triangular top of the façade overturning.
F macroelement.

Typology I: Macroelements identification



Typology II: Macroelements identification

Building typologies and possible macroelements

I_A		Isolated buildings. Examples include stores, dwellings or offices.	F, CO, TS, PR
I_B		Row buildings. Typical in commercial and industrial districts.	F, CO, TS, PR
II		Longitudinal or central plan with one to three naves. Normally churches but also found examples include banks or museums.	TS, LN, F, T, D, SA, A, A-N, C, T, PR
III	Foyer / Auditorium / Stage	Longitudinal plan with three separated components, the Foyer, Auditorium with upper gallery and Stage. In the foyer the same macroelements as in the typology I_B are identified. Examples are theatres, opera houses or event venues.	TS, B, F, CO, PR, SA, S
IV	Institutional, industrial (Russell, 2010) (To be classified)		

Macroelements

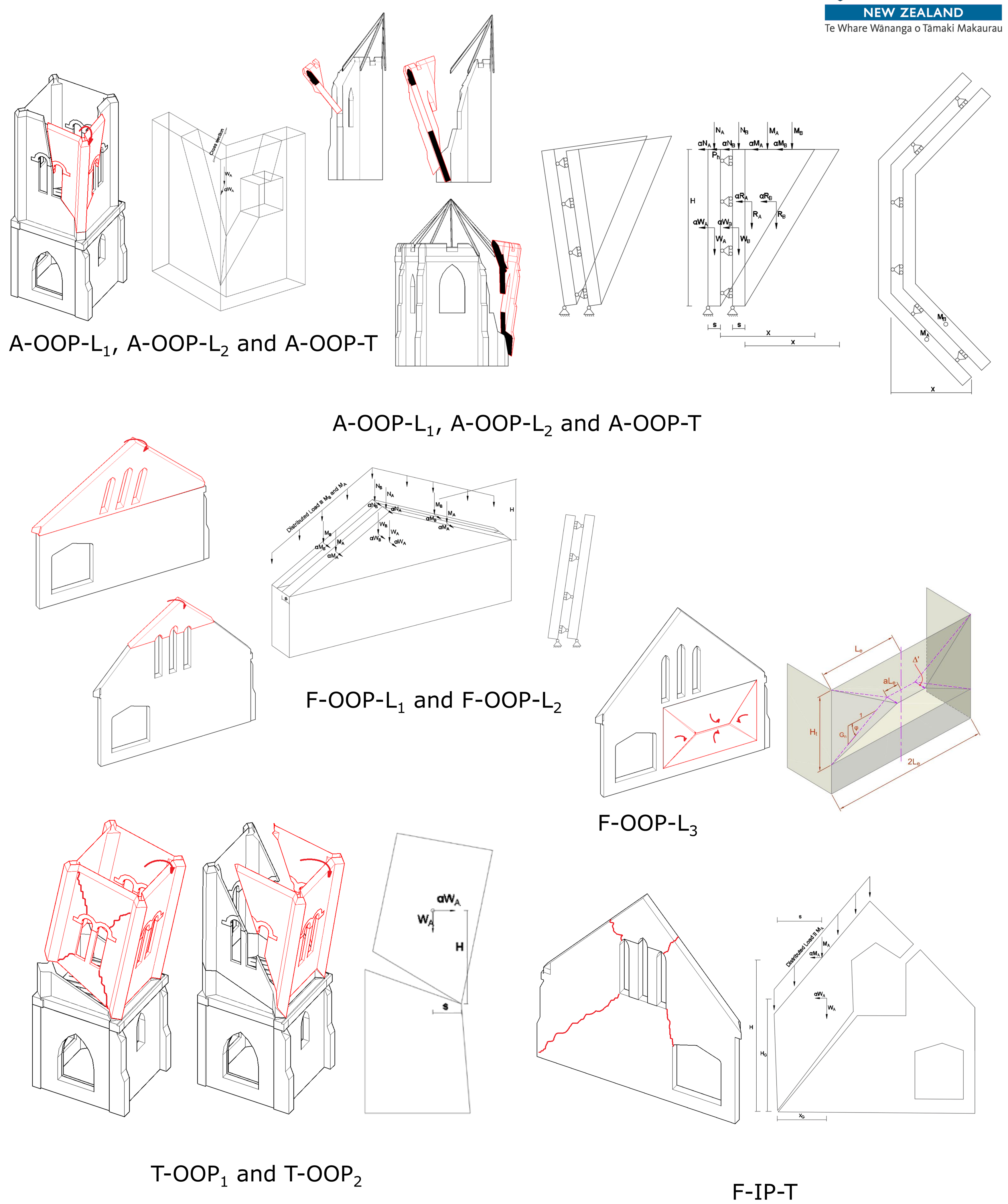
ID	Macroelements	Description
A	Apse	In a church, termination of the main building at the opposite side of the façade.
A-N	Atrium-Narthex	In a church, the lobby or entrance.
B	Boxes	Seating area in the auditorium usually at both sides of the stage.
T	Tower	Slender structure normally taller than the rest of macroelements. Typically holds a bell or a clock.
C	Chapels	Space attached at either side of the transversal structure.
CO	Corner	Element that combines the F and TS.
D	Dome	Rounded vault with a circular base.
F	Façade	Front wall of the building facing the street.
LN	Lateral Nave	In a church, parallel nave to the central nave.
PR	Projections	Single blocks. E.g.balconies or ornamentation.
S	Stage	In a heritage civic building, termination of the main building at the opposite side of the façade.
SA	Separation Arch	Wall between two macroelements with an opening in the form of a curved or flat arch. (Chancel Arch, Proscenium Arch..)

URM Typology classification and vulnerability assessment

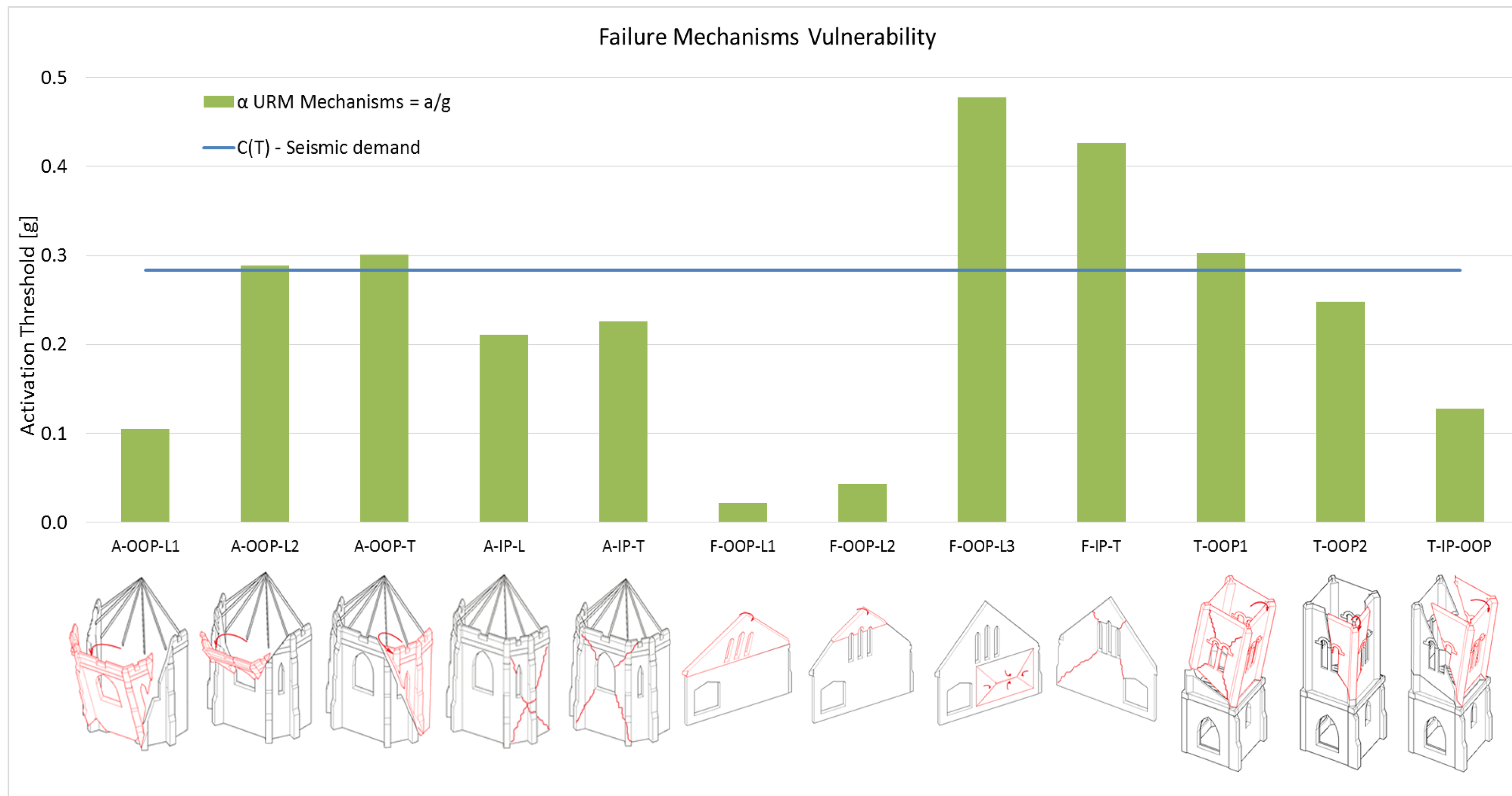
Existing unreinforced masonry (URM) buildings are often composed of traditional construction techniques, with poor connections between walls and diaphragms that results in poor performance when subjected to seismic actions. In these cases the application of the common equivalent static procedure is not applicable because it is not possible to assure "box like" behaviour of the structure. In such conditions the ultimate strength of the structure relies on the behaviour of the macro-elements that compose the deformation mechanisms of the whole structure. These macroelements are a single or combination of structural elements of the structure which are bonded one to each other. The Canterbury earthquake sequence was taken as a reference to estimate the most commonly occurring collapse mechanisms found in New Zealand URM buildings in order to define the most appropriate macroelements.

When the macro-elements and their connections are defined, the next step is to impose equilibrium conditions and find the collapse mechanism most likely to be formed via determination of the activation threshold (α = a/g). The classification of a building into macroelements and collapse mechanisms allows the definition of analytical methods to assess the seismic vulnerability.

In addition to the definition of the assessing process, the reported case study would serve as an example for professionals around New Zealand. The level of considered earthquake shaking is consistent with New Zealand loading standards and described in terms of the elastic site hazard spectrum C(T).



Collapse mechanisms and analytical model



Activation threshold compared to the seismic demand