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Experimental evaluation of cyclic behavior of batten columns

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ABSTRACT

An experimental study was performed for batten columns subjected to combination of constant axial compression and reversed cyclic lateral loads to evaluate their cyclic response, available ductility and post failure behavior under seismic conditions. To determine and evaluate the available ductility of batten columns, the backbone curves have been developed using experimental hysteresis curves of columns. The effect of different parameters such as axial compression, distance between battens and distance between chords on the available ductility of batten columns have further been studied. The results reveal that the available ductility of batten columns is considerably low compared with solid web columns. The failure mode of batten columns is the combination of local and overall buckling of their bottom chords. The geometrical specifications of batten columns have no considerable and uniform effect on their available ductility. Moreover, it is shown that the backbone curves of batten columns are basically different from solid web columns.

1. Introduction

Batten columns are compression members composed of two or more similar longitudinal components (chords) which are connected at points along their length with batten plates as transverse connectors. These connectors ensure that the column behaves as one integral unit to achieve the maximum axial capacity. In the past decades, many research activities were conducted on the buckling problem of batten columns. Design recommendations and methods for calculation of buckling load for batten columns based on the approach proposed by Engesser in 1891, has been presented by Bleich [1], Timoshenko and Gere [2], Aslani and Goel [3], Temple and Elmahdi [4], Galambos [5], and other researchers.

When a batten column is subjected to lateral load or bending moment about its hollow axis (axis perpendicular to battens) in addition to axial compression, the additional internal actions will be imposed to its members (chords and battens). In this case, it is expected that the batten column will have different behavior and failure modes. If the lateral load or displacement is exerted due to seismic actions, there will be more complexities in the column behavior due to nonlinearities and its post-failure response. The failure studies of batten columns in the Bam earthquake (26th December 2003) indicate the different local failure modes such as local buckling, batten plate ruptures, weld rupture, lateral torsional buckling and also global buckling about hollow axis [6]. These different failure modes demonstrate that the seismic performance of batten columns is unsafe and uncertain. Few researches were reported about the behavior of batten columns in seismic conditions and their ductility. An experimental research was performed on the latticed columns under cyclic axial and flexural actions by Kleiser and Uang [7]. This research was performed to evaluate the cyclic behavior of a type of as-built steel latticed member for the seismic retrofit of the San Francisco–Oakland Bay Bridge. In the appointed research, cyclic testing of three half-scale specimens was conducted. For eccentrically loaded specimens, local buckling at the end panel caused significant degradation in compressive strength; moreover, net section fracture of flange angles near rivet holes where lacing bars were connected was observed as well. Bifurcation type global buckling was observed for the concentrically loaded specimen, causing a drastic drop in compressive strength. The buckling strength can be reliably predicted when the shearing effect and the appropriate effective length are considered. All three specimens were able to reach and exceed the strength predicted by the Load and Resistance Factor Design interaction formulas by about 6%, but this over strength was slightly lower than that typically found in wide-flange beam-columns. Based on these test results, a modified axial force–moment interaction relationship was proposed [7]. According the test results the ductility capacity ranged from 2.0 to 2.4. Sahoo and Rai [8] have performed a study that examines the effect of battens and their connections on the behavior of batten columns under seismic conditions. The objective of that research is to develop a design of ductile built-up beam-column, which can reach full plastic moment carrying capacity of the section without instability. The study is based on the testing of five battened double-channel members subjected to axial compressive loads and reversed cyclic lateral loads. The reversed cyclic loads are established so that the battened double-channel members experience substantial inelastic deformations in tension and in compression in presence of axial compressive loads, similar to those expected during earthquakes. The tests reveal that under

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