NUMERICAL INVESTIGATION ON FAILURE MECHANISM OF SLENDER STRUCTURAL WALLS

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Abstract

The overall behavior of the slender structural wall is determined by the behavior of the plastic hinge region at the wall base. A slender structural wall subject to a lateral load is damaged at the wall base. The failure of a slender structural wall with confined end-zones is caused by the crushing of the confined concrete, crushing of the unconfined concrete, fracture and buckling of the flexural re-bars, and fracture of the lateral re-bars. In this study, the crushing of the confined concrete and crushing of the unconfined concrete are investigated by section analysis. Moreover, the slender structural walls have flexural behavior and the behavior of bending members can be explained by moment–curvature relation. The moment-curvature relation for a section is determined using an analysis procedure that satisfies the requirements of strain compatibility, equilibrium of forces, and the stress-strain relations. The proposed moment-curvature relation is extended well into failure stage. Finally, correlation studies between analytical and experimental results are conducted with the objective to establish the validity of the proposed procedure. The occurrence of each failure modes depends on the quantity of confinement reinforcement, the depth of compressive zone, the depth of confined zone and properties of concrete and steel.

Keywords: Slender structural walls, Failure mechanism, Moment-curvature relation, Confined concrete, Unconfined concrete.

1. INTRODUCTION

In accordance with the development of industrial society and the expansion of the magnitude of economies, structures have become larger and more complex. The safety and serviceability assessment of those complex structures necessitates the development of accurate and reliable methods and models for their analysis. To ensure the safety of structures in the case of earthquake, both analytical and experimental studies about structural behavior under over-load conditions and cyclic loads are carried out side by side [1], but experimental studies are expensive and time consuming and give us limited information. Especially for reinforced concrete (RC) structures which are brittle compared to steel structures, it is very important to describe the behavior of the RC structures under over-load conditions and estimate their ultimate strength accurately.

Generally, a slender structural wall subject to a lateral load is damaged at the wall base. Therefore, the overall behavior of the wall is determined by the behavior of the plastic hinge region at the wall base. The deformability of the wall which has no end-zone confinement in its cross-section is determined by the ultimate compressive strain of concrete (ε_u) in the plastic hinge region. However, current design codes and researchers have proposed different ε_u values. Wallace [2] and Priestley [3] proposed $\varepsilon_u = 0.004$ for use in the ductility design of the wall. The UBC [4] and New Zealand design code [5] specify, $\varepsilon_u = 0.003$ and FEMA [6] uses $\varepsilon_u = 0.005$. Therefore, the deformability of a wall can be evaluated differently according to the design codes and recommendations used for the design of the wall. The deformability of a wall with laterally confined end-zones is more difficult to evaluate.

The overall behavior of the wall with a partially confined end zone is more complicated than that of the wall with a completely confined compressive zone. Confined and unconfined compressive zones showing different behaviors coexist in the cross-section of a wall. Furthermore, the behavior of the confined concrete varies according to the amount and the details of the lateral re-bars. ACI 318-02 [7] and the New Zealand design code [5] require that at least half of the depth of the compressive zone be laterally confined. The Canadian design code [8] requires that a depth not less than c(0.4+1.5c/L) be confined. Where c is total depth of the compressive zone and L is the wall depth. Wallace [2] and Priestley [3] proposed that the region in