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FLEXURAL BEHAVIOUR OF TERNARY BLENDED STEEL FIBRE REINFORCED CONCRETE BEAMS USING CRIMPED FIBRES

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ABSTRACT

Concrete is a construction material which is most widely used in the world. Its use has been so extensive because of ease of construction and its properties like compressive strength, flexural strength and durability. Plain concrete is very good in resisting compressive stresses but possesses a low modulus of rupture, limited ductility and little resistance to cracking. Tensile strength of concrete is very low which is taken care of by the incorporation of steel which is strong in resisting tensile stresses. In the recent past, behaviour of reinforced concrete beams in flexure has been studied extensively.

In the present investigation an attempt has been made to study the Moment of resistance of ternary blended steel fiber reinforced concrete beams. The mineral admixtures used in the study are fly ash and metakaolin. Fly ash is the waste product from the thermal power plants and its production in large amount poses severe environmental problem. So its use in concrete contributes to the environmental pollution control. The binary blend of concrete using fly ash has the advantage of producing better workability but there is a late development of strength. When metakaolin is used in the concrete, there is an early gain of strength but the concrete produced is lesser workable. So, when the fly ash and metakaolin are used, the ternary blend of concrete gives better workability as well as there is an early gain in strength. The steel fibres used in the experiments are of crimped shape with an aspect ratio of 80. Varying percentages of metakaolin and fly ash by weight of cement as partial replacement of cement were taken for the tests. The percentage of mix proportions of ternary blend yielding optimum results for M30 grade concrete were obtained. Tests were conducted on ternary blended concrete beams with varying percentages of crimped steel fibres (0%, 0.5%, 0.75%, 1%, and 1.25%). Compressive strength of concrete has been determined by testing standard cubes (150mmx150mmx150mm) at 7 days and 28 days of curing. Flexure strength of ternary blended fibre reinforced concrete beams is determined by testing beams of size 1400mmx100mmx150mm under two point loads in the universal testing machine at the age of 7 days and 28 days. The beams have been provided with longitudinal reinforcement. 6mm bars dia at tension member and 12mm bars dia at compression member.

The percentage increase in flexure carrying capacity of ternary blended steel crimped fibre reinforced concrete beams compared to ternary blended concrete was 21.58%

KEYWORDS: Concrete, Ternary Blended Concrete, Fibre Reinforced Concrete, Steel Crimped Fibres, Shear Strength, Shear failure, Fly ash, Metakaolin, Aspect Ratio, Workability.

INTRODUCTION

Concrete is a mixture of Portland cement, water, sand and gravel or crushed stone, which when placed in the forms and allowed to cure, becomes hard stone. Concrete is a construction material which is most widely used in the world. The name concrete comes from the Latin "concretus", which means to grow together. This is a good name for this material and the chemical hydration process, which mainly occurs over time scale of hours and days causes the material to grow together from a viscoelastic, moldable liquid into a hard, rigid solid. It is hard to imagine modern life without concrete. About five billion tonnes of concrete is used around the world each year. The most common type of cement in general usage is the Portland cement. Some other types of cements that are in use are Rapid Hardening cement, Extra Rapid Hardening Cement, Sulphate Resisting Cement, Quick setting cement, Portland Pozzolana Cement. PPC includes 15 to 35% of pozzolanic material. Cement is divided into three grades based on the 28 days strength as 33 grade, 43 grade and 53 grade. 0.23 of w/c ratio is required for chemical reaction with Portland cement components and 0.15 w/c ratio is required to fill gel pores. Therefore a total of 0.38 of w/c ratio is required. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

TERNARY BLENDED CONCRETE

Ordinary concrete has a single cementitious material i.e. cement. Binary blend of concrete includes cement as the binding material and a pozzolanic material being added. Ternary blended concrete marks the inclusion of two different pozzolanic materials to the concrete with cement acting as the primary binding material.Admixtures are very fine when compared to cement. In worst case, the admixtures are atleast twice as fine as cement. Admixtures are rich in silica content. They not only act as replacement to cement but also enhance the durability of concrete. Durability of concrete is increased by the reduction of Calcium Hydroxide content which causes Sulphate Attack. Fly ash from coalfired power plants and metakaolin are both important in modern concrete technology. Used in together with Portland cement, they contribute to concrete with selected properties.In the present investigation Ternary Blended Fibre reinforced concrete has been used. The binary blend of concrete using fly ash has the advantage of producing better workability but there is a late development of strength. When metakaolin is used in the binary blend of concrete, there is an early gain of strength but the concrete produced is lesser workable. So, when the fly ash and metakaolin are used, the ternary blend of concrete gives better workability as well as there is an early gain in strength.

Fly ash

Metakaolin

BEAM FLEXURE BEHAVIOUR

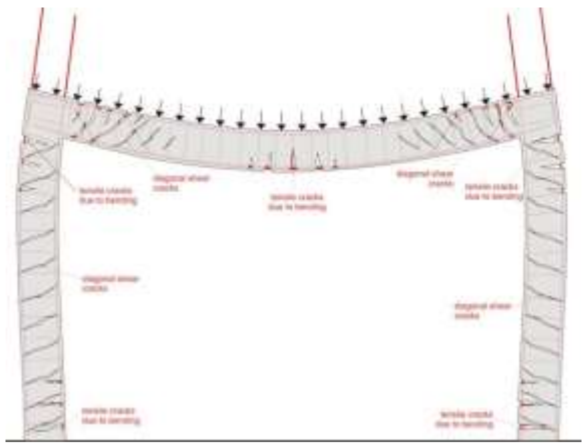
Steel fibres are generally found to have aggregate much greater effect on the Moment of Resistanceof SFRC than on either the compressive or tensile strength, with increases of more than 100%having been reported. The increases in Moment of resistence is particularly sensitive, not only tothe fibre volume, but also to the aspect ratio of the fibres, with higher aspect ratio leading tolarger strength increases. Figure describes the fibre effect in terms of the combinedparameter Wl/d, wherel/dis the aspect ratio and W is the weight percent of fibres. It shouldbe noted that for Wl/d> 600, the mix characteristics tended to be quite unsatisfactory.Deformed fibres show the same types of increases at lower volumes, because of theirimproved bond characteristics.

Flexural:-

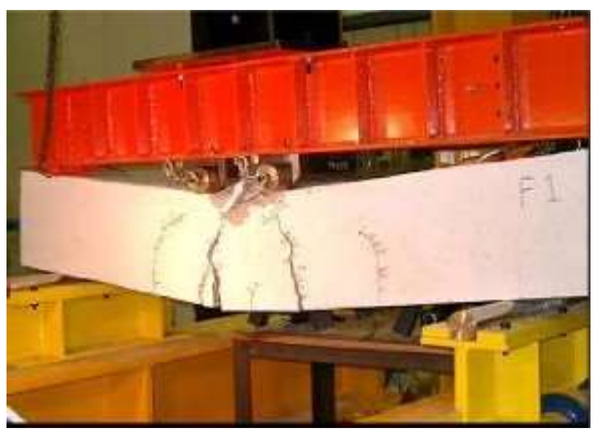
The effect of Wl/d on the Moment of resistence of mortar and concrete .

Toughness:-

As was indicated previously, fibres are added to concrete not to improve the strength, but primarily to improve the toughness, or energy absorption capacity. Commonly, the flexuraltoughness is defined as the area under the complete load-deflection curve in flexure; this issometimes referred to as the total energy to fracture. Alternatively, the toughness may bedefined as the area under the load-deflection curve out to some particular deflection, or out tothe point at which the load has fallen back to some fixed percentage of the peak load.Probably the most commonly used measure of toughness is the toughness index proposed byJohnston and incorporated into ASTM C1018. As is the case with Moment of resistence, flexuraltoughness also increases at the parameter Wl/dincreases.The load-deflection curves for different types and volumes of steel fibres can varyenormously, as was shown previously in. For all of the empirical measures oftoughness, fibres with better bond characteristics (i.e. deformed fibres, or fibres with greateraspect ratio) give higher toughness values than do smooth, straight fibres at the same volumeconcentrations.



Flexural pattern



Flexural Cracks in Beam

Table 1.Typical oxide composition of Fly ash

S.No	Characteristics	Percentage (%)
1	Silica, Sio_2	49-66
2	Alumina, Al_2O_3	16-29
3	Iron Oxide, Fe_2O_3	4-11
4	Lime, CaO	0.7-3.7

5	Magnesia, MgO	0.3-2.7
6	Sulphur Trioxide, SO_3	0.1-2.2
7	Loss on ignition	0.4-1.98
8	Surface Area m^2/kg	230-600

Table 2.Chemical composition of Metakaolin

S.No	Compound	Percentage (%)
1	Sio_2	52.3
2	Al_2O_3	44.7
3	Fe_2O_3	0.52
4	MgO	0.11
5	CaO	0.21
6	Na_2O	0.33
7	K_2O	0.22
8	SO_3	0.11
9	Loss on ignition	1.4

Table 3. Properties of crimped steel fibers

S.No.	Property	Value	Remarks
1	Diametr	0.45mm	Properties confirms to ASTM A820 Standard requirement
2	Length	36mm	
3	Aspect ratio	80	
4	Tensile strenth	1100Mpa	
5	Specific gravity	0.78	

Mixing of material

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Mixing of crimped steel fiber

Slump test

Compaction Factor Test

Set up for compression test

Testing of cube

TEST RESULTS AND DISCUSSIONS

The results obtained from compression test of cubes of Ternary Blended Concrete are shown in the table 4.0. The content of fly ash as a replacement of cement was increased and the results obtained for 10%, 15%, 20%, 30%, 35% and 40% are shown below. The compressive strength of TBC was observed to be optimum with 30% replacement of cement by fly ash.

Table 4.1 – Cube Compressive Strength of Ternary Blended Concrete

S.No	Designation of Mix	28 day strength (MPa)
1	M0F0	38.89
2	M10F10	42.67
3	M10F15	45.84
4	M10F20	46.26

5	M10F30	50.26
6	M10F35	43.71
7	M10F40	40.28

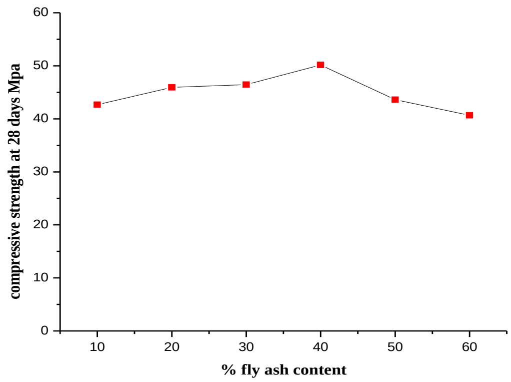

Fig 4.1 Variation of Compressive strength of TBC with increase in Fly ash content The percentage increase in the Compressive strength of TBC when 30% fly ash was used as replacement of cement was 29.28%.

Table 4.2 – Percentage increase in Cube Compressive Strength of Ternary Blended Concrete with various mixes compared with Plain Concrete

S.No	Designation of Mix	% increase in compressive strength at 28 days
1	M10F10	9.95
2	M10F15	18.42
3	M10F20	19.72
4	M10F30	29.29
5	M10F35	12.41
6	M10F40	4.84

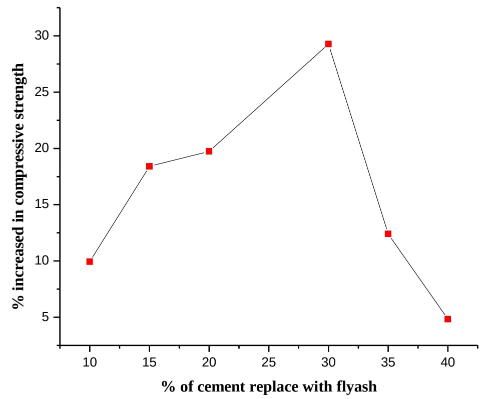

Fig 4.2 Percentage Increase in the Compressive Strength of TBC with increase in fly ash content compared with plain concrete

Table 4.3 - Cube Compressive Strength of Ternary Blended SFRC

S.No	**Designation of Mix**	**28 day strength (MPa)**
1	M10F30S0	50.19
2	M10F30S0.5	50.92
3	M10F30S0.75	51.21
4	M10F30S1.0	52.62
5	M10F30S1.25	50.73

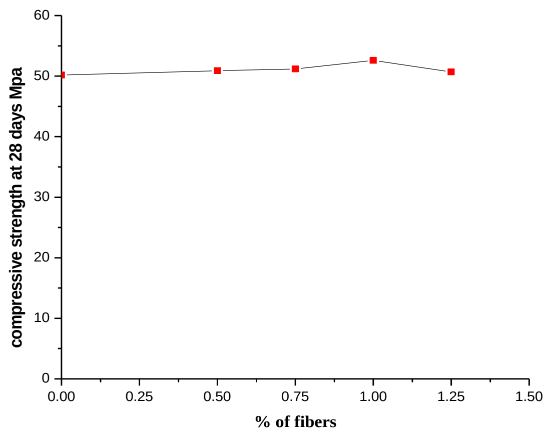

Fig 4.3 Variation of Compressive strength of TBSFRC with increase in fibre content The percentage increase in the Compressive strength of TBSFRC when 1% fibre content was used was found to be optimum which is 5%

Table 4.4 – Percentage increase in Cube Compressive Strength of Ternary Blended SFRC with various mixes compared with Ternary Blended Concrete

S.No	Designation of Mix	% increase in compressive

		strength at 28 days
1	M10F30S0.5	1.42
2	M10F30S0.75	2.37
3	M10F30S1.0	4.76
4	M10F30S1.25	2.21

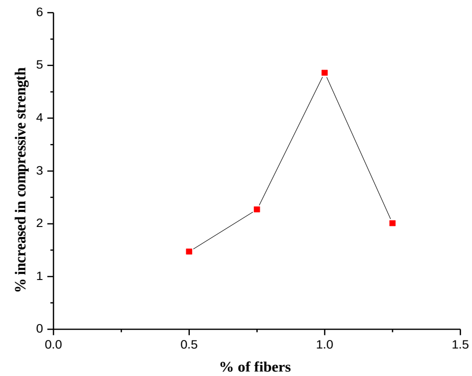

Fig 4.4 Percentage Increase in the Compressive Strength of TBSFRC with increase in fibre content compared with TBC

CONCLUSION

- The Flexure behaviour of the beams has improved with the presence of fibres.the moment carrying capacity of Fibre reinforced concrete beams is increased by 21.58%.
- Moment carrying capacity of Fibre reinforced concrete beams of 0.5% of fibre is 7.16%.and 0.75% of fibre is 12.60%.and 1.25% of fibre is -6.685%.
- There has been an increase in moment carrying capacity of beams by 21.58% with the inclusion of 1% crimped steel fibres.
- Specimens containing higher percentages of volume of fibers show greater elastic properties. As regain the original shape on unloading.
- The concrete mix was found to become strongly cohesive and stable compared to that of ordinary plain concrete. No bleeding was observed. This may be due to the void filling action of the metakaolin and fly ash particles, which gives a high cohesion to the mix.
- Compressive Strength of Concrete increases with the replacement of cement with the mineral additives Fly ash and Metakaolin. However beyond certain limit of their addition, the strength decreases. The maximum Strength is obtained when 10% Metakaolin and 30% fly ash by weight of cement is used as partial replacement of cement. And was found to be 29.28% higher. when Compare to plain concrete specimen. Further the compressive Strength of ternary blended concrete increases marginally with the addition of fibre. the maximum increase was found to be 5% for 1% of fibre.

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