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Failure analysis of shear columns to seismic events

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ABSTRACT

Columns which are shorter than normal floor height of the structure are called as short columns. Observations which are made on damaged buildings during earthquakes show that different column heights cause failure during earthquakes. Also if a building has columns with different heights and sections, some irregularities are formed in structure including short column. Displacement, moment and shear force values of columns under vertical loads are related to column height. So the structures are damaged during earthquakes because of these displacement irregularities. For preventing short column damages, regulations are made in codes of some countries. In this study, reasons of short column, effects of short column on structural behavior under seismic loads (moment and shear force) and effects of short columns on structures which have different floor heights from 1 to 10 are studied for different span widths, floor numbers and codes. In this study it is determined that; decreasing stirrup spacing, controlling and limiting shear stress and placing elastic materials between column and walls can minimize short column effects.

1. Introduction

The behavior of columns in earthquakes is very important since column failures may lead to additional structural failures and result in total building collapses. For example, in the Izmit and Duzce (1999) earthquakes, the most frequent observed cause of structural failure was linked to inadequate beam-to-column, short column-to-beam in ground storey and slab-to-column connections [1]. Building configurations may cause columns to be over stressed. Columns of unequal length result in unequal load distribution and hence failure. Column construction and underlying soils also are factors in column failures. The slides in this set illustrate these and a variety of other column failure types. The columns were made more vulnerable to damage when their spans were shortened by beam and infill wall. This is knows as the "short column" effect. When columns are shortened, the effect makes them less ductile.

Short columns when subjected to cyclic horizontal displacements cause particularly a brittle behavior. They exhibit increased initial stiffness and shear response. They show increased response, stiffness degradation and low energy dissipation capacity for displacements larger than the displacement which corresponds to the maximum shear response. As "short" are characterized columns with shear ratio $\alpha_s = 2.5$. Shear ratio α_s is defined as $\alpha_s = M/Vh$, where M, V are the moment and the shear force acting at the end cross section, and h is the depth of the element [2].

Because of undesired behavior seismic loads and earthquake damages, many studies are made on short columns. Short column case takes its place in many countries earthquake code [3,4]. Carbon or glass fiber-reinforced polymers were used to strengthen the short columns. It is found that short columns, even ones designed according to current codes, suffered brittle shear failures. It is demonstrated experimentally that it is possible to strengthen the shear resistance of short columns such that a flexural ductile failure occurs by developing plastic hinges at both ends of the column [5]. In new buildings, short column effect should be avoided to the extent possible during architectural design stage itself. When it is not possible to avoid short columns, this effect must be addressed in structural design [6].

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