

INVESTIGATING THE RESIDUAL DESIGN RESISTANCE OF STEEL MEMBERS UNDER PITTING CORROSION

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Steel is a widely used material in civil engineering and construction, considering its various advantages, including strength, design flexibility, safety, cost-effectiveness, and construction efficiency. However, their long-term performance is often compromised by material deterioration mechanisms, such as pitting corrosion, which can severely impact structural integrity. The reduction in cross-sectional area, material loss, and weakening of steel sections caused by corrosion-related deterioration impact the structural integrity and load-bearing capacity of steel members. Unlike uniform corrosion, pitting corrosion is a highly localised deterioration process that produces small surface cavities in steel, which in turn causes a considerable loss of structural strength. Although extensive research has addressed the impact of pitting corrosion on the residual strength of Circular Hollow Sections (CHS), limited attention has been given to Square Hollow Sections (SHS), leaving a notable gap in current knowledge. This research investigates how pitting corrosion affects the residual design resistance of SHS members through experimental testing and numerical modelling. This study examines the influence of critical pitting parameters, including pitting intensity, location, and distribution, on the structural integrity of steel members. The experimental investigations were carried out on SHS with artificially introduced local pits on the surface of the members. These controlled imperfections enabled a systematic evaluation of how varying pit characteristics influence the residual strength and failure behaviour of the members. Axial compression tests were performed on the SHS specimens to evaluate how localised corrosion affects their load-bearing capacity. SHS specimens with both uniformly arranged and randomly distributed pits were examined, while ensuring an equivalent Degree of Pitting intensity (DOP) across specimens. Finite Element (FE) modelling was employed to replicate the tested specimens, providing a numerical framework to validate the experimental results. The accuracy of the simulations was confirmed by comparing numerical results and experimental data. Following validation, the FE models were used to conduct a detailed study of the behaviour of members with randomly distributed pitting. Statistical analysis was included to measure the impact of variability in pit characteristics on the residual structural performance. The validated numerical results revealed that randomly distributed pitting led to greater variability in strength and distinct differences in failure patterns compared to uniformly pitted members. The findings indicate that uniform corrosion reduces strength by 14%, while random pitting reduces the strength by over 30% for the specific pitting intensity considered in this study. As the pitting intensity increases, the strength reduction may range from 7% to over 50%. The maximum strength reduction occurs when the pits form in the middle of the specimen, indicating a critical vulnerability in the structural integrity under pitting corrosion. In summary, this research emphasises the significance of pitting corrosion in assessing the residual strength and long-term performance of steel structures.

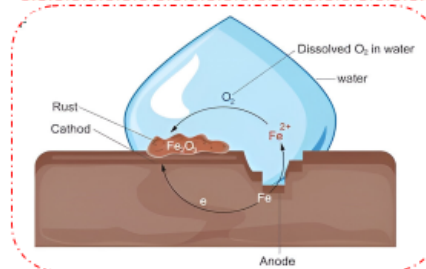
Keywords: Axial compressive test, Pitting corrosion, Random pitting modelling, Statistical analysis, Square hollow sections

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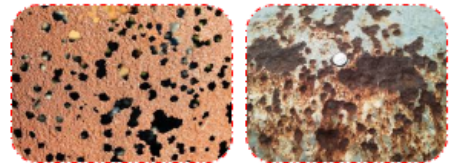
Background

Pitting corrosion occurs due to the exposure of the passive layer of steel to the air and water



Why pitting corrosion?

- Random pitting arrangement and depth
- Localised loss of thickness

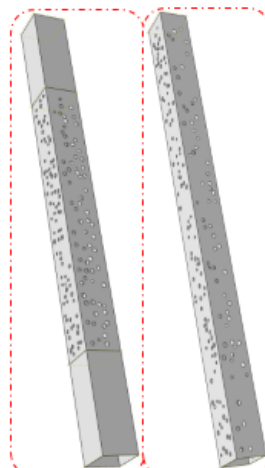
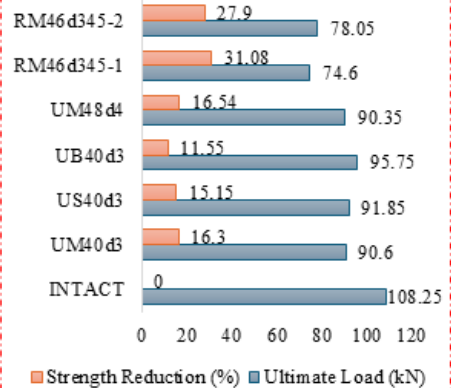


Experimental testing and numerical modelling



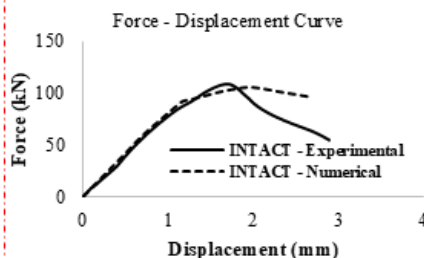
Materials and Methods

- 7 test specimens with different pit locations and intensities
- 500 mm length testing specimens
- Tensile test using UTM
- Axial compressive tests



Numerical Modelling

ABAQUS- based numerical modelling



Model validation

Conclusion

Uniform corrosion reduces strength by 14 %, while random pits reduce the strength by over 30% for the selected DOP

As the pitting intensity increases, the strength reduction may range from 7% to over 50%.