UNIVERSITI TEKNOLOGI MARA

APPLICATION OF ULTRA-HIGH-PERFORMANCE CONCRETE WITH QUARRY DUST MIX IN THE REHABILITATION AND RETROFITTING OF CORRODED STEEL COLUMNS

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ABSTRACT

Steel structures are an important component of the Industrial Building System (IBS) in Malaysia. The technology is renowned for its expedited construction, reduced labour requirements, and straightforward assembly. Nevertheless, a significant number of steel buildings have experienced corrosion as a result of harsh environmental conditions, such as high temperatures and humidity. The corrosion of steel members in IBS leads to a reduction in the load-bearing capacity and structural integrity of the structure. The objective of this study is to assess the effectiveness of UHPC-QD (Ultra High-Performance Concrete with quarry dusts partial substitute for cement) in protecting corrosion-damaged steel columns and to reduce environmental impact. The UHPC-QD used in this research is economically efficient due to optimisation, with a specific emphasis on enhancing strength and durability for the purpose of reinforcing the corroded steel column. UHPC-QD to create a composite to encase the ~~using~~ corroded H-Shape steel columns. Steel specimens are immersed in a solution of hydrochloric acid (HCl) to accelerate the corrosion process until they experience appreciable weight loss. The study involved constructing finite element models of normal and reduced-thickness universal columns (UC) specimens to assess corrosion and various rehabilitation methods for corroded UC using UHPC-QD. The models included fully encased (S3), fully encased with bolts shear connector (S4), and fully encased with British Reinforcement Concrete (BRC) (S5) configurations to simulate failure behaviour. The results indicated that the bonding properties of UHPC-QD and the UC were improved with shorter interval durations. Moreover, the bond strength initially increased and then decreased when the difference in strength between UHPC and UC lessened. The rehabilitation technique using UHPC-QD led to a more than fivefold improvement in the axial capacity of the corroded UCs, demonstrating the efficiency of the UHPC-QD repair method in recovering the load-bearing capacity of corroded steel columns. The axial capacity in S3, S4, and S5 has increased by 76%, 79%, and 77% respectively. The calculated results closely aligned with the observed experimental occurrence, indicating that buckling primarily occurred in the mid-span. Additionally, the elastic strain at the axial load on site was minimal, rendering the structure more prone to buckling. Utilising UHPC-QD for rehabilitating corroded steel columns would enhance their strength and durability. The most economically efficient form of rehabilitation, which involves totally encasing the corroded steel-framed buildings with bolt shear connectors, was done at the UiTM Machang campus. The study emphasises a practical and economical approach to rehabilitating rusted steel columns.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The introduction of steel columns in the 19th century marked a significant shift in construction, enabling the creation of taller, more complex, and efficient buildings. Initially, steel columns were not widely adopted due to their high cost and complexity of fabrication (Wermiel, 2009). Technological advancements in steel production, such as the Bessemer process and open-hearth technique, reduced the cost and increased accessibility of steel, making it a viable material for construction projects (Abdulrahimzai, Salah, & Abushreitah, 2023). These advancements also facilitated by the efficient transportation of steel, further promotes its use in building design and construction.

Corrosion of steel structures negatively impacts the economy and environment due to increased energy and material consumption. Corroded structures are often rehabilitated at high costs or demolished, leading to environmental challenges, safety hazards, and interruption of industrial operations. The cost of corrosion is a constant charge to a country's GDP, with the annual cost in the US estimated at up to $5.5 billion. On a global scale, the global cost of corrosion is estimated at US$2.5 trillion, equivalent to 3.4% of the global GDP (Bowman et al., 2016; Rajendran, 2018) . The Bhopal Accident of Union Carbide India Limited company in 1984 caused the death of 3000 people and injury of almost 500,000 people. In 1985, 12 people lost their lives in Switzerland due to corrosion of stainless-steel rods supporting a swimming pool roof. In 2004, four people died and seven were injured due to accelerated corrosion of piping rupture in Japan.

Steel column design has evolved over time, with early approaches based on elastic models replaced by ultimate-strength methods and load and resistance factor design (LRFD) methods. However, there are many challenges to maintaining the structural integrity of industrial building systems (IBS) until their lifespan ends. One of the significant challenges is the corrosion of metals; locally corrosion member of a structure loses its bearing capacity, which can significantly cause human injury and