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Fracture analysis and design of stainless steel staggered bolted connections

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ABSTRACT

Stainless steel staggered bolted connections combine the superior properties of stainless steel with the structural advantages of staggered bolt arrangements. They not only maintain excellent ductility and corrosion resistance but also optimize load transfer paths, improve material utilization, and reduce the number of bolts required. As a result, these connections have been widely applied in public buildings, marine engineering, and chemical equipment. However, compared with conventional stainless steel bolted connections, research on the strength and failure mechanisms of staggered bolted connections remains relatively limited. This study therefore conducted systematic experimental and numerical analyses. A total of 30 austenitic and duplex stainless steel staggered bolted connections were tested to examine the influence of material type and geometric parameters on connection strength. The experimental results indicated that net section fracture along the staggered path was the predominant failure mode, while shear cracking around the bolt holes was also observed in some specimens. An extensive parametric study was also performed using numerical modelling. Based on the experimental and numerical findings, this study systematically evaluated the predictive accuracy of existing design standards in estimating the net section fracture resistance of stainless steel staggered bolted connections. The results revealed that the current standards fail to accurately capture the failure mechanisms of staggered connections. In response, an improved design method was proposed, incorporating modifications to better predict the net section fracture resistance of stainless steel staggered bolted connections. Additionally, reliability analysis was conducted to establish an appropriate partial safety factor for practical engineering applications.

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