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Buckling Prevented Variable Stiffness Knee Braced Steel Frame

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Abstract

A new configuration has been suggested for knee braced steel frames to avoid buckling of diagonal member. High performance of KBF is based on the plastic deformation of knee anchor. Buckling of diagonal member deranges this functionality and causes to reduction in ductility level and energy dissipation rate. Buckling effects on nonlinear static behavior of KBF under cyclic loading has been previously studied by author. Buckling of diagonal element can be avoided using buckling resistant details for axial member or more flexible sections for knee anchor. An alternate and more practical approach is utilization of variable stiffness knee elements. High energy dissipation rate of this system has been evidenced from the hysteretic response of its nonlinear analysis under static cyclic loading. Such a detail is practical using an auxiliary element parallel and in contact with the knee anchor. OpenSees Gap element and no-tension material have been employed to model the contact between the knee anchor and auxiliary element. Suggested technique has been used in nonlinear time history analysis of seismically excited multi storey KBFs under different earthquake records aiming to find the optimal composition of the proposed detail and to compare its performance with traditional KBF. Utilization of modified detail in case studies resulted in 29% reduction in maximum displacement response of seismically excited structure and more energy dissipation rate. Efficiency of the proposed mechanism is not sensitive to the frequency content and other characteristics of exciting earthquake.

Keywords: Knee Braced Steel Frame, Variable Stiffness Anchor, Buckling, Incremental Dynamic Analysis

1. INTRODUCTION

Moment-resisting frame (MRF) and concentrically braced frame (CBF) are ordinary types of lateral loads resisting systems for steel structures. Excellent ductility level of MRF which provides more energy dissipation and considerable stiffness of CBF which restraints story drifts are major advantages of these traditional systems which have been gathered in eccentrically braced frame (EBF) proposed by Roeder and Popov [1]. This system involves fuse-like component that dissipates energy by the formation of plastic flexural or shear hinges. These sacrificial components form on the end or mid of gravity loads bearing girders in the mostly known configurations of EBF systems leads to uneconomically large sections for beams, fig 1; however, the seismic performance of EBF systems has a great interest in new researches proceeded by Mastrandrea and Piluso [2].

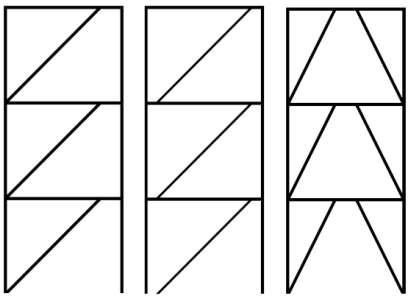

Figure 1: Conventional EBF Systems

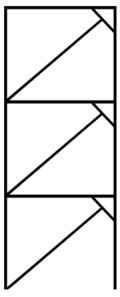

Figure 2: KBF System General Configuration

Separation of the yielding component from the beam elements and its renewability are the main advantages of knee bracing frame (KBF) presented by Aristizabal -Ochoa [3], fig2. Different features of this bracing system have been investigated by Balendra and Sam [4, 5, 6] and further Mofid and Khosravi [7] studied it for its optimal configuration. Buckling of diagonal members which is the main deficiency of CBF systems is likely also for KBF systems. Plastic deformation capacity of knee member shall be limited not only for