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Comparison of Suspended Zipper Braced Frame and Chevron Braced Frame

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Abstract

Chevron bracing system is prone to buckling of the first story compression brace while the tension one is still at its linear stage of axial behavior. This phenomenon produces an unbalanced vertical force imposed to the top beam leading to concentration of story drifts in one story. Zipper is a vertical member that is added to brace to beam connections in all stories except the 1st one resulting in contribution of the bracing elements at upper stories to lateral force resistance of the structure. Also, this system leads to more economical section for the 1st story compression brace member and uniform distribution of drifts over the height of the structure. Brittle response is considered as one of the main problems of this system, to avoid which the last story members are strengthened. In this study, this system, referred to as Suspended Zipper Braced Frame, is compared with Chevron bracing system in terms of ductility, economic considerations & drift ratios. For this purpose, three 3-9 and 20 story frames are analyzed using the nonlinear static analysis approach in ABAQUS6.6. The results indicate more ductility and uniform story drifts of the suspended zipper braced frames in comparison with chevron ones in three models and less steel weight for 3 and 9 story frames.

Keywords: Suspended zipper braced frame, Ductility, Steel weight, Pushover analysis, Story drift.

1. INTRODUCTION

Concentric Braced Frames (CBF) are among the most efficient structural systems in steel constructions for resisting lateral forces due to their complete truss action. However, these structural framing systems have not been considered ductile by building codes and past design practices [6]. Chevron bracing system is prone to buckling of the first story compression brace while the tension member is still at its linear stage of axial behavior. This phenomenon produces an unbalanced vertical force imposed to the top beam leading to deformation of a soft story mechanism. To overcome this problem Khatib et al.[4] suggested zipper braced frame. Zipper is a vertical member between brace to beam connections in stories in chevron braced frames which delivers the unbalanced vertical force to upper stories [2] and makes them help the 1st story braces in resisting lateral force. This results in distribution of damage over the height of the structure. Tremblay and Tirca [3] studied the behavior of this system analytically and concluded that the frames subjected to severe near-fault earthquake motions collapse immediately due to simultaneous buckling of all compression braces resulting in brittle displacement of the frame. Leon et.al.[5] suggested the same zipper braced frame with strong members in the last story. This resulted in linear behavior of the last story members while the below ones were in plastic stage leading to ductility of the frame. This system is called Suspended Zipper Braced Frame. Figure 1 compares the formation of plastic hinges in C.B.F and suspended zipper braced frame using SAP 2000. Specially Inverted V Braced Frame is a ductile chevron braced frame with strong beams in the 1st story to resist the unbalanced vertical force of the 1st story braces which is recommended in recent codes. In this paper the suspended zipper braced frame is compared with Equivalent Specially Inverted V Braced Frame in 3 – 9 and 20 story frames in terms of ductility, steel weight and story drift ratio distribution using ABAQUS6.6 [1].