Analytical Evaluation of Inter-Story Beam Effects on Lateral Stiffness of Moment Frames

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Abstract

The effects of inter-story beam on lateral stiffness of one-story moment frame with an arbitrary span length and distance from main beam for preventing frame form soft story and weak story irregularities are evaluated in this paper. The two-dimensional analysis was performed based on the slope - deflection method. Initially, lateral stiffness of a one-story moment frame without inter-story beam was calculated, and then the coefficient of Increased Lateral Stiffness (ILS) due to inter-story beam was calculated for several states used to FRAME1 program. The results and graphs were adjusted for the effects of different factors on ILS, such as stiffness of the inter - story beam, ratio of column height to span length and the ratio of stiffness of the main beam to inter-story beam. In all cases, the range of optimal distance of the inter-story beam from main beam for achieving higher ILS is calculated.

Keywords: Lateral Stiffness, Inter-story Beam, Static Analysis, Soft Story, Weak Story

1. INTRODUCTION

Irregularities in the building height are the most important factors of seismic design. These irregularities occur when the buildings is not symmetric in the view and section. This deviation leads to two types of problems in the buildings: (1) torsion and (2) stress concentration. Arnold et al. (1994) underlined the torsion is often due to the plan or geometry irregularity that leads to great uncertainty in strength calculation of buildings. Because of inappropriate distribution of resistant element, local stress concentration occurs in structure [1]. Arnold (1983) said using modern framed structures in which the stresses are very high in proportion to amount of structural materials, configuration irregularities will lead to dangerous torsion and stress concentration that do not view in more traditional buildings [2]. The degree of configuration irregularity of buildings is one of the most important factors for the determination of the analysis procedure in seismic design of buildings against earthquake [3].

The size and geometry form of buildings are not the perfect parameters for determining of seismic irregularity, therefore, the relations must be considered between seismic performance and strength distribution, stiffness and mass of building, and the size, nature and location of structural and non-structural components. Arnold (1983) also said the distribution of lateral forces in irregular structures with large differences in lateral strength or stiffness of adjacent stories or other unusual features shall be determined considering the dynamic characteristics of structures [2].

Soft story and weak story are of the most common samples of irregularities. In the seismic design codes such as UBC code and Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard No. 2800, 2007), the above irregularities were defined as: “SOFT STORY is one in which the lateral stiffness is less than 70 percent of the stiffness of the story above and WEAK STORY is one in which the story strength is less than 80 percent of the story above [4,5].” Soft story and weak story are different in the difference between stiffness and resistance of one story and stories above. These concepts are often mistaken for each other and even used improperly. Guevara-Perez (2012) has defined the soft or flexible story based on the stiffness difference (or resistance to the displacements) of one story and the rest of them, and the weak story based on difference in lateral strength (or resistance to the seismic forces) of one story and the rest of them. Both of them may be present simultaneously in one building. [3]. Yoshimura (2002) states that these irregularities occur when a few structural or non-structural components (with seismic resistance) are present in one story, whereas many of those are in the above stories or when the shear walls in upper stories do not