Study of Engineered Cementitious Composite With The Use of $CaCO_3$ Whisker Modified Agent

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Abstract- *This paper aims at developing $CaCO_3$ whisker modified ECC with local ingredients in China. $CaCO_3$ whisker is a kind of micro scale fibrous material (inorganic single crystal) with a diameter of 0.5–2 μm and an aspect ratio of 20–60. It has a high tensile strength of 3–6 GPa and high elastic modulus of 410–710 GPa. Therefore, $CaCO_3$ whisker can potentially reinforce the ECC materials at microscopic level. In this study, cube compressive and uniaxial tensile tests were conducted to investigate the influence of $CaCO_3$ whisker on ECC's mechanical properties. The experimental results indicated that incorporating $CaCO_3$ whisker can improve compressive strength and tensile strain-hardening behavior (especially tensile strain capacity). When $CaCO_3$whisker was added at the optimal content of 0.5% by volume of total ECC mixture, the compressive strength of composite increased from 23 MPa to 30 MPa, and the ultimate tensile strength and tensile strain capacity increased by 53% and 114%, respectively. Addition of $CaCO_3$ whisker can also enhance the robustness of ECC mixtures. The coefficient of variation of mechanical properties was found to be reduced by 90% compared to that of the ECC without $CaCO_3$ whisker. In addition, when $CaCO_3$ whisker is added, fly ash content has negligible influence on ultimate tensile strength of the composite, which suggests that the frictional bond strength of fiber/matrix interface is significantly affected by $CaCO_3$ whisker.*

Keywords- $CaCO_3$ whisker,Engineered Cementitious Composite (ECC),Compressive strength,floral strength,Tensile strength.

I. INTRODUCTION

Engineered Cementitious Composite (ECC), also called **bendable concrete**, is an easily molded mortar-based composite reinforced with specially selected short random fibers, usually polymer fibers.In terms of material constituents, ECC utilizes similar ingredients as per fiber reinforced concrete (FRC). It contains water, cement, sand, fiber, and some common chemical additives. Coarse aggregates are not used as they tend to adversely affect the unique ductile behavior of the composite.

CaCO3 whisker is a kind of inorganic mineral micro-fiber with excellent physical, chemical and mechanical properties , which can play the role of chopped fiber in the microstructure of composites. Early studies showed that CaCO3 whisker could improve the mechanical properties of cement , and also had good durability in the alkaline environment of cement . In this research, CaCO3 whiskers and polypropylene fibers were added into the cement mortar together and the split tensile strength was tested to evaluate the performance of matrix to resist tensile stress. Through the splitting tensile test, the composite toughening effect of whiskers and fibers on cement mortar were studied and the toughening mechanisms were discussed.

II. EXPERIMENTAL PROGRAMME

The properties of materials used in preparation of concrete is determined as per the codal provisions and described as follows:

In this study, raw materials include cement, fly ash, silica sand, CaCO3 whisker and PVA fiber. lists the chemical compositions of Portland cement and fly ash. The fine silica sand has a size distribution of 106–212 lm and a mean size of 150 lm. The CaCO3 whisker has a length of 20–30 lm and a diameter of 0.5– 2 lm. The physical properties and chemical compositions of CaCO3 whisker provided by manufacturer are listed in The microscopic morphology of CaCO3 whisker is shown in The WW PVA fiber was used in this study, and its physical and mechanical properties are listed in The mix proportions of ECCs in this study are listed in , where D4-0 is the control mix without CaCO3 whisker. The influence of CaCO3 whisker content on ECC's mechanical properties was investigated based on this mix proportion. Mixtures with 0.5%, 1% and 2% CaCO3 whisker by volume form the first test series to screen for the optimal CaCO3 whisker content.

Once the optimal CaCO3 whisker content was determined (0.5%), the combined effect of fly ash and CaCO3 whisker was also investigated by varying the content of fly ash (FA/C = 3.0, 2.2 and 1.2). The ECC mixtures were labeled as D3.0-0.5, D2.2-0.5 and D1.2-0.5, which form the second test series.

Table - 1
Physical Properties of Cement

Physical Properties:(Reference: Ultratech cement test certificate)

Particulars	Results	As Per IS 12269:2015
Specific Grevity	3.15	3.10-3.15
Fineness (m^2/kg)	330	225
Consistency	29.6	26%-33%
Initial Setting Time(min)	130	30 min
Final Setting Time(min)	170	600 min

Table - 3
CaCo3 Whisker

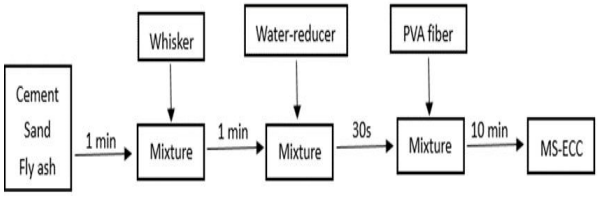
Length 20–30 mm
Diameter 0.5–2 µm
Density 2.8 g/cm3
Tensile strength 3–6 GPa
Elastic modulus 410–710 GPa

B. Concrete Mix Proportioning

NOMINAL MIX DESIGN FOR BENDABLE CONCRETE

As we are not using coarse aggregate in the Bendable Concrete, there is no separate mix design for the Bendable concrete. For this research we have to estimate the differentmixes having different constituents which are Fibers and Fine aggregate Super Plasticizer.

Machine Mixing: -



C. Test Procedure

Cube moulds of size 70.6mm x 70.6 mm x 70.6 mm were prepared. After 24 hours these moulds are removed and test specimens are put in water for curing. These specimens are tested using compression testing machine after 7, 28 and 56 days of curing. Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam to resist failure in bending. It is measured by loading 100 x 100 mm x 500 mm concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MPa) and is determined by third-point loading test.

III. TEST RESULTS

Compressive strength

The compressive strengths of ECCs with different CaCO3 whisker content are shown in As can be seen, when 0.5% volume fraction of CaCO3 whisker was added, ECC has the largest compressive strength of 30 MPa. It increases by 30% compared to that of D4-0 (without CaCO3 whisker). This could be a result of the filler effect of CaCO3 whisker in composite, which increases the compactness of matrix In addition, due to the small diameter and high aspect ratio of whisker, it can bridge flaws at microscopic level, which may delay micro-cracks from developing into macrocracks, as shown in However, when the CaCO3 whisker content increases to 1% and 2%, a significant decrease in compressive strength can be observed comparing to D4-0.5. Firstly, the very low activity of CaCO3 whisker causes the relative weaker strength of matrix when excessive CaCO3 whiskers were added. Secondly, the poor dispersion and agglomeration of CaCO3 whiskers when excessive content was added may result in new defects in composite and therefore reduces the compressive strength.

Tensile strain hardening:

The uniaxial tensile results of ECCs with different CaCO3 whisker content are shown in and . As can be seen from, the first cracking strength of ECC D4-0.5 is slightly largerthan that of D4-0. However, subsequent increase of CaCO3 whisker content leads to reduced first cracking strength, which is even smaller than that of D4-0. The first cracking strength of ECC is mainly governed by matrix strength

IV. CONCLUSION

This paper focuses on using CaCO3 whisker to modify ECC with local ingredients and PVA fiber in China. The compressive strength and uniaxial tensile behavior of ECCs were evaluated, and the optimal content of CaCO3 whisker was determined. The combined effect of CaCO3 whisker and fly ash was also investigated. The specific conclusions can be drawn as follows:

(1) Incorporating optimal content of CaCO3 whisker can improve the tensile strain capacity of ECC significantly plausibly due to the reduction of chemical bond of fiber/matrix interface. In addition, acicular morphology of CaCO3 whisker can increase the roughness of interface and therefore the frictional bond strength. This can further enlarge the margin of strain hardening criteria and improve the tensile strain capacity.

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