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EFFECT OF SULPHATE ATTACK ON MECHANICAL PROPERTIES OF ENGINEERED CEMENTITIOUS COMPOSITE CONCRETE: A REVIEW

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Abstract— Conventional concrete is modified by random dispersion of short discrete fine fibres to improve its properties. Several fibres have been used so far to improve the properties of conventional concrete via: asbestos, steel, glass, carbon, nylon etc. A new advancement in the engineered cementitious composite concrete is the use of polypropylene fibre which has shown better results in improving the compressive & flexural strength of concrete composites. Polypropylene (PP), also known as polypropene, is a fibre that is used for strengthen concrete and for protection of concrete against micro cracks. The aim of the study is to determine the effect of sodium sulphate on mechanical properties and durability of engineered cementitious composite concrete. Sodium Sulphate solution, prepared by adding a definite percentage (5%) of sodium sulphate (Na_2SO_4) in deionized water to examine the sulphate resistance of the concrete. The concrete specimens were cured in both normal and sulphate water for 7, 28 and 56 days. The properties which were determined during investigation are workability, permeability, compressive strength and flexural strength and compared with that of the control concrete for both the normal and sulphate environment.

Keywords— Polypropylene fibre, Sodium Sulphate, micro cracks, polypropene, durability.

I. INTRODUCTION

Fibres have been used to reinforce brittle materials since ancient times; straws were used to reinforce sun baked bricks, horse hair was used to reinforce plaster and more recently, asbestos fibres are being used to reinforce Portland cement. Patents have been granted since the turn of the century for various methods of incorporating wire segments or metal chips into concrete. The low tensile strength and brittle character of concrete have been bypassed by the use of reinforcing rods in the tensile zone of the concrete since the middle of the 19th century. The research by Romualdi & Batson and Romualdi & Mandel on closely spaced wired and random fibres in the late 1950s and 1960s was the basis for a patent based on fibre spacing. The Portland cement Association (PCA) investigated fibre reinforcement in the late 1950s. Another patent based on bond and aspect ratio of the fibres was granted in 1972. In the early 1960s, experiments using plastic fibres in concrete with and without steel reinforcing rods or wire meshes were conducted. Experiments using glass fibres have been conducted in USA since the early 1950s as well as the UK and Russia. Applications on fibre reinforced concrete have been made since the mid-1960s for road and floor slabs, refractory materials and concrete products.

Concrete made with hydraulic cement, containing fine or fine and coarse aggregate, and discontinuous discrete (separate) fibres is called Fibre Reinforced Concrete (F.R.C.). These fibres can be made from natural material (asbestos, sisal, cellulose) or are a manufactured product such as glass, steel, carbon, and polymer. The purposes of reinforcing the cement-based matrix with fibres are to increase the tensile strength by delaying the growth of cracks, and to increase the toughness (total energy absorbed prior to total separation of the specimen) by transmitting stress across a cracked section so that much larger deformation is possible beyond the peak stress than without fibre reinforcement

The paper is about the use of polypropylene fibre which has shown better results in improving the compressive & flexural strength of concrete composites. Polypropylene fibre can be used in normal concrete and self-compacting concrete to enhance its properties and also increase its sulphate resistance. This type of concrete can be effectively used in concrete structures like sewage pipes, drainage pipes, marine structures which are prone to premature deteriorations due to the chemical (sulphate) attack. Also this of type concrete can be used in structures like bridges and pavements which are susceptible to large deflections. This paper relates to the field of construction (concrete production). The polypropylene fibre used as replacement of cement gives this method a new meaning in improving the tensile strength of concrete by delaying the growth of cracks

II. LITERATURE REVIEW

Hezhi Liu et al (2017), conducted an experimental investigation on the self-healing behaviour of Engineered Cementitious Composites (ECC) under aggressive sulphate and chloride conditions. Resonant frequency (RF) and mechanical properties including stiffness, first cracking strength, ultimate tensile strength and tensile strain capacity are experimentally determined for ECC specimens that are preloaded to 1% strain and exposed to sulphate and sulphate-

chloride solutions to simulate the service environment of hydraulic structures. The raw materials include Type I Portland cement, Class-F fly ash, fine silica sand, water, poly-vinyl alcohol (PVA) fibres, and a high range water-reducing admixture (HRWRA). The test is carried out using a 25 kN capacity testing frame under displacement control at 0.5 mm/min. It is found out that the performance of ECC is not adversely affected by the aggressive solutions. Instead, self-healing of the micro cracks is observed leading to partial recovery of the mechanical properties. It is also found that ECC tends to heal faster and more completely in sulphate solutions than in water.

Pal S., Mishra M.K et al (2016), conducted an experimental investigation to study the effect of acidic water on fibre reinforced concrete. The acidic water is prepared by using concentrated Hydrochloric acid in deionised water. The Fibre-reinforced concrete (FRC) samples are cured in normal water and acidic water for 56 days. The concrete samples are studied for compressive strength, split tensile strength and flexural strength. The untreated & treated polyester fibre is added 0%, 0.20%, 0.25% & 0.30% by weight of cement in M grade of concrete. It is found out that strength of FRC cured in acidic water, decrease at every percentage addition of untreated and treated polyester fibre when compared with normal water curing. The optimum percentage of polyester fibre that can be used to reinforce concrete is 0.25%.

Ealias, et al (2014), conducted an experimental study to assess the strength characteristics of concrete when coarse aggregate is partially replaced with coconut shells and coir fibres. Material properties such as specific gravity, density and water absorption of coconut shell and coir fibres are tested as per IS: 2386 (part III) – 1963. Strength properties are analysed by conducting compressive strength test as per IS: 516 - 1959 and splitting tensile strength test as per IS:5816 - 1999. The compressive strength test on M25 and M30 concrete mix is carried out for conventional concrete and CA replaced by coconut shells and coconut shell plus coir and results of 7 days, 14 days and 28 days are compared. Similarly, other tests carried out are PH test, Electrical Resistivity test, Temperature resistivity test, chloride test, sulphate test, improvement of strength using fly ash. It is found out that yhe concrete with coarse aggregate partially replaced with coconut shell and coir fibres shows lesser strength but can recommended for low cost construction with addition of fly ash. Strength properties of concrete having coconut shell and coir fibres improve to 80% – 95% by the addition of fly ash.

Ardeshana, et al (2012), conducted research on fiber reinforced concrete materials carrying Polypropylene Triangular Fibers which help to develop intelligent infrastructure with elegantly integrated sensing. The standard consistency of cement is tested and found 27 %. The fixed quantity of cement, course aggregate, fine aggregate (sand), admixture and water with variable percentage of polypropylene fibre of triangular shape and 12 mm length. The first 15 cubes are casted without fibres. The second batch is with fibre of 0.15 % of cement and after that 0.20%, 0.25%, 0.30%, 0.35%, 0.40% of polypropylene fibre is casted. The three cubes are tested on 7 days' period, other three cubes are tested on 28 days and remaining nine cubes are immersed in chemical solution of NaCl, Na2SO, MgSO4 to research the marine environment effect on fibre reinforced concrete after 28 days curing in pure water. It is found out that addition of polypropylene triangular fibres improved durability of concrete and higher the durability, higher will be the resistance to marine structures attacks.

Erdog˘an Özbay, et al (2012), conducted research on the dual effect of freeze–thaw cycles with sodium sulphate solution on the performance of non-air-entrained Engineering Cementitious Composites (ECCs) with high volumes of slag. ECC specimens containing three different levels of slag content as a replacement for cement (55%, 69% and 81% by weight of total cementitious material) are exposed to aggressive sodium sulphate solution under freezing–thawing cycles. The load–deflection response associated with ultimate mid-span deflection and flexural strength/stiffness is determined, along with crack development behaviour. For comparison purposes, the freezing–thawing resistance (in water) of control ECC specimens is also evaluated. It is found out that increased slag content (S/PC) improved the ductility, hardened air content, water absorption, porosity and sorptivity of ECC, while marginally decreasing the compressive and flexural strengths.

M.T. Bassuoni, M.L. Nehdi (2009), conducted a study on the durability of a wide range of SCC mixture designs to sulphate attack when other related damage mechanisms (cyclic environmental conditions and flexural loading) is considered. For this study, 21 SCC mixtures with a (w/cm) of 0.38 are prepared using single, binary, ternary and quaternary binders. The mixtures are divided into three groups: group A (non-air-entrained SCC with a sand-to-total aggregates mass ratio [S/A] of 50%); group B (air-entrained SCC mixtures with S/A of 40 and 60%); and group C (air-entrained SCC with fibre reinforcement and sand-to-total aggregates plus fibres mass ratio of 50%). Constituent materials are mixed in a mechanical mixer in accordance to ASTM C 192. It is found out that based on the performance in the full-immersion exposure, all the tested SCC mixtures can qualify for use in 'very severe' alkali sulphate exposure. In the case of combined exposure, cyclic environmental conditions and flexural loading caused cracking in the cementitious matrix and led to direct ingress of the solution into considerable depths of the SCC specimens.

J. R. Al-Feel, N. S. Al-Saffar (2008), conducted an experimental investigation to study the effect of curing methods on the compressive, splitting, and flexural strengths (modulus of rupture) of self-compacting concrete in comparison to those of normal concrete. The self-compacting concrete consists of Portland cement (P.C) limestone powder (L.S) (L.S 8% / 92% P.C), sand, gravel and super-plasticizer. The specimens are cured in the air and water, for the period of 7, 14,

and 28 days. Three specimens are tested for each point of each property. The results shows that the water cured specimens gave highest compressive strength, splitting tensile strength and flexural strength than specimens cured by air about 11%, 10% and 11% for self-compacting concrete at 28 days respectively. It is found out that self-compacting concrete give high early strength i.e. strength before 28-days.The failed specimens indicates that there was no segregation and a good bond between aggregate and matrix.

III. CONCLUSIONS

Based on the study done, it can be concluded polypropylene fibres can be used to enhance the tensile strength of concrete which in turn delays the growth of cracks and to increase the toughness (total energy absorbed prior to total separation of the specimen) by transmitting stress across a cracked section so that much larger deformation is possible beyond the peak stress than without fiber. The workability of the engineered cementitious composite concrete has been found to decrease with an increase in the concentration of polypropylene fiber in the concrete mix. The loss in compressive strength is less in engineered cementitious composite concrete as compared to the normal concrete which shows that engineered cementitious composite is resistant to sodium sulphate.

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