Geometric Imperfection and Residual Stress Effects on the Axial Performance of WAAM Steel Stub Columns

Background: Wire Arc Additive Manufacturing (WAAM) offers a groundbreaking approach to fabricating steel and stainless-steel tubular structures with high geometric flexibility. However, WAAM components inherently exhibit **geometric imperfections** (e.g., wall thickness variations, local distortions) due to the layer-by-layer deposition process. These imperfections can critically compromise the load-bearing capacity and stability of stub columns under axial compression, yet current international design codes (e.g., EN 1993-1-1, AISC 360) lack provisions for WAAM-produced sections.

This thesis aims to systematically investigate the **combined effects of geometric imperfections** on the axial behavior of WAAM stub columns through experimental testing, advanced numerical modeling, and microstructure analysis. The results will directly support the development of WAAM-specific design guidelines, addressing a critical gap in modern structural engineering.

Research Objectives

1. **Material Characterization**
    - Conduct tensile coupon tests on WAAM materials to determine elastic-plastic properties and calibrate finite element models.
2. **Geometric Imperfection Quantification**
    - Perform 3D laser scanning on WAAM stub columns to extract local and global imperfection profiles.
3. **Axial Compression Testing**
    - Evaluate the compressive strength, buckling modes, and failure mechanisms of WAAM stub columns at ambient temperature.
4. **Integrated Numerical Modeling**
    - Develop Abaqus FE models incorporating scanned imperfections and residual stresses, validated against experimental results.

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