Effect of Plate Thickness on the Width and Distribution of Cracks on Engineered Cementitious Composites (ECC)

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ABSTRACT

In retrofit works, the thickness of the repair layer is critical in preserving the structural integrity and aesthetic appeal of the original structure. ECC is a recently designed ductile fiber reinforced material suitable for use in retrofit works. In this study, the effect of thickness of ECC plates on the width and distribution of cracks was analyzed. It was observed that there was no significant variation in crack width and distribution with increase in plate thickness. Rather, all ECC plates produced multiple fine cracks with an average width of 0.08mm. Therefore, the thickness of plates has no impact on the width and distribution of cracks.

KEYWORDS: ECC; repair layer; thickness; crack width; crack distribution.

INTRODUCTION

Structural integrity and economic viability are always intertwined in the design of structures. Therefore, the question whether a structure will perform the desired functions within the design period is as critical as how much it will cost to implement the project. Material composition, safety factors and tolerances all come into play in optimization of designs. In this regard, understanding the properties and behavior of construction materials is a critical component.

Plain cement materials such as cement pastes, mortars and concretes are commonly used for construction. Despite being ubiquitous, these materials have several inherent deficiencies related to the material structure and failure modes. These deficiencies diminish their capacity to perform certain functions. Concrete, for instance, is brittle under severe loading, deteriorates under normal service load and its reinforced structures lack sustainability (Li VC, 2005). The brittleness is a result of the production of a typical Griffith type (Griffith, 1921) crack while deterioration is caused by both internal and external factors which can be physical, chemical or mechanical (Neville, 1996). Concrete therefore lacks both early age performance and long-term durability. Durability is as critical in the retrofit and repair of structures as it is in new ones. Therefore the use of plain cement materials for repair or retrofit works produces structures with poor durability which exhibit premature repair deterioration. This in turn exposes the repaired structures to aggressive environments and consequently, endless, uneconomical cycle of repairs (Li M and Li VC, 2006).

Efforts to address the brittle behavior of plain concrete materials have led to modern concepts of fiber reinforcement and interface engineering (Li VC, Dhanada, Mishra and Hwai, 1995). Engineered Cementitious Composites (ECC), a member of the High Performance Fiber Reinforced Cement Composites (HPF RCC) group, is a fiber reinforced cement based composite material that is excellent at crack dispersion. Formed primarily from cement and sand with fiber and certain chemicals as additives, ECC are systematically engineered to achieve high ductility under tensile and shear load. It can achieve maximum ductility in excess of 3% under uniaxial loading with only 2% volume of fiber content. This moderate amount of short discontinuous fibers allows flexibility in construction execution, including self-consolidation casting (Kong, Bike and Li VC, 1996) and shot-crating (Kim, Kong and Li VC, 2003). Structural products have been manufactured by extrusion of ECC (Stang and Li VC, 1999) with a strain capacity 500 times that of normal concrete or other fiber reinforced concrete (Kunieda, Rokugo and Miyazato, 2006). ECC develop multiple fine cracks less than 0.1mm as opposed to the through crack of unlimited width developed by plain cement materials. The tight crack width of ECC is important to the serviceability of ECC structures as the tensile ductility is to the structural safety at ultimate limit state (Li VC, 2005).

In retrofit or repair works, the strength of the substrate/repair layer bond is critical. Due to the inherent properties of plain cement materials, the drying shrinkage of the new material restrained by the old material leads to cracking and interface de-lamination between the repair and the concrete substrate. This phenomenon can introduce water and other deteriorative agents into the repaired system that will in turn accelerate further deterioration. However, it has been verified experimentally, that when an adequate bond is provided, the high ductility of ECC could relieve shrinkage induced stresses in the ECC repair layer and at the ECC/concrete interface thereby suppressing large surface cracks and interface de-lamination (Li M and Li VC, 2006).

PROBLEM DESCRIPTION

Despite the apparent structural superiority of ECC over normal concrete for retrofit and repair applications, the use of ECC is currently

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