ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

EXPERIMENTAL STUDY ON BEHAVIOUR OF FIBER REINFORCED TERNARY BLENDED CONCRETE USING DIFFERENT TESTS

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ABSTRACT

The construction techniques have been modernized with focus on high strength, dense and uniform surface texture, more reliable quality, improved durability, and faster construction. High strength concrete is a type of high performance concrete with a specified compressive strength of 50Mpa or greater. Optimum concrete mixture design results from locally available materials that make the fresh concrete place-able and finish-able and that ensure the strength development and other desired properties of hardened concrete as specified by the designer high strength concrete containing metakaolin and flyash as admixture along with crimped fibers were cast and tested to study the mechanical properties. The concrete was designed to have compressive strength of 60Mpa. Pozzolona's such as metakaolin and flyash as mineral admixture imparts additional strength to the concrete by reacting hydration products to create additional c-s-h gel. The part of the paste responsible for strength, a common practice is to use a super plasticizer.

Concrete mixes containing varying percentages 0%, 5%, 10%, 15% and 20% replacement of cement by metakaolin and flyash with constant w/c ratio of 0.32 and 0.25%, 0.5%, 0.75% and 1% by volume of crimped fibers were also prepared. The effect of mineral admixture with and without crimped fibers on the hardened properties of concrete was investigated. Mixtures with metakaolin and flyash at higher percentages replacement exhibited lower workability, less bleeding and slightly lower air content. Mixtures incorporating metakaolin with fibers developed marginal increase in compressive strength, split tensile strength and greater flexural strength and more ductility at higher percentages of fibers at all ages. The enhancement was more pronounced as the age of curing is more, i.e. 28 days.

This report concentrates mainly on studying the basic strength properties like cube compressive strength. Split tensile strength and modulus of rupture of metakaolin and flyash blended high strength with crimped fibers at the age of 28 days. The results are analyzed to make useful conclusions regarding the basic strength properties of the ternary blended concrete with various percentages of fibers.

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

INTRODUCTION

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any desired shape. The relative quantities of aggregate, cement and water mixed together, control the properties of concrete in wet state as well as hardened state. RCC, PSC, precast concrete are the functional extensions of concrete in modern days. Cement is a building material made by grinding calcined limestone and clay to a fine powder, can be mixed with water and poured to set as a solid mass or used as an ingredient in making mortar or concrete. 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, Sulphate Resisting Cement, Quick setting cement and Portland Pozzolana Cement. PPC includes 15 to 35% of pozzolanic material. Cement is categorized into three grades based on the 28 days strength like 33 grade, 43 grade and 53 grade.

Aggregates give body to the concrete. Fine and coarse aggregates make up the bulk of a concrete mixture. The presence of aggregate greatly increases the robustness of concrete over and above that of cement which otherwise is a brittle

material, and therefore concrete is a true composite material. Size, shape, texture and grading of aggregate effects the quality of concrete. Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate and fills voids within it, and allows it to flow freely. Less water in the cement paste will make a stronger, more durable concrete; more water will give an free-flowing concrete with a higher slump. A 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 the gel pores. Therefore the total of 0.38 of w/c ratio is required for chemical reactions and to occupy gel pores.

TERNARY BLENDED FIBRE REINFORCED CONCRETE

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 at least 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 coal fired 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. Ternary blended Fibre Reinforced Concrete is that which has the inclusion of two different pozzolanic materials with the Portland cement and also containing fibres distributed randomly in the matrix of the concrete. Ternary Blended mixtures give high strength, low permeability and corrosion resistance. The pozzolanic materials like fly ash, silica fumes, metakaolin, rice husk etc. are used in the ternary blend.

Table 1 – Properties of Fly ash

S.No	Constituents	Percentage (%)
1	Silica, Sio_2	60.8
2	Alumina, Al_2O_3	31.02
3	Iron Oxide, Fe_2O_3	3.97
4	Lime, CaO	0.72
5	Magnesia, MgO	1.51
6	Sulphur Trioxide, SO_3	0.84
7	Loss on ignition	0.21
8	Surface Area m^2/kg	237
9	Drying Shrinkage	0.013
10	Bulk Density	1.26

Table 2 – Properties of Metakaolin

S.No	Property	Value
1	Specific Gravity	2.55
2	Accelerated pozzolanic active index, % of control	88
3	Residue on 45 micron sieve, % chemical analys	1.32

4	Loss on Ignition	0.71
5	Silica (SiO_2)	52.26
6	Iron Oxide (Fe_2O_3)	0.61
7	Aluminum (Al_2O_3)	43.19
8	Calcium Oxide (CaO)	1.02
9	Magnesium Oxide (MgO)	0.62

Table 3 - Properties of hooked steel fibers

S.No	**Property**	**Value**	**Remarks**
1	Diameter	0.45mm	Properties confirms to ASTM A820 Standard requirements
2	Length	36mm	
3	Aspect ratio	80	
4	Tensile strength	11Mpa	
5	Specific gravity	0.78	

Fig 1: Compression Test of cube

Fig 2: Split Tensile Strength Test of Cylinder

Fig 3: Flexural Strength Test of Beam

TEST RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH OF TBC

The results obtained from compression test of cubes of Ternary Blended Concrete are shown in the table1. The content of Metakaolin as a replacement of cement was increased and the results obtained for 0%, 5%, 10%, 15%, and 20% are shown below. The compressive strength of TBC was observed to be optimum with 10% replacement of cement by Metakaolin

Table 4 – Cube Compressive strength of Metakaolin Blended Concrete in N/mm^2

S.No.	Designation of Mix	7 day strength	28 day strength
1	M10Fi0%	61.08	91.88
2	M10Fi0.25%	64.94	96.12
3	M10Fi0.5%	63.07	96.42
4	M10Fi0.75%	65.93	99.71
5	M10Fi1%	62.38	94.44

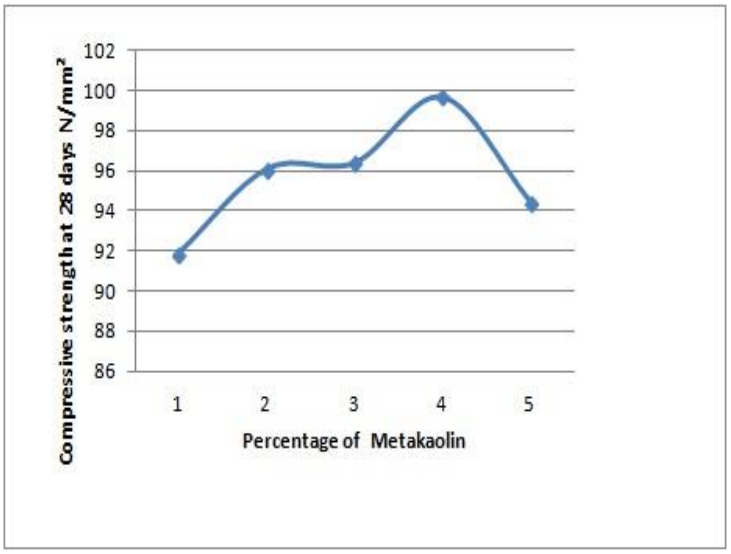

Fig4: Variation of Compressive strength of Metakaolin with increase of Fibers

Table 5 – Cube Compressive strength of Fly ash Blended Concrete in N/mm²

S.No.	Designation of Mix	7 day strength	28 day strength
1	F20Fi0%	48.66	89.33
2	F20Fi0.25%	47.61	90.52
3	F20Fi0.5%	48.81	87.92
4	F20Fi0.75%	52.44	91.59
5	F20Fi1%	46.72	88.64

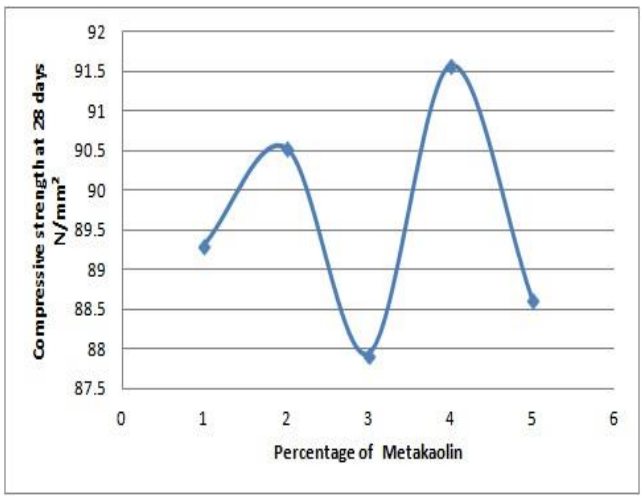

Fig5: Variation of Compressive strength of Fly ash with increase of Fibers

Table 6 – Cube Compressive strength of Fly ash and Metakaolin Blended Concrete at 28 days in N/mm²

S.No.	Designation of Mix	28 day strength
1	F10+M10+Fi0%	97.59
2	F10+M10+Fi0%	95.97
3	F10+M10+Fi0%	99.29
4	F10+M10+Fi0%	101.25
5	F10+M10+Fi0%	93.77

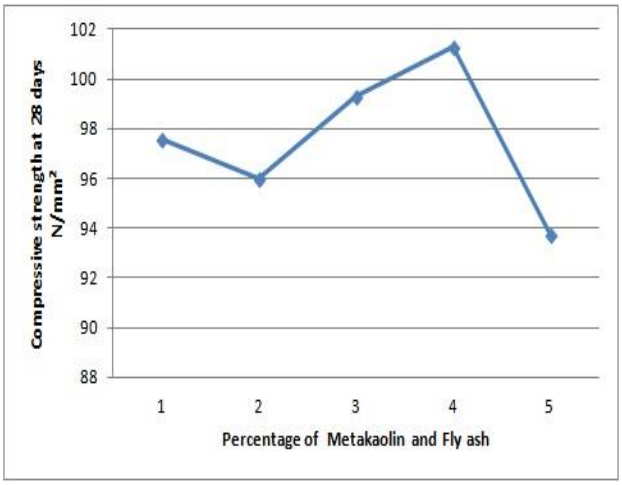

Fig6: Variation of Compressive strength of Metakaolin and Fly ash with increase of Fibers

Table 7 – Split Tensile Srength of Fly ash and Metakaolin Blended Concrete at 28 days in N/mm²

S.No.	Designation of Mix	28 day strength
1	F10+M10+Fi0%	10.33
2	F10+M10+Fi0%	10.71
3	F10+M10+Fi0%	10.63
4	F10+M10+Fi0%	11.22
5	F10+M10+Fi0%	9.85

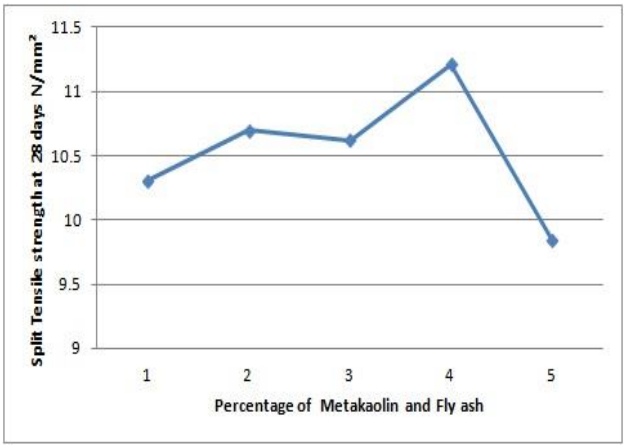

Fig7: Variation of Split Tensile strength of Metakaolin and Fly ash with increase of Fibers

Table 8 – Flexural Srength of Fly ash and Metakaolin Blended Concrete at 28 days in N/mm²

S.No.	Designation of Mix	28 day strength
1	F10+M10+Fi0%	8.02
2	F10+M10+Fi0%	9.03
3	F10+M10+Fi0%	10.35
4	F10+M10+Fi0%	12.03
5	F10+M10+Fi0%	11.86

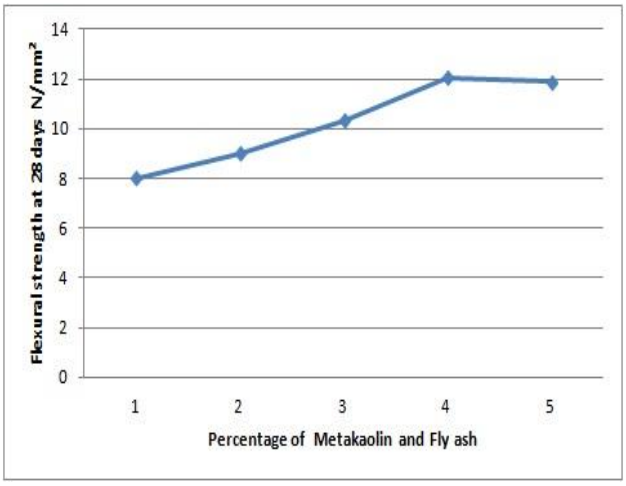

Fig8: Variation of Flexural strength of Metakaolin and Fly ash with increase of Fibers

CONCLUSION

- Metakaolin is an effective pozzolona and results in enhanced early strength and ultimate strength of concrete.
- The compressive strength of young concrete, i.e., 7 days is improved by blending the OPC with 10% of metakaolin by weight.
- The 10% replacement with metakaolin is the most optimum replacement, enhancing the concrete's compressive strength at all ages.

- The 28-days compressive strength of concrete was improved by partial replacements of OPC by metakaolin in the range up to 10% by weight, and was at the 20% level still maintained. The highest 28-days strength improvement of concrete can be expected at partial replacements in the 10-15% range.
- The combined use of metakaolin and a super plasticizer allowed increasing the aforementioned partial replacement levels, i.e. to 20% in the case of maintaining strength.
- Ternary blending by Metakaolin in combination with Fly Ash was found leading to further technical improvements to concrete strength. Especially, blended concrete mixtures with Metakaolin / Fly Ash -ratio to 50/50 by weight revealed higher efficiency for improving strength at older ages.
- Addition of flyash results in economy of the mix because of low cost of fly ash.
- Addition of fibers to all the mixes clearly indicate improvements in all the properties such as compressive strength, split tensile strength, and most importantly increased flexural strength, this property is very useful in arresting the cracks to a large extent.

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