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Improvement in Geometric Design of Reinforced Concrete Structural Walls to Resist Earthquake Effects

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Reinforced concrete (RC) structural walls are critical components of the lateral load resisting system of multi storeyed RC buildings. They impart high lateral stiffness and strength to the building system, and also reduce lateral deflection during strong earthquake shaking. Thus, proper transfer of forces from building to underlying soil through the wall-footings is of major concern in earthquake resistant design of RC buildings.

Conventional walls with marginal taper in footings exhibit severe stress concentration under extreme deformation demands during earthquake shaking. Based on linear elastic finite element analysis of isolated RC slender wall-footing system, a new tapered configuration is proposed for the wall-footing unction to improve flow of forces. In walls without enlarged boundary elements, the proposed profile over the height of taper consists of linear taper followed by a parabolic curve. In walls with enlarged boundary elements, proposed profile consists of linear taper only; geometry of boundary elements is recommended to start from the top of tapered region. Analytical expressions involving structural and soil parameters are derived to define the tapered geometry. Under expected vertical and lateral forces on wall during flexural overstrength, slender wall-footings are expected to lose contact with underlying soil. Extensive parametric study shows significant improvement in flow of forces in the transition region of the proposed slender wall-footing junction. Observed stress response shows expected plastic hinge region to be above the tapered portion of wall-footing; stresses in tapered region remain elastic. During strong earthquake shaking, inelastic response and dissipation of energy are expected to occur above the tapered portion. Thus, the height of taper can be tuned to shift the region of potential seismic damage in RC slender wall away from footing level, especially to above ground level.

Analytical expression is derived of displacement ductility capacity of tapered slender walls with partial contact at bottom. This gives a conservative lower bound estimate of displacement ductility capacity in walls with and without enlarged boundary elements. A step-wise seismic design procedure is proposed. This incorporates capacity design of plastic hinge region above the tapered portion and elastic design of tapered portion. During partial contact of wall-footing with underlying soil, anchors are required to reduce uplift of footing base and mobilise the required flexural strength.

Linear elastic finite element analysis of isolated RC squat wall-footing also is carried out under expected vertical and overstrength lateral forces to improve flow of forces at the wall-footing junction region. Overstrength lateral force is

estimated from a softened strut-and-tie model. In walls without enlarged boundary elements, proposed tapered configuration is a linear taper along its entire height. In walls with enlarged boundary elements, boundary elements are recommended to be concealed along with linear taper over its entire height. Analytical expressions are derived correlating relevant structural and soil parameters against possible seismic failure criteria of squat wall-footing. Under estimated vertical and lateral forces, squat wall-footings of moderate aspect ratios are expected to lose contact with underlying soil; thus, soil or rock anchors are required to mobilise required strength in walls and reduce footing uplift. Detailed parametric study shows the requirement of stress-based seismic design philosophy for primary design of tapered squat walls to suppress compression based failure modes.