UNIVERSITI TEKNOLOGI MARA

STRUCTURAL BEHAVIOUR OF REINFORCED CONCRETE BEAM WITH RUBBERISED ENGINEERED CEMENTITIOUS COMPOSITE (RECC) SUBJECTED TO FATIGUE LOAD

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ABSTRACT

Recently, RC beams have been primarily used in engineering works, from small constructions to tall buildings. Previously, existing structural elements of RC beams were designed by structural designers only for gravity loads and did not consider dynamic loads in designing structural buildings. This is mainly because of structural weaknesses in strength concrete, poor reinforcement detailing, and a lack of capacity design principles. Engineered Cementitious Composite (ECC) is an effective way to enhance the structural performance of a building. However, research has consistently shown that limited studies use ECC with crumb rubber. The study aims to determine the optimum percentage of Rubberised Engineered Cementitious Composite (RECC) as a partial fine aggregate replacement through compressive strength, evaluate the structural behaviour of RC beams with optimum RECC in terms of ductility through fatigue load tests, and assess the crack pattern of RC beams with optimum RECC through fatigue load tests. The fatigue load was tested and compared to the structural behaviour of RC beams retrofitted with RECC subjected to fatigue load. The studies involve 3 phases of experimental work. In phase 1, prepare materials (crumb rubber, fly ash, silica sand, water, and cement). A different proportion of 0%, 5%, 10%, 15%, and 20% crumb rubber as partial fine aggregate replacement in the RECC mixture. In Phase 2, 54 RECC samples were used to determine the optimum percentage based on compressive strength. In the third phase, 3 RC beam samples were used, measuring 1000 mm x 220 mm x 220 mm. Sample 1 is subjected to static load testing to determine its maximum load capacity, while Sample 2 and 3 are subjected to fatigue load testing using 15% of the maximum load of Sample 1. As a result, the optimum percentage of crumb rubber is 5%, replacing the sand in the ECC obtained in this study. The analysis of load versus displacement and ductility indicates that the RC beam sample before and after being retrofitted with RECC can accommodate the applied loading in terms of structural behaviour. Analysis of the crack behaviour of RC beams with optimum RECC through a fatigue load test shows that the crack type is a flexural crack. Using 5% of RECC shows a positive impact on development. RECC creates a Crack Arresting Zone (CAZ) that reduces crack length and crack width.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Nowadays, Reinforced Concrete (RC) is primarily used as a structural component in structural works, from small constructions to tall buildings. For example, in statically indeterminate structures, it gives the elements the capacity to behave according to the assumptions specified by the designer of the structural system. Since the structure's design and execution follow design theories, limitations are imposed by reasonably acceptable on-site procedures (Lari, 2020). Previously, existing structural elements of RC beams were designed by structural designers only for gravity loads and could not endure dynamic loads. This is mainly because of structural weaknesses related to limited material properties, typically low-strength concrete, poor reinforcement detailing, and the lack of capacity design principles (Beschi et al., 2012).

Ganesh and Murthy (2023) reported that building structure components like RC beams suffered significant damage during service life, primarily due to in-service loading conditions (static and fatigue loads), durability issues, and faulty construction practices. The extent of damage and deterioration in the existing concrete structures necessitated a strengthening procedure to improve their serviceability.

According to Fakih et al. (2021)and Xiao et al. (2021), the primary materials of Engineered Cementitious Composite (ECC) are fine aggregate, cement, fiber, and admixtures, while no coarse aggregate is needed for the mixture. ECC is aimed to have the high brittleness and cracked tendency of standard concrete caused by high compressive strength to increase ductility and repairability (Kewalramani et al., 2017). Rubberised composite is an affordable construction material that withstands more pressure and impact when compared to standard concrete. Therefore, rubberised composite can be used in buildings as earthquake shock-wave absorbers, highway pavement construction, and airport runways (Safan et al., 2017).

Based on the findings of Alaloul et al. (2020), tests on structural concrete using crumb rubber are rare and have shown contradictory results. The test on structure components using Rubberised Engineered Cementitious Composite (RECC) generally had higher ductility than standard concrete. According to Assaggaf et al. (2021), Aleem