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BOND STRENGTH OF SAND-COATED SMA REBARS WITH MECHANICAL COUPLERS

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ABSTRACT

This research evaluates the pullout test configuration and bond strength of sand-coated SMA rebars with different mechanical couplers. The study is divided into three phases, each corresponding to a specific objective. In the first phase, a pilot study was conducted to identify the optimal pullout test configuration for determining the bond strength between mechanical couplers and steel rebars. Three pullout test configurations were implemented namely Uniform Pullout Test (UPT), Direct Pullout Test (DPT), and Direct Tension Pullout Test (DTPT), each adopted from international standards. The results indicated that the DPT configuration provided the most consistent bond strength predictions compared to UPT and DTPT. Additionally, the results from Phase One reveal that the bond strength performance did not rely solely on the pullout test setup (e.g., clamp zone length); other factors such as bar diameter and coupler type also played a crucial role. Emanating from the outcome of Phase One will serve as the basis for the pullout test configuration used in Phase Two. In Phase Two, the effect of SMA surface roughness was first investigated by applying sand with varying particle sizes, ranging from 0.6 mm to 1.18 mm, to create different surface textures on the SMA rebars. Two different couplers namely Mechanical Bolted Coupler (MBT) and Full Grout Coupler (FGC) were used to investigate the effect of surface roughness on the performance of bond strength. The experimental pullout test was configured based on the DPT setup method. The results indicated that different coupler types yield different bond strength performances. For the FGC coupler, coarser sand particles resulted in higher bond strength, and vice versa. In contrast, for the MBT coupler, bond strength was reduced by 72% with the introduction of the sand coating. This highlights that, in addition to rebar surface roughness, the type of coupler plays a significant role in determining the bond performance of SMA rebars. In Phase Three, a prediction model for determining the bond strength of mechanical couplers was derived using the experimental data collected from Phase Two through regression analysis. The prediction model is applicable for the steel MBT connections, the sand-coated SMA MBT connections, and the sand-coated SMA FGC connections, where the percentage error of the predicted value was less than 10%.In conclusion, this study highlights that effect of clamp zone did play an important on bond strength, the surface roughness shows significance when FGC coupler for sand-coated SMA reinforcement was utilised,. Finally, the good prediction model with less 10% error for sand-coated SMA connections was developed, which highlights the novelty of this thesis.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

The bond stress slip of rebar within the concrete plays a critical role in deformation of reinforced concrete (RC) members. Over the year, researchers have been exploring to better understand the bond behaviour with rebar within the concrete (Daghash et al., 2017; E. Choi et al., 2018). In traditional RC structure, load continuity is achieved through lapping of steel reinforcement rebars. However, the weak bond between overlapping rebar often happened in high stress regions which lead to significant cracking under loading, especially seismic loading. This issue becomes more critical in large construction, especially bridges and infrastructures, where the resistance of the overlapping area and the connection between existing rebar cages play a vital role in ensuring overall structural performance. To overcome these issues, mechanical couplers make a more reliable alternative to traditional lap splices which significantly improves the joint integrity of rebar, in which the structure does not rely entirely on concrete bonds for load transfer (Dabiri et al., 2022).

In accordance with building code recommendations to ensure the integrity of structures, many researchers have explored the use of mechanical coupler joint between structures in construction (Jacinto et al., 2023; Dabiri et al., 2013; Dahal & Tazarv, 2020; Bompa & Elghazouli, 2017). Several standard and design codes have established specific pull-out testing criteria for mechanical couplers to ensure effective splicing (ASTM A1034, ISO15835-1). These standards focus on ensuring sufficient tensile strength and minimising the slip of the rebars within the couplers. Accordingly, the total slip value measured from test should not exceed 0.1 mm (ASTM A1034). Although the mechanical coupler connection demonstrated high efficiency and widely used, the performance variation among the different couplers according to different standards from the perspective bond slip relationship are rarely documented.

In the seismic scenario, the mechanical splices maintain integrity when the steel reinforcement is stressed into the inelastic region. However, the outcome still results in permanent deformation, leading to a significant crack in the plastic hinge region. Considering the extent of the damage, a new theory of minimizing residual deformation