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Behaviour of large fabricated stainless steel beam-to-tubular column joints with extended endplates

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Abstract. This paper presents the flexural behaviour of stainless steel beam-to-tubular column joints with extended endplates subjected to static loading. Moment-rotation relationships were investigated numerically by using Abaqus software with geometric and material nonlinearity considered. The prediction of damages among components was achieved through ductile damage models, and the influence of initial geometric imperfections and residual stresses was evaluated in large fabricated stainless steel joints involving hollow columns and concrete-filled columns. Parametric analysis was subsequently conducted to assess critical factors that could affect the flexural performance significantly in terms of the initial stiffness and moment resistance. A comparison between codes of practice and numerical results was thereafter made, and design recommendations were proposed for further applications. Results suggest that the finite element model can predict the structural behaviour reasonably well with the component damage consistent with test outcomes. Initial geometric imperfections and residual stresses are shown to have little effect on the moment-rotation responses. A series of parameters that can influence the joint behaviour remarkably include the strain-hardening exponents, stainless steel strength, diameter of bolts, thickness of endplates, position of bolts, section of beams and columns. AS/NZS 2327 is more reliable to predict the joint performance regarding the initial stiffness and moment capacity compared to EN 1993-1-8.

Keywords: stainless steel; beam-to-column joint; tubular column; concrete-filled column; residual stress

1. Introduction

Stainless steel has gained growing popularity in engineering practice during the last few decades owing to its various benefits such as high ductility, significant strain hardening, better corrosion and impact resistance, and relatively low maintenance expenses in the whole life cycle (Han *et al*. 2019, Hasan *et al*. 2017 and Yousuf *et al*. 2014). These preferable benefits contribute to a wide range of applications of stainless steel as the primary structural material in building and bridge construction (Baddoo 2008 and Paul *et al*. 2017). Currently, a vast majority of stainless steel structures are based on a cold-formed manufacturing process. However, large fabricated stainless steel structures are expected to achieve a wider application in mega projects and complicated structural forms by virtual of its flexible fabrication. Although the high initial cost, resulting from the chemical composition of nickel, temporarily limits an extensive use as an alternative to carbon steel, it is advisable to promote academic research on the stainless steel structures in order to have a comprehensive understanding of the structural behaviour, and to propose robust design guidance.

Considerable previous research has been carried out to investigate the performance of stainless steel beams, columns and connections (Dai and Lam 2010, Lee *et al*. 2014, Kim and Lim 2013, Kiymaz and Seckin 2014 and Averseng *et al*. 2017). Arrayago and Real (2016) and Gkantou *et al*. (2019) performed experimental studies on simply supported and continuous beams to investigate the flexural behaviour in terms of the cross-section slenderness limits. Comparisons between test results and design codes were thereafter made to assess the adequacy of current specifications for stainless steel. Tondini *et al*. (2013), Huang and Young (2014), Jandera and Machacek (2014) and Tokgoz (2015) investigated the performance of stainless steel columns under fire conditions, eccentric loading and biaxial loading experimentally and numerically. Residual stress distribution patterns were explored to evaluate the influence on the column behaviour. Research results were compared with design provisions throughout the world contributing to the improvement of design guidance. Lui *et al*. 2014, Zhao *et al*. 2016 and Lopes *et al*. 2019 discussed the structural performance of stainless steel beam-columns subjected to various loading conditions. By means of experimental programmes and numerical analysis, three types of stainless steel including austenitic, ferritic and duplex were considered respectively to look into the varied behaviour. Cai and Young (2018) reviewed a wide range of literature regarding stainless steel bolted connections at ambient and elevated temperature. A suggested design bearing resistance factor was compared to the current design codes and proved to be applicable to various

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