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Seismic performance of Q690 high strength steel welded H-section columns

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Abstract

In order to further study the seismic performance of Q690 high strength steel (HSS) columns, a finite element (FE) model was built up by using general FE analysis software ABAQUS. H-section columns under horizontal cyclic loading were simulated. The influences of web width-to-thickness ratio, flange width-to-thickness ratio, column slenderness ratio and axial compression force ratio on the load-bearing capacity and deformation capacity were analyzed. The FE analysis result shows that the Q690 HSS H-section columns have a good seismic performance. And the simplified formulae of the load-bearing capacity and deformation ability of the Q690 H-section columns under the cyclic loading are obtained.

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Keywords: Load-bearing capacity; deformation capacity; web width-to-thickness ratio; flange width-to-thickness ratio; column slenderness ratio; axial compression force ratio.

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1. INTRODUCTION

With the development of the steel production and manufacture process, high strength steel (HSS) structures have been increasingly applied to building and bridge constructions in recent years, due to their advantages in structural safety, architectural function, economical benefit, resource saving, etc. Compared with conventional mild carbon steel members, the application of HSS members could not only reduce member size and save building space, but also show considerable economic benefits through reducing the workloads of transportation as well as welding and shortening the time of construction (Wang et al. 2015). In the previous studies, the seismic performance tests of Q690D welded H-section columns under regular cyclic loadings were carried out (Li et al. 2013; Chen et al. 2014). However, these tests did not obtain the critical surface of local buckling and global buckling. And the results are just based on qualitative analyses rather than quantitative analyses.

In this paper, the seismic performance of Q690 H-section HSS columns is studied numerically. Firstly, the effect of axial compression force ratio, column slenderness ratio, web width-to-thickness ratio and flange width-to-thickness ratio are analyzed, respectively. Then, different regular cyclic loading patterns are defined to study their effects. Finally, a set of simplified formulas for the load-bearing capacity and deformation capacity of Q690 H-section HSS columns under regular cyclic loads is proposed.

2. ANALYTICAL MODEL

2.1. Finite element model of Q690 high strength steel columns

To investigate the effects of main parameters on the seismic behavior of Q690 H-section steel columns, 29 columns (as listed in Tab. 1) are analyzed using the general finite-element software ABAQUS. Cross section of analytical Q690 H-section steel columns is shown in Fig. 1. Analytical model of Q690 H-section steel columns is shown in Fig. 2. Subsequently, a large deformation finite element analysis procedure is carried out to examine the behavior of columns subjected to lateral cyclic loads. where: R_f = flange width-to-thickness ratio, R_w = web width-to-thickness ratio, λ = column slenderness ratio, L = column height, t_f = flange thickness, t_w = web thickness, B = flange width, h = web height, $n = P/P_y$ = axial compression force ratio (where the axial yield force P_y is computed when the full cross section is in plasticity).

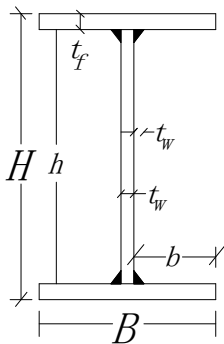


Figure. 1. Cross section of analytical columns

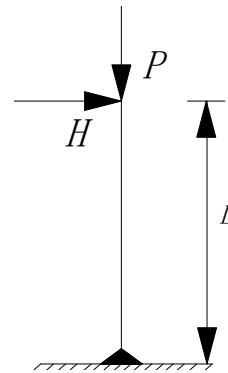


Figure. 2. Analytical model of Q690 columns

4-node reduced integrated shell element of S4R is employed for simulating the column specimens. For shell element, to investigate and simulate local buckling in detail, the meshing is refined locally in the column lower part, and the minimum size of refined meshing shell elements is 4mm×4mm.

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