FLEXURAL BEHAVIOR OF ECC CONCRETE USING PVA FIBER

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ABSTRACT

This paper presents an experimental study on flexural behavior of bendable concrete. Bendable concrete also known as Engineered Cementitious Composites abbreviated as ECC, characterized by high ductility and crack width control. It improves the conventional property of normal concrete. A Bendable concrete is composed of same ingredient as the conventional concrete but it is reinforced with Poly Vinyl Alcohol (PVA) Fiber which increase the strength, in addition to that volume of cement is partially replaced by fly ash. Here the coarse aggregate is not used since it causes major cracks. The PVA fiber is mixed with cement as per percentage. It is given by 0.5%, 1%, 1.5%, 2% by volume of cement and fly ash. Conventional concrete are almost un-bendable and have a strain capacity of only 0.1% making them highly brittle and rigid. This lack of bendability is major cause for failure due to low tensile strength and low resistance to cracks. This paper presented the comparative study on conventional concrete and Bendable concrete by comparing the strength properties and ductile behavior of under flexural load it can be seen that the slab can deform sufficiently without direct failure. For this purpose, we have casted slabs and its strength and flexibility properties have been tested. To compare the compressive and split tensile strength of conventional and bendable concrete the cubes and cylinder are tested. Through the results obtained, the ductile behavior and strength property of the bendable concrete was analyzed.

INTRODUCTION:

Concrete consisting of cement, water, fine and coarse aggregates are widely used in civil engineering constructions. Though making concrete is convenient and inexpensive, its brittle behavior is a major disadvantage to fulfill this Bendable concrete is introduced. Bendable concrete is also known as engineered cementitious composites (ECC) easily moulded mortar based composite reinforced with specially selected short random fibers. Here we use Poly Vinyl Alcohol (PVA) Fiber is an ideal environment-friendly cement reinforced material. It has some structural strength and can also be used for shrinkage control. While they cannot replace reinforcing steel, they improve the mechanical properties of cured concrete, boosting its strength. The PVA fiber consists of unique molecular structure due to this it resist the weather and it have good affinity to cement ,effective prevention of crack formation, improve bending strength, impact strength & strength. It is used as the seismic resistance of the concrete.

Bendable concrete consists of same ingredients as normal concrete like cement, sand, water but in this the cement is partially replaced by fly ash, silica fume, and also the strength is attain by adding different dosage of poly vinyl alcohol fiber. However, a coarse aggregate is not used in bendable concrete because the property of bendable concrete is formation of micro cracks with large deflections. The addition of high-range water reducing (HRWR) agent in ECC required to impart good workability. Now a days poly vinyl alcohol fiber are widely used in ECC which provide a pseudo ductile behavior similar to steel. The structural designer have found that bendable concrete control the inherent of crack with and also tolerate the damage.

OBJECTIVE

The main objective of the paper is to study the ductile behavior of concrete and increasing in strength of concrete by addition of fiber and check the crack resistance capacity of the concrete.

LITERATURE REVIEW:

Tahir Kemal erdem (2013) had discussed the experimental results show that ECC with combination mineral admixture can achieve strain hardening behavior, tensile capacity of ECC can be more than 2.5% at 90 days. Fly ash has been necessary ingredient for ECC with tensile strain capacity. The mechanical properties of ECC can be improved by addition of slag with high volume of fly ash at early age the compressive strength of ECC can be effectively increased by addition of slag. Due to absence of coarse aggregate the dry shrinkage of ECC mixture is higher than normal concrete. From this the admixture fly ash is added in bendable concrete to increase strain hardening behavior.

Yu zhu et al.(2012) carried out the study on ECC which have high ductility and strength and early stages. A number of investigations were made on shrinkage behavior of ECC with addition of admixtures such as fly ash and blast furnace slag. In the laboratory different test are carried out including direct tensile test, four

point bending test, compressive strength and drying shrinkage. This study shows that addition of mineral admixtures can achieve strain hardening behavior. From this study the cement is partially replaced by fly ash which gives double beneficial such as increasing in strength as well as reduction of cost.

Qian et al. (2010) made the experimental study to found out the influence of curing condition on self healing behavior of ECC in the pre cracking time. There are different types of curing condition such as air curing, 3 % of CO_2 curing cyclic wet / dry curing and water curing. The pre crack of ECC is determined using four point bending test. For all curing condition the deflection capacity can get differ in ECC.

The flexural strength of pre cracked sample get increase at the age of 14 days and 28 days, due to hydration of cementitious material. Because of this self healing behavior of bendable concrete it is used as a retrofitting that is apply a cement paste on the cracked structure which increase the durability and strength of the cracked structure.

Victor C li et al. (2012) A study to improve the fiber distribution by mixing sequence**.** In the mixing sequence, all solid and liquid materials are mixed and then fiber is added. before the fiber addition undesirable plastic viscosity cause poor fiber distribution and also results in poor hardened properties.

Inference of the paper, the mixing sequence are investigated and comparing the results of uniaxial tensile test and fiber distribution analysis. The tensile strain capacity and ultimate tensile Strength of ECC are increased by adjusted mixing sequence adjusted mixing sequence also improves the fiber distribution.

INGREDIENT OF BENDABLE CONCRETE

Bendable concrete is composed of cement, sand, fly ash, water with small amount of admixtures and an optimal amount of fibers. In this mix coarse aggregate is not used because it increases the crack width.

CEMENT

We have used Ordinary Portland cement (OPC) of grade 53(Ultratech cement) conforming to IS 8112-1989 [12] .The specific gravity of OPC cement is 3.15.

SAND(FINE AGGREGATE)

Fine aggregate is naturally occurring granular material composed of finely divided rock and mineral properties. The fine aggregate was passing through 2.36mm sieve and had a specific gravity of 2.68. the grading zone of fine aggregate was zone III as specified in IS 383-1978 [13].

SUPER PLASTICIZER

Super plasticizer used is conplast. It is the admixture added in the time of batching. The maximum effect is achieved when the super plasticizer is added after adding 50-70% of water. It is the water reducing agent and it is used to increase the workability. Water is added as per the water cement ratio. Water cement ratio is 0.4.

FLYASH

Fly ash is produced in the Thermal power station. Class F fly ash is utilized so the cost is reduced. Replacement of fly ash have ranged between 30-75%.In RCC structure use of fly ash have reduce the heat generation without loss of strength and also increase the strength of ECC concrete.

PVA FIBER

Poly vinyl alcohol fiber is suitable for reinforcing material in cementitious composites .it has high strength and modulus of elasticity. It ranges from 25-40GPa. Fiber elongation is about 6-10%. The length of the fiber is 12mm. The tensile strength of fiber is 880-1600MPa. PVA fiber is strong bonding with cement matrix is the one of the remarkable character.

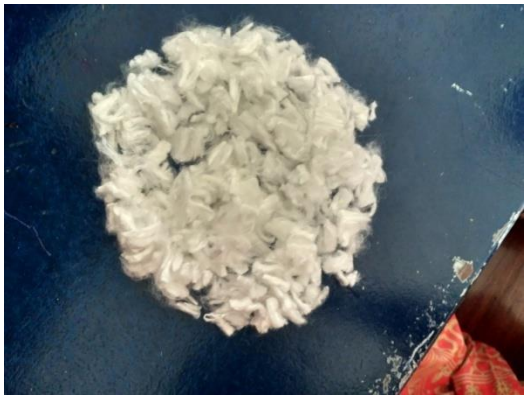


Figure1: PVA fiber

WATER

Water should be free from acids, oil, alkalis, vegetable and other organic impurities. Generally water fit for drinking is fit for making concrete. Water has to function in the concrete mix. Firstly it chemically reacts with cement to form a cement paste. Secondly it serves as lubricant in the mixer of aggregate and cement.

. Mix Design:

The concrete mix proportion for M30 concrete was arrived based on IS10262-2009 [14] method and is given in Table 1.

PROPORTION OF BENDABLE CONCRETE

Table 1: *Mix proportion for M30 concrete*

Mass of cement	Mass of fly ash	Mass of fine agg.	Mass of water	Water cement ratio
360	180	1080	144	0.4

All mass in kg/m^3

In this proportion the PVA fiber is added in different dosages such as 0.5%, 1%, 1.5%, 2%. From this proportion the optimum percentage of fiber that increase the ductile behavior of concrete is found out and it is compared with the ductile property of conventional concrete. The mix proportion ratio is 1:1.97:2.57:0.5. Super plasticizer is added 600ml/bag.

MIXING AND CASTING

Once the mix design is finalized, the mixing is carried out. The mixing of bendable concrete is done by hand mixing. First add the sand , 50% of cement, 50% of flyash, 50% of water and super plasticizer. Then remaining 50% of sand, cement and water is added and mixed slowly until it attain the homogeneity. After the mixing is done the fresh concrete is casted into the slab, cubes, cylinder mould, the size of the slab is 0.7X0.15X0.025m.During placing the

concrete in the mould tamping was done by tamping rod. Compaction is the one of the important factor it increase the strength of the concrete. Improper compaction leads to honey combing. After that level the surface and allow to set over the night.

Fig: 2 casting of slab

CURING

After 24 hours the slab is demoulded from the mould. Then it is placed in the curing tank for 28 days to attain the hardened property of concrete. Curing is important factor which prevent the losing of moisture and also increase the strength. After 28 days remove the slab, cubes and cylinders from the curing tank to conduct the flexural test to compare the deflection of bendable concrete and normal concrete.

COMPRESSION TEST:

The compressive strength of concrete was carried out using concrete cubes of size 150 × 150 × 150 mm, which were cast with the above mix proportions and tested at 28 days. The ultimate load at which the cube failed was taken.

SPLIT TENSILE TEST:

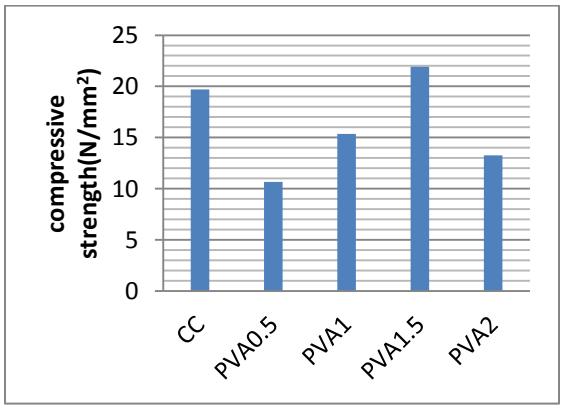
Split tensile test was carried out using concrete cylinders of size 150 mm diameters and 300 mm height. After 28 days of water curing, the concrete cylinders were subjected to split tensile test using CTM.

BENDING TEST OF SLAB

Bendable concrete is characterized by the bending property i.e., high curvature below the actual bending.

RESULT AND DISCUSSION

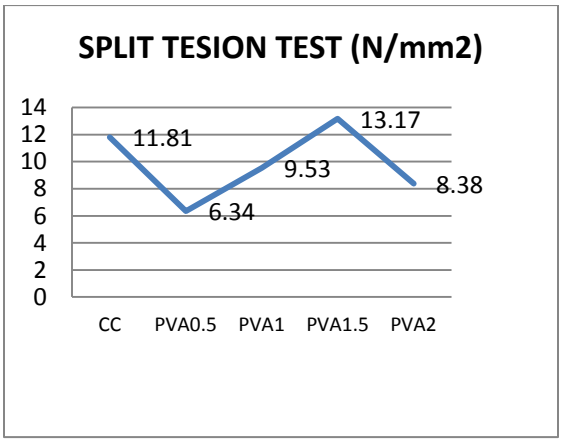
Figure 2: *Compressive strength variation*



Compressive and split tensile strength variation for bendable concrete with varying proportions of PVA fibers are shown

From the graph, it is found that the compressive strength is increase as the percentage of fiber increase upto 1.5% and then there is reduce strength at 2%. From this 1.5% of fiber is consider as optimum percentage. And also it interfere that the PVA1.5 is considerably higher than the conventional concrete. Thus the addition of fiber increase the strength of concrete.

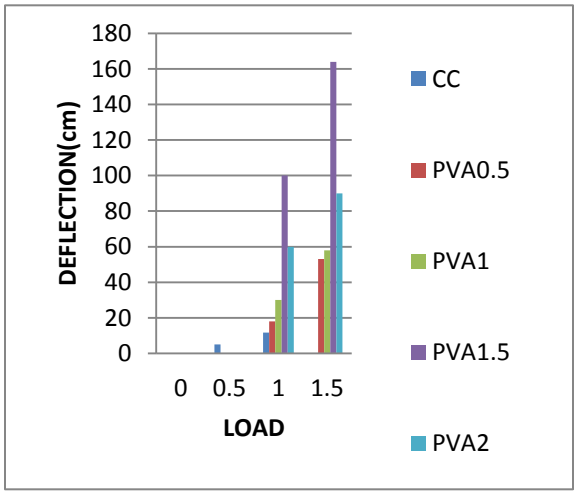
Figure 3: *Split tensile strength variation*



The same trend is observed in split tensile strength also, which can be seen in figure 3. The split tensile strength is higher at 1.5% and further addition of fiber leads to decrease in tensile strength. So it has high tensile strength compare to normal concrete.

PVA0.5, PVA1, PVA1.5, PVA2 denotes the percentage of fiber added such as 0.5%, 1%. 1.5%,2%. This graph shows the comparison of load vs. deflection between the conventional and bendable concrete.

Figure 4: *Load vs deflection graph*



The normal concrete show maximum deflection 11.6cm with cracks at1kN and after continuous loading the cracks are developed and it breaks. But the bendable concrete slab does not show any deflection up to 0.5kN. After continuous loading the slab starts to bend instead of forming cracks. The slab withstand up to 1kN with maximum of 164cm in the 1.5% addition of fiber. As compare to other slab with different percentage of fiber the 1.5% shows high ductile behavior and it also strong enough. The slab of 2% fiber show less ductile behavior compare to 1.5% so the PVA1.5% is considered as optimum percentage of bendable concrete.

Conclusion

The present study indicates the comparison between conventional concrete and ECC -pva fiber with 50% of fly ash.

Its shows that Compressive strength increases with increasing fiber content. But when it reaches up to its optimum value of 1.5 %, and it starts decreasing with the increasing content of fiber.

The compressive strength at 1.5% is higher than 2% replacement of fiber and conventional conventional concrete. Similarly the split tensile strength is higher at 1.5% than the other percentage of fiber and normal concrete.

According to this result the slab is withstanding high load and as compare to conventional concrete the bendable concrete withstand high load deflect with minor cracks instead of forming failure of structure.

It was noticed that Fibers reduces the w/c ratio which leads to the low workability but the workability can be maintained by super plasticizers.

The advantage offered by ECC over conventional concrete becomes more compelling. Also use of fly ash leads to less environmental impact because disposal of fly ash is serious issues, hence its Eco friendly.

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