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A comparative study of the effect of the slenderness ratio of Gusset Plates on the behavior of Special Concentrically Braced Frames (SCBF)

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Abstract

Special Concentrically Braced Frame (SCBF) is increasingly utilized as a Seismic Force Resisting System in steel structures. SCBF systems are expected to undergo a significant amount of inelastic deformation during a severe earthquake. The strength of brace connections are thought as one of the most effective parameters on the inelastic behavior of these systems. In this paper, the effect of the slenderness ratio of the compressive area of Gusset Plates on the ductility and energy dissipation of the SCBF systems is studied. Several concentrically braced frames with different amounts of slenderness ratios were analyzed by nonlinear finite element method. The models were subjected to cyclic loads, and seismic characteristics of the braced systems were compared.

Keywords: SCBF, seismic, ductility, energy dissipation, gusset plate

1. INTRODUCTION

Special Concentrically Braced Frames (SCBFs) are one of the most well-known Seismic Force Resisting Systems (SFRSs) that show a significant amount of stiffness during earthquakes. Lateral stiffness of SCBF systems is produced by axial behavior of the diagonal members which due to their high amount of stiffness can lead to an increase in the amount of base shear and a decrease in the amount of the ductility and energy dissipation. In 1978 Jain, Goel and Hanson [1] organized a study on the cyclic performance of braces of different slenderness ratios and showed that the decrease of strength and compressive stiffness of braces are caused by increasing their slenderness ratios. In 1980, Black, Wenger and Popov [2] conducted an experimental study to show the influence of the slenderness ratio of the braces on their cyclic behavior. The results were depicted by appropriate diagrams which show the reduction of strength and compressive stiffness of braces according to enhancement of the slenderness ratio.
One of the most important parameters that affects the capacity of ductility and energy dissipation of this system, is the slenderness of gusset plates which have the role of connecting braces to columns and beams. The forces or rotations of the brace must be accommodated by the gusset plate. So it is required to take more studies about the optimum size of the gusset plates in SCBF systems. Black and his assistants [2] also worked on the effects of boundary conditions of braces with different slenderness ratios and resulted that changing the boundary conditions from pinned-pinned to fixed-fixed have a small positive influence on the ductile behavior of the braces. In 2012, Yao Cui and his assistants [3] worked on the ultimate strength of interface weld connection between gusset plate and frame elements when the brace is in tension. They conducted Pilot experimental study with four specimens and proved that the evaluation recommended by AIJ [4] works well. They also developed a verified finite element analysis model to conduct a parametric study. The parameters studied were the brace angle, gusset plate size, and eccentricity of brace. From the parametric study it was confirmed that the brace tensile force is primarily transferred to the interface weld within an extension of Whitmore region, which is named as the effective region in the AIJ evaluation [4], this region is affected by the gusset plate geometrical constraint.

2. DESIGN OF GUSSET PLATES

According to the AISC 2010 seismic provision [5], the brace connections shall be able to resist the 1.1 times the expected brace strength P_n and the value of P_n can be calculated by Equation 1: