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EXPERIMENTAL STUDY ON BEHAVIOR OF TERNARY BLENDED CRIMPED STEEL FIBER REINFORCED CONCRETE BEAM IN SHEAR

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ABSTRACT

Concrete is most widely used construction material because of ease of construction and its properties like compressive strength and its durability. It is difficult to point out other material of construction which is versatile as concrete. This is well known that plain concrete is very good in resisting compressive strength but possesses less specific modulus, low ductility and very little resistance to cracking. Internal micro cracks inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks eventually leading to brittle failure of concrete.

Several admixtures have been developed to improve the strength and workability properties of concrete. Of all admixtures used in concrete, Micro Silica occupies a special position for quite a some reasons. The improvement of the durability, resistance to sulphate, freezing and thawing, alkali silica reaction, frost attack, increase in the compressive strength, reduces the permeability and bleeding. Micro Silica effectively improve the structure of interface eliminates the weakness of the interfacial zone. In the past, attempt has been made to improve tensile strength of concrete. This was achieved by the addition of small closely spaced and randomly oriented fibers, dispersed uniformly in the matrix. The fibers acts as crack arrestor and substantially improves in static and dynamic properties. Shear strength of steel reinforced concrete beams has been the subject of many controversies and debates since the beginning of 20th century. The shear strength of reinforced concrete beams has been extensively studied over the last five decades. A large number of experimental and analytical works have been carried out for the case of slender beams (having a shear span to depth ratio a/d > 2.0) with and without shear reinforcement under two-point loading.

Transversely loaded reinforced concrete beams may fail in shear before attaining their full flexural strengths if they are not adequately designed for shear. Unlike flexural failures, shear failures are very sudden and unexpected, and sometimes violent and catastrophic. A thorough knowledge of the different modes of shear failures and the mechanisms involved is necessary to prevent them.

The present experiment is carried out to investigate the compressive and shear strength of ternary blended steel fiber reinforced concrete with 6% of micro silica and 15% of fly ash by weight of cement as partial replacement of cement and addition of different percentages like 0%, 0.5%, 0.75%, 1% and 1.25% of crimped steel fibers with aspect ratio of 80. Compressive strength of concrete is measured by testing standard cubes (150mmx150mmx150mm) at the age of 7 and 28 days, Shear strength of concrete is measured by testing beams (1400mmx100mmx150mm) at the age of 28 days.

Micro Silica and Fly Ash along with Steel Fiber in concrete has shown considerable improvement in the compressive and shear strength of concrete. From the test results it is observed that concrete mixture with 6% Micro Silica and 15% Fly ash replacement of cement has shown the maximum compressive strength of 41.8MPa at 28 days. Concrete mixture with 6% Micro Silica and 15% Fly ash replacement of cement along with 1% crimped steel fiber has shown significant improvement in various properties at the age of 28 days indicated by 12% increase in compressive strength and 24% increase in shear strength. Hence ternary blended crimped steel fiber reinforced concrete with 6% micro silica and 15% fly ash is a novel material having superior performance characteristics compared with conventional concrete.

KEYWORDS: Shear strength, Crimped fibers, Ternary blends, Micro silica and Fly ash.

INTRODUCTION

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded in any no. of shape. The relative quantities of cement, aggregate and water are 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 mix 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 Extra Rapid Hardening, Sulphate Resisting, Portland Pozzolana Cement. PPC includes 15 to 34% of pozzolanic material. Cement is classified into three grades based on the 28 days strength as 33 grade, 43 grade and 53 grades Aggregates give body to the concrete. whereas Fine and coarse aggregates make up the bulk of a concrete mixture. The presence of aggregate increases the robustness of concrete over and that of cement, which is a brittle material, and that's why concrete is a good composite material. Combining water with the cementitious material forms a cement paste by the hydration process. The cement paste with the aggregate together, fills voids with it, and makes it to flow more freely. Less water in the cement paste will become a stronger, more durable concrete; more water will give an free-flowing concrete with a higher slump. 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 a total of 0.38 of w/c ratio is required for chemical reactions and to occupy gel pores. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

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 Micro silica 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 Micro silica 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. In the past work has been carried out extensively on behavior of fibre reinforced concrete in shear with plain concrete. Some of the researchers have also studied the shear behavior of binary blended fibre reinforced concrete. The study carried out on the shear behavior of ternary blended fibre reinforced concrete in the past has been scanty.Figures

BEAM SHEAR BEHAVIOR

Reinforced masonry beams must be designed for shear as well as bending. Maximum shear occur near to supports. Shear failure is actually a diagonal tension failure that is brittle in nature and should be avoided.

Shear force is present in beams at sections where there is a change in bending moment along the span which is equal to the rate of change of bending moment. An exact analysis of shear strength in reinforced concrete beam is complex. Many experimental studies have been conducted to understand the various modes of failure that could occur due to possible combination of shear and bending moment acting at a section. The main obstacle to the shear problem is the large number of parameters involved and some of which may not be known. Therefore, for some time, researchers have concentrated on the internal mechanism of shear failure. The usual arrangement for investigating shear failure is that of a beam subjected to symmetrically placed two equal concentrated loads 'P' at distance 'a' (shear span)

from the supports. It has the advantage of combining two different test conditions, viz, pure bending, that is, no shear force is present between the two loads P, and constant shear force in the two end regions or shear spans.

Table 1 - Typical oxide composition of Fly ash

S.No	Characteristics	Percentage(%)
1	Silica, Sio2	49-67
2	Alumina, Al2O3	16-28
3	Iron Oxide, Fe2O3	4-10
4	Lime, CaO	0.7-3.6
5	Magnesia, MgO	0.3-2.6
6	Sulphur Trioxide, SO3	0.1-2.1
7	Loss on ignition	0.4-1.9
8	Surface Area m2/kg	230-600

Table 2 - Typical Oxide Composition of Micro Silica

S.No.	Characteristics	Specification As per ASTM C 1240	Percentage
1	Silica, SiO2	85-96	92.0
2	Alumina, Al2O3	0.5-3.0	2.8
3	Iron Oxide, Fe2O3	0.2-2.0	1.4
4	Lime, CaO	0.1-2.5	2.3
5	Magnesia, MgO	0.5-1.5	1.1
6	Loss on ignition	0.1-6.0	2.5
7	Surface Area m2/g	>15	18.9
8	Moisture Content	<3	1
9	Bulk Density kg/m3	-------	450-650

Table 3 - Properties of Crimped 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	1100Mpa	

FIG . Test Setup for compression test

FIG. Test Setup for Shear under Two Point Loading

Fig. Crack Pattern of Beam Failed in Shear

TEST RESULTS AND DISCUSSIONS

Concrete with 6% Micro Silica and Various Percentage of Fly Ash

Compressive strength of concrete with 6% micro silica and various percentages of fly ash were found to increase with increase in fly ash content. The 7, 28 days strengths were found to increase marginally over the control mix. The maximum strength is achieved with 15% addition of fly ash.

Table 4.1 Compressive Strength of Various Concrete Mixtures with Constant Micro Silica and Different Percentage of Fly Ash at Different Ages

S.No.	Mix ID	Compressive Strength (MPa)	
		7 days	28 days
1	S0F0	22.	37.3
2	S6F10	22.	38.2
3	S6F15	25.	41.8
4	S6F20	24.	39.3
5	S6F25	23.	38.2

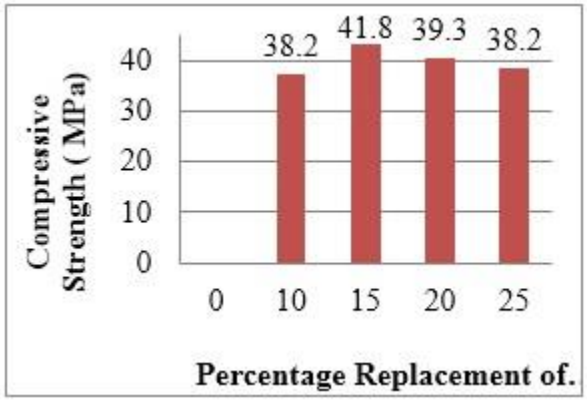

Figure 4.1: Compressive Strength Vs Percentages Replacement of Fly ash and constant Micro Silica of 6% at the Age of 28 Days: Concrete with 6% Micro Silica and 15%Fly Ash along with Steel Fibers

Compressive strength of concrete with 6% micro silica and 15%fly ash was found to increase with increase in fiber content. The 7, 28 days strengths were found to increase marginally over the control mix. The maximum strength is achieved with 1.0% addition of fiber. The increase was observed as 12% over the ternary blended concrete at the age of 28 days

Table 4.2 Compressive Strength of Various Concrete Mixtures with Various Percentages of Steel Fibers at Different Ages

S.No.	Mix ID	Compressive Strength (MPa)	
		7 days	28 days
1	S0F0C0	22.0	37.3
2	S6F15C0	25.8	41.8
3	S6F15C0.5	27.5	42.6
4	S6F15C0.75	30.3	46.2
5	S6F15C1.0	33.8	46.8
6	S6F15C1.25	31.4	44.1

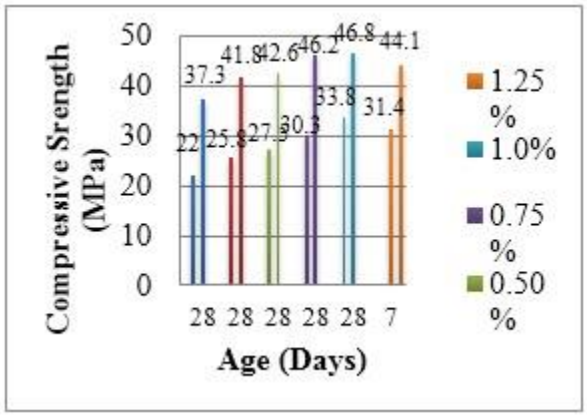

Figure 4.2: Compressive Strength Vs Age of Mixes with Different Percentage of Steel Fibers

Shear Strength:

Beam specimens were tested for shear strength. The tests were carried out confirming to IS 516-1959[11] the specimens were tested under two point loading the average value of 3 specimens for each category at the age of 28 days is tabulated in the Table 4.4. The percentage increase in shear strength of various concrete mixtures over ternary blended concrete is also tabulated in the Table 4.4. Figure 4.4 shows the graphical representation of variation of shear strength of ternary blended fiber reinforced concrete mixture with various percentages of fiber at the age of 28 days and Figure 4.5 shows the graphical representation of percentage increase in shear strength over ternary blended mix with percentage addition of fibers at the age of 28 days.

Concrete with 6% Micro Silica and 15%Fly Ash and Steel Fibers:

Shear strength of concrete with 6% micro silica and 15%fly ash was found to increase with increase in fiber content. The maximum shear strength is achieved with 1.0% addition of fiber. The increase was observed as 24% over the ternary blended concrete at the age of 28 days

Table 4:Shear Strength of Various Concrete Mixtures at Age of 28 Days and Percentage Increase over Ternary Blended Concrete

S.No.	Mix ID	Shear Strength (MPa)	Percentage Increase over Ternary Blended Mix
1	S0F0C0	1.80	-
2	S6F15C0	1.88	-
3	S6F15C0.5	2.15	14.4
4	S6F15C0.75	2.22	18.1
5	S6F15C1.0	2.33	24.0
6	S6F15C1.25	2.22	18.1

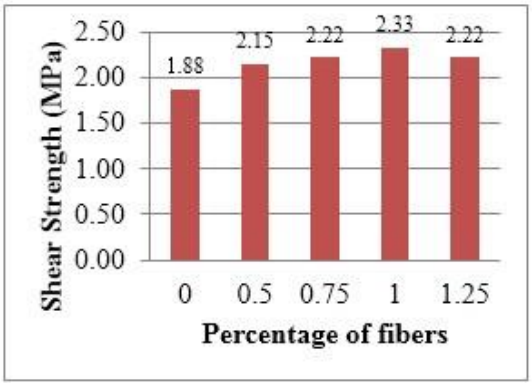

Figure 4.4: Shear Strength Vs Percentage Addition of Fibers at the Age of 28 Days

CONCLUSIONS

General

From the experimental investigations on shear strength of concrete containing steel fibers, micro silica and fly ash the following conclusions are drawn.

Conclusions

Addition of steel fibers ranging from 0% to 1.0% by volume of concrete enhances the shear stress better compared to compressive stresses. The maximum increase in strength is achieved for concrete mix having 1.0% fiber content. Shear strength was increased by 24% where as compressive strength for corresponding concrete mix is increased by 12% at the age of 28 days. Optimum percentage of concrete mix containing micro silica and fly ash as partial replacement of cement was found to be 6% and 15% respectively.

The addition of micro silica as second mineral admixture to form the ternary blended concrete improves the initial age strength development. Ternary blends of OPC with micro silica and fly ash are particularly useful to render greater durability to concrete. Concrete beams without fibers failed in shear which corresponds to sudden failure along a single shear crack. Addition of steel fiber consistently decreased crack spacing's and sizes, increased deformation capacity and changed a brittle mode to a ductile one

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