FINITE ELEMENT MODELING ON THE FLEXURAL BEHAVIOUR OF COMPOSITE PRECAST HYBRID FIBER REINFORCED LIGHWEIGHT AGREGATE CONCRETE SLAB

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ABSTRACT

Abstract

This research was conducted to produce structural lightweight concrete with better tensile strength, by adding mixed fibrous materials of steel and polypropylene fibers in to the concrete mix that utilizes lightweight pumice breccia as coarse aggregate. The optimum composition of Hybrid Fiber Reinforced Lightweight Aggregate Concrete (HyFRLWAC) is then used as the material for stay in-place formwork and applied for the construction of composite plates using partially precast concrete system by utilizing the self-compacting concrete (SCC) as a topping layer. This study focused on determining the appropriate strength limit criteria which can be applied to analyze the interface strength between two types of high performance concrete materials (HyFRLWAC as the substrate layer with SCC topping) without any shear connector.

Experiments were conducted to determine the optimal composition of HyFRLWAC. Compressive strength test performed on 45 specimens that consist of 15 variants to investigate the effects of variations in the composition of aggregate, partial replacement of cement with silica fume, and the addition of hybrid fibers. Experimental investigations were also performed on 15 specimens of splitting tensile and 15 specimens of flexural tensile test for five variations of hybrid (steel and polypropylene) fibers composition. The optimum composition of HyFRLWAC which obtained from the experimental test then utilized as the substrate layer. The tensile strength between HyFRLWAC with SCC was tested using pull-off test method, while the cohesion strength was investigated using modified bi-surface shear test. The variations were designed based on the substrate surface conditions and compressive strength of SCC which is used as the topping layer. Evaluation of the tensile strength was implemented in 10 variants, and 15 variants for the cohesion investigation. The condition of the substrate surfaces were prepared in a smooth condition (as-placed), and grooved for tensile strength test. Furthermore, the grooves were prepared in longitudinal and transverse direction for the cohesion test. After 28 days, on the top of the substrate were casted with five variations of SCC compressive strength as the topping layer. In this stage, 30 specimens were prepared for pull-off test, and 45 for modified bi-surface shear test. The next test was conducted to determine the effect of normal force on the shear strength of the interface. Tests conducted on 54 test specimens of double L-shaped shear test, which consists of 18 variants (three substrate surface variation with six variations of the magnitude of normal force). The final stage of the research is full-scale testing of the nine composite concrete slabs. The slabs prepared in smooth substrate surface conditions (as-placed), grooved in longitudinal direction, and grooved in transverse directions.

Structural lightweight concrete (LWC) can be produced when the mixtures utilized pumice breccia as coarse aggregate and its volume fraction range between 55% and 75% to the total volume of aggregate. The mechanical strength of LWC can be optimized by replacing 9% by weight of cement with silica fume, as well as the addition of hybrid fibers with a composition of 0.1% of polypropylene fiber and 1.0% of steel fiber by volume of concrete. Tensile and cohesion strength of the interface that utilizes HyFRLWAC as substrate and SCC as topping layer is affected by the compressive strength of the topping layer. When the topping casted with SCC in between 30 MPa to 60 MPa, the tensile strength of the smooth interface can be calculated as , and for the grooved substrate, the formula should be . Cohesion strength can be calculated as , with the value of c are: 0.999 for as-placed substrate surface, 1.258 for the longitudinal grooved, and 1.312 for transversal grooved surface. When a combination between shear and compressive stress working on the interface area, the interface shear strength can be calculated as , with μ are: 0.728 for as-placed substrate surface, 0.959 for the longitudinal grooved surface, and 1.181 for transversal grooved surface. If the interface receives a combination of shear and tensile stress, then , with k are: 3.399 for as-placed substrate surface, 4.097 for longitudinal grooved surface, and 4.205 for transversal grooved surface. Physical model tests and the stress analysis results showed there is none of the concrete composite slab specimens experiencing a combination of shear stress and normal stress exceeding the strength limit of the interface.

Kata Kunci: *Composite Concrete Slab, Flexural Test, HyFRLWAC, Numerical Modelling, SCC*