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In-plane bending behaviour of stainless-clad bimetallic steel welded tubular T-joints with different welding configurations

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ABSTRACT

Stainless-clad (SC) bimetallic steel, a layered high-performance material composed of two metals with distinct properties, offers high strength, excellent corrosion resistance, and cost-effectiveness. It is particularly competitive in structural applications requiring high corrosion resistance. Integrating SC bimetallic steel into tubular structural systems by fabricating it into closed-section tubular components (with the cladding layer positioned externally) presents a promising strategy for developing SC bimetallic steel tubular systems, especially for offshore engineering. However, academic research on this novel tubular structural type remains limited, particularly regarding the welding configuration, which is critical for tubular joints. The dual-metal composition of SC bimetallic steel, combined with the presence of a bonding interface, introduces unique characteristics to tubular joints fabricated from this material. These include distinct structural behaviour variations resulting from different welding configurations and the potential for separation of the two component metals at the bonding interface of the bimetallic steel plate within the joint region. Such features pose significant challenges for the design, fabrication, and performance assessment of these joints.

Based on this, the present paper proposes two welding configurations for SC bimetallic steel tubular T-joints, specifically focusing on the region between the chord and the brace. The first configuration, SCWT1, involves milling off the local cladding metal on the chord face in the joint region, filling the substrate region with carbon steel welding consumables, and using stainless steel welding consumables for the transition and cladding regions. The second configuration, SCWT2, uses stainless steel welding consumables for the entire weld region without milling off the cladding metal.

This paper experimentally investigates the structural behaviour of SC bimetallic steel welded tubular T-joints with the proposed welding configurations under monotonic brace in-plane bending. Full-scale tests generated extensive data on the behaviour of both T-joints, including comparisons of failure modes, bonding interface conditions, and joint moment resistances. The research demonstrates that the two welding configurations between the chord and brace exhibit similar joint performance, including comparable moment resistance and failure modes. More importantly, the bonding interface in both T-joints remained intact, confirming the collaborative performance of the substrate and

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cladding metals, even under extensive deformation. Specifically, in the T-joint with SCWT1, the cladding metal in the joint region was milled off, and the newly deposited weld metal formed a sound bond with the substrate metal, with no failure observed. In the T-joint with SCWT2, the cladding metal in the joint region was left intact during welding, and cross-section confirmed undamaged bonding interfaces, further validating the effectiveness of both welding configurations.

Therefore, using a welding configuration with pure stainless steel consumables (SCWT2) is preferable. However, if another configuration is adopted, the removal of local cladding metal must be carefully controlled to ensure the milled region is fully refilled with weld metal.

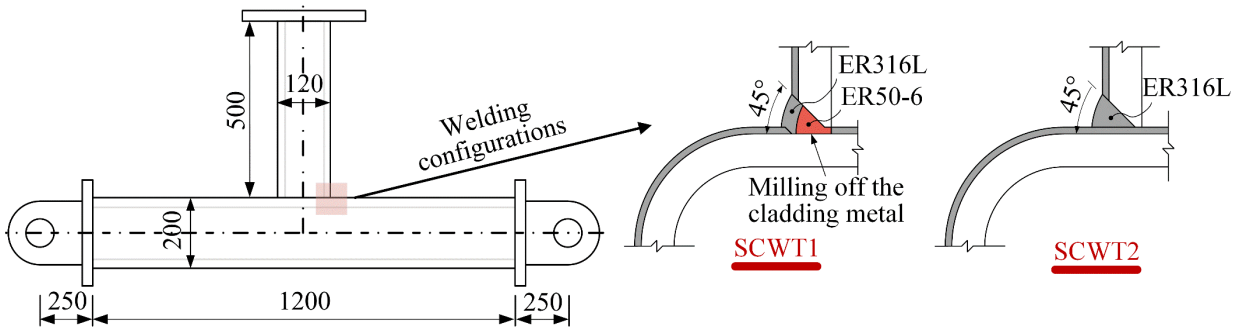

Fig. 1 Welding configurations

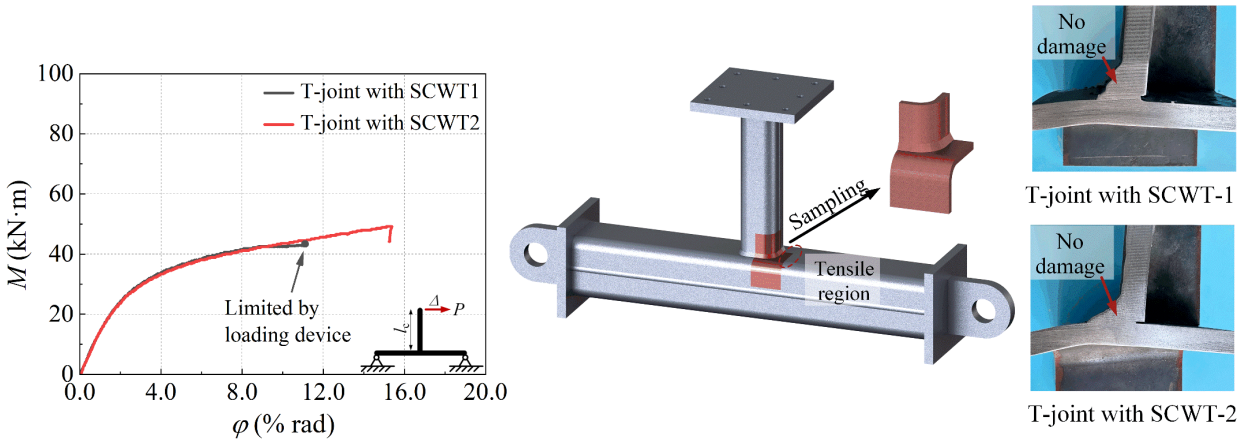

Fig. 2 Joint moment resistance and bonding interface state

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