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Effects of Partial Fixity of Column Base Connection on Overall Response of Steel Structures

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Abstract

Fixity of column base connection plays a major role in overall behavior of steel structures. Although it is usually idealized as fully pinned or fully rigid, in reality it often exhibits semi-rigid behavior. The current study investigates the nonlinear behavior of regular column base connection and assesses its partial fixity. Therefore, results from analyses of several steel frames modeled with pinned or fixed ends were utilized to design column base connection. Respectively each connection was modeled by nonlinear finite element method to obtain the relative rigidity of each set of connection. Then, corresponding effects have been applied to steel frames to investigate semi-rigidity effects on overall structural responses. The results clearly indicate that regular column base connection behaves in a semi-rigid manner. It is shown that in cases where the column bases are classified as pinned, they often have significant rotational stiffness. Meanwhile, assumedly rigid connections may exhibit considerable rotation.

Keywords: Column Base Connection, Steel Frame, Fixity, Finite Element

1. INTRODUCTION

Column base connection is one of the most important components in steel structures. It connects column to foundation directly so that the structure reactions can be transferred to the foundation. Fixity of column base connection plays a key role in overall behavior of the structures. In common practice, the behavior of column base connection is usually idealized as fully pinned or fully rigid. However, in reality it often exhibits semi-rigid behavior that can significantly affect the overall frame response especially its drift and moment distribution. In order to make reliable designs, it is essential to take semi-rigidity effects into account.

Several parameters influence the fixity of column base connection. Researchers have conducted a number of investigations to assess these parameters effects. Salmon et al. have conducted one of the earliest studies on column base connection fixity [1]. They theoretically studied the moment-rotation characteristics of column base connections. They defined upper and lower bounds for maximum resisting moment and maximum rotation for the connections. Picard et al. experimentally studied the influence of the column axial load on the flexibility factors for bending about the principal axes of column base connections [2]. The test results indicated that the axial loads applied to the column may significantly increase the rotational stiffness of the connection and influence the frame response. They found that the thickness of the base plate is an important parameter which affects the moment capacity of column base connection. Lau et al. assessed the effects of base plate connectivity on the load carrying capacity of a single column with different slenderness ratios [3]. The test results clearly showed that columns with slenderness ratios in excess of 100 which have flat ends can carry loads in excess of the Euler pinned buckling loads. Steenhuis et al. concluded that poor grout quality decreases the stiffness of column base connection [4], thus emphasizing the quality of construction works. An experimental and analytical study was performed by Astaneh et al. to generate information on actual cyclic behavior and ductility of column base connections [5]. It was recommended to model base plates as semi-rigid connections and not as “pinned” or “fixed” conditions. Fahmy has proposed a classification that many other researchers agree with [6]. Base plates are roughly sorted according to whether the thickness is smaller, equal to, or greater than that required to form a plastic hinge in the plate. Jaspart et al. suggested stiffness boundaries for the classification of column bases depending on the structural system (sway or non-sway frames) [7]. The derivation of the boundaries is based on a sensitivity study of the structural system to the variation of the rotational stiffness properties of the column bases. However, there are few investigations about the effects of column base connection partial fixity on overall response of steel structures. The current study investigates the nonlinear behavior of regular column base connection and assesses its partial fixity by using three-dimensional finite element method. Results from analyses of several