Analytical Damage Evaluation of Non-structural Reinforced Concrete Walls

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Background

In Japan, the non-structural (NS) walls are not designed to resist earthquake load, which makes them vulnerable to relatively low levels of seismic excitation. Previous earthquakes have highlighted that while structural components may remain intact, damage to NS walls can result in significant dysfunction and costly repairs. Thus, anticipating damage scenarios for infill walls under lateral loads is essential. This knowledge can also be used in the design or sizing of such walls.

Numerical Model Descripton

Since the shear span ratio of NS walls is typically not very high, there exists an interaction between shear and flexural response. Shear-Flexure Interaction-Multiple Vertical Line Element Model (SFI MVLEM) is used in this research. It uses RC panel in a two-dimensional fiber-based macroscopic model to couple the axial and shear response providing systematic prediction of the response of RC walls under reversed lateral loading.

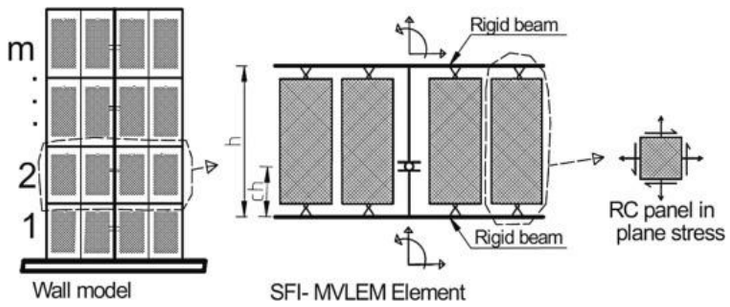


Fig.: Representation of SFI MVLEM model

Description of Damage States

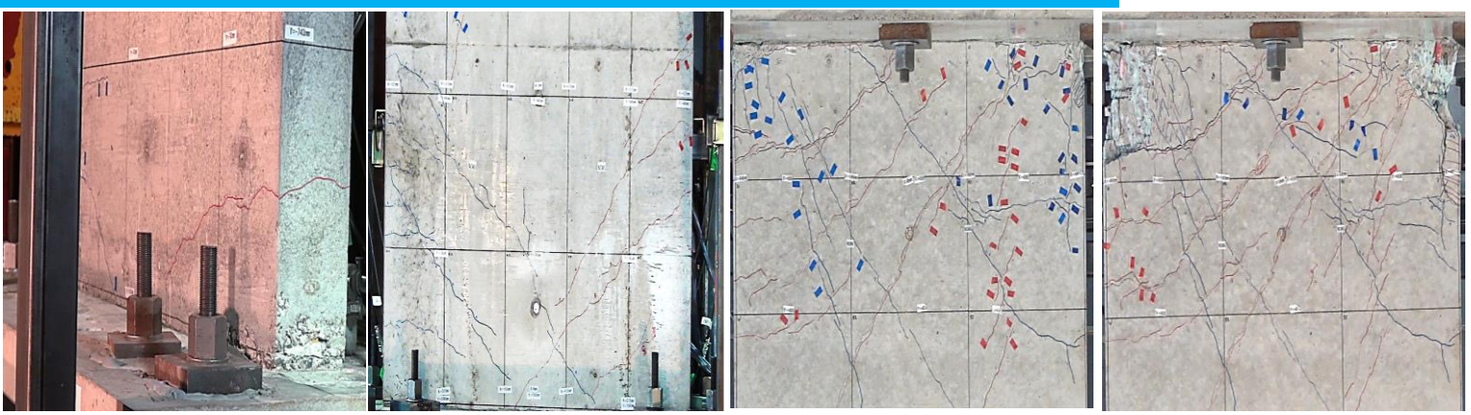
Damage state	Damage description	Material Limit strain	Repair method
DS1	Appearance of residual cracks No compressive damage	$\varepsilon_s < \varepsilon_y$ $\varepsilon_c < \varepsilon\ at\ 2/3f_c'$	No repair / Cosmetic repair
DS2	Maximum residual crack width < 0.4mm No compressive damage	$\varepsilon_s < 0.008$ $\varepsilon_c < 0.002$	Cosmetic repair / Crack injection
DS3	Maximum residual crack width < 1mm Appearance of compression cracks Initiation of spalling	$\varepsilon_s < 0.015$ $\varepsilon_c < 0.004$	Crack injection / Minor concrete patching
DS4	Onset of buckling Crushing	$\varepsilon_p{}^* < \varepsilon_{buck}{}^{**}$ $\varepsilon_c < 0.008$	Rebar / Concrete replacement

ε_s : tensile strain of longitudinal rebar
ε_c : concrete compressive strain
ε_y : yield strain of longitudinal rebar
f_c' : concrete compressive strength
$\varepsilon_p{}^*$: compression reloading strain
$\varepsilon_{buck}{}^{**}$: compression reloading strain at buckling

Conclusions

- Four damage states are defined and quantified in terms of material strains for the NS walls based on damage progression and required repair methods.
- The observed damage during the experiment at the defined strain limits justifies the quantification of damage states

Observations at Analytical Drift Ratios



DS1 DS2 DS3 DS4

Social Impact

- The research can be used in anticipating damage scenarios and required repair efforts for NS walls under a given demand using a simple numerical tool. It can be helpful in forecasting the post-earthquake functionality of buildings during the design phase and can assist in designing or sizing walls based on required performance.