

Comparing calculation methods of storey stiffness to control provision of soft storey in seismic codes

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Abstract. Numerous buildings have been damaged or destroyed in previous earthquakes by developing soft storey. Almost all the seismic codes have provisions to prevent soft storey in structures, most of them have recommended the ratio of stiffness between adjacent storeys, but none of them has proposed the method to calculate the storey stiffness. On the other hand a great number of previous researches on stiffness have been focused on approximate methods and accurate methods by using analytical softwares have been almost neglected. In this study, six accurate methods for calculating the storey stiffness have been studied on 246 two-bay reinforced concrete frames. It is shown with the results of the statistical study and structural analysis that method 3 in which there is no modification of the original model and the forces with triangular distribution similar to seismic forces are applied to the center of mass of all storeys has acceptable accuracy and desirable efficiency for designing and controlling structures.

Keywords: storey stiffness; soft storey; calculation methods; earthquake; seismic codes

1. Introduction

One of the most important causes of damage to buildings in past earthquakes is soft storey. Soft storey occurs due to the discontinuity of stiffness in height. If the stiffness of a storey (usually ground storey) is significantly lower than that of the upper storeys, a significant portion of the lateral displacement concentrates on ground storey and soft storey is formed (Asteris 2003, Arnold 2006, Arslan and Korkmaz 2007, Mulgund and Kulkarni 2011, Tabeshpour et al. 2012, Harmankaya and Soyluk 2012, Caterino *et al.* 2013, Saiful *et al.* 2014, Varughese *et al.* 2015). Several factors can lead to the occurrence of this phenomenon; Sometimes the geometry and dimensions of the structural elements have not been properly designed for example greater height of columns, removing some columns, lateral bracings and shear walls in a story especially ground floor due to architectural design (Fig. 1) and sometimes reducing or eliminating infill walls in a storey leads to form soft storey (Özmen and Ünay 2007, Asteris 2003, Zhao *et al.* 2009, Arnold 2006, Mulgund and Kulkarni 2011, Yatağan 2011, Tabeshpour *et al.* 2012, Saiful *et al.* 2014,

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