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REVIEW ARTICLE

EXPERIMENTAL INVESTIGATION OF LAYERED CONCRETE MATRIX CONSISTING OF NORMAL AND FIBRE REINFORCED HIGH PERFORMANCE CONCRETE

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ABSTRACT

This paper presents detailed experimental investigations on compounding technology with two layered as well as three layered reinforced cement concrete, consisting of fibre reinforced high performance concrete (FRHPC) and Normal strength concrete (NSC) to improve the efficiency of concrete matrix (M_{60} and M_{20}) and consequently to enhanced load carrying capacity of different layered concrete matrix and also to study compatibility condition between FRHPC and NSC layers. Since, High performance concrete (HPC) is a specialized series on concrete designed to provide several benefits in the construction of concrete structure. The Mechanical properties of layered fibre reinforced high performance concrete matrix along with normal strength concrete was studied by preparing several varying thickness of FRHPC and NSC layers. Compressive strength, split tensile strength and flexural strength of the layered concrete matrix specimens were carried out to assess the enhancement in strength and same is to be optimized with minimum use of FRHPC to obtain increased strengths.

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INTRODUCTION

Concrete is the most versatile and most widely used construction material worldwide and has played a very important role in the civilization of mankind. It has the unique distinction of being the only construction material actually manufactured Concrete is a brittle in nature but is strong in compression and weak in tension. The tensile strength of plain concrete is about 10% of its compressive strength. Concrete tensile stress produced from the externally applied loads, temperature changes, or shrinkage in a member reaches the tensile strength of the material which lead formation of tensile cracks in reinforced concrete flexural members containing conventional, Hence there is an intense need to take measures that can control the tensile cracking of concrete, overall safety of a structure and increase its useful life by use of short discrete fibers in concrete is one approach to mitigate the cracking and increasing the tensile straining capacity. A more economical approach is lies in enhancing the tensile strength and fracture toughness of concrete material. This can be achieved by integration of high performance concrete with fibres.

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Literature review

Two-concrete layers of different strength fall into the category of composite structures. Consisting of fiber reinforced high performance concrete and normal strength concrete. It is seen that in R.C.C. beams are effective when the reinforced concrete (RC) section carries rather big bending moments in compression zone and the tensile zone respectively.When the concrete in tension layer and compression layer made with different concrete strengths. The possibility of such scheme in practical at new constructions using two layer beams is logical because as the beam span becomes longer and the service load increases, so a higher concrete strength is required in the beam's compression zone to withstand rather large bending moments. As concrete in the tension zone of the section contributes little to the beam's load bearing capacity, this zone is made of NSC. In the recent years, much of the literature and research is emphasized on the use of High performance concrete on the compressive zone of the flexural member, i.e., the compression layer made with high performance concrete while the tension layer made of normal concrete, so as higher concrete strength is required in the beam's compression zone to withstand rather large bending moments. As concrete in the tension zone of the section contributes little to the beam's load bearing capacity, this zone is made of NSC (Iskhakov and Ribakov, 2008) two-layer bending pre-stressed beam consisting of steel fibered High strength concrete in compressed zone and normal strength concrete in tensile zone" The HSC layer made of steel fiber will allows improving the beams compressed zone plastic properties, (Holschemacher *et al*., 2012) The grades of concrete used is M25, M50 and M69 strength of concrete and distribution of fibers in beams cross section has a direct influence on the bending elements (Eramma *et al*., 2014) Concrete grade variation in tension and compression zones of RCC beams. As the depth of higher grade concrete increases in compression zone, resistance to first crack development also increases strengthening of RCC beam. Therefore, the research on use of different concrete matrix is at a relatively new idea, very limited research regarding their effectiveness in strength and optimizing of concrete matrix in layers. Hence an attempt has been made through the present investigation to study the effect of use of different concrete matrix in Two-layer and three layers composite consisting of FRHPC (M60+steel fibre) and NSC (M20) with varying different thickness of FRHPC and NSC to obtain Maximum Strength for minimum thickness of FRHPC and same is to be optimized which may leads to economical advantage with different concrete grades as innovative construction methods.

MATERIALS AND METHODS

In this present investigation OPC 53 Grade Ultra tech , fine aggregates passing through 4.75 mm sieves and entirely retained on 150µ with grading Zone II, 60 % of coarse aggregate passing 20 mm sieve size and retained on 12.5mm sieve, remaining 40% of coarse aggregate passing 12.5 mm sieve size and retained on 10 mm sieve, Glenium ACE 30, with Poly carboxylic based ethers as Super Plasticizer/ chemical admixture, Micro silica available in densified form and Ground Granulated Blast Furnace Slag (GGBFS), Crimped end steel fibers having aspect ratio of 80 were used. The physical properties to suit requirement to be used in present investigations on cement, fine aggretate, coarse aggregates and water were conducted in accordance with Indian standards. Ordinary potable water was used for mixing and curing purpose. Properties of materials used in present investigation are specific gravity of cement 3.05, normal consistency 31%, specific gravity of silica fume and GGBS are 2.26 and 2.32 fineness modulus and specific gravity for fine aggregate and coarse aggregates are 3.86, 6.10, 2.65 and 2.68 respectively. To determine the mix proportions for M60 grade concrete (FRHPC), tests on trial mixes were carried out and was finally selected with required workability of 25-50mm slump, 8% of silica fume is replaced by weight of cement, 15% of GGBS, 0.8% of superplasticzier, 0.65% steel fbers, were used in the concrete mix in the present investigation. The mix proportion obtained for FRHPC (M60) and for NSC(M20) after trial mixes are, Cement: Silica fume: GGBS: FA: CA: Water (0.759: 0.097: 0.144 :0.769:1.979:0.30) and Cement: FA: CA: Water (1:2.136:3.35:0.55) respectively.

Test specimens

A series of test specimens are chosen for the investigation and all are having a unique nominal sectional dimensions for cubes 150 mm, cylinders 150 mm dia. and 300mm height and prisms 100 X 100 X 500mm respectively. The tests specimens are divided into six categories (Case A to Case F) of concrete matrix according to the depth of Fibre Reinforced High Performance Concrete (FRHPC) and Normal Strength Concrete (NSC) in layers are listed in Table No. 1.

Casting the specimens

Weigh batching is employed for experimental study. Mixing process involves weighed cement which is mixed with silica fume and GGBS. The known weight of FA, CA and steel fibers were mixed with above ternary blended mixes, further measured water is mixed with super plasticizer. The above materials are mixed until homogeneous concrete mix is obtained. For preparing specimens care was taken to maintain the quality of concrete in fresh state, which involves by proper batching, mixing, adequate compaction, curing and method of testing were quality maintained.

Methodology of test

The experimental setup, casting, curing of specimen and testing procedure were carried out in accordance with IS 456-2000 and 516:1959, Clause 5.1 upto 5.6 respectively.

Test programme

The present experimental investigation involves determination of following test programs:

- Compressive Strength Test
- Split-Tensile Strength Test
- Flexural Strength Test

The concrete matrix designation with description for case A, case B, case C, case D, case E and case F were under study for the present research investigations, the specimens are tested for 3 days, 7 days, and 28 days and the results are tabulated in Table No. 3, 4 and 5.

RESULTS AND DISCUSSION

General

The basic law of concrete technology states that the strength of concrete within the plastic range is inversely proportional to water-cement ratio or lower the water-cement ratio greater its compressive strength and vice-versa. Among all strengths, the compressive strength is generally considered as most important property of concrete and gives overall picture of quality of concrete.

Table 1. Layered Concrete Matrix Designation

S.No.	Concrete Matrix Designation	Description
1	Case A	M20 grade concrete (Control specimen).
2	Case B	M60 grade concrete. (Control specimen).
3	Case C	M20 grade concrete while layer of 0.22d made with high strength concrete.
4	Case D	M20 grade concrete while layer of 0.31d made with high strength concrete
5	Case E	Upper layer made of HPC M60 (0.22d), middle layer made of M20 (0.39d) and bottom layer made of M60(0.39d)grade concrete
6	Case F	Upper layer made of HPC M60 (0.30d), middle layer made of M20 (0.35d) and bottom layer made of M60(0.35d)grade concrete

Fresh properties of concrete

The properties of fresh concrete obtained are summarized below

Table 2. Properties of Fresh Concrete

Concrete Type	Slump (mm)
CASE A (M20) (w/c = 0.55)	50
CASE B (M60 (Cement 77% + SF 8% + GGBS 15%) + 0.65% steel fibers. (w/c = 0.30)	50

Compressive Strength Test

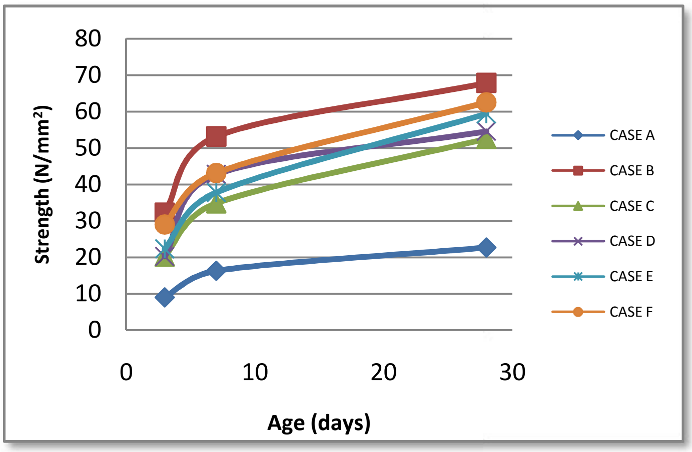
The compressive strength was studied on different ages of concrete. The cubes were tested at 3 Days, 7 Days and 28 Days. The cube mould of 150mm x 150mm x 150mm size is taken as per IS: 516-1959 specification.

Table 3. Compressive strength test results for different cases

Concrete type	3 day strength (N/mm^2)	7 days strength (N/mm^2)	28 days strength (N/mm^2)
CASE A	9.00	16.27	22.67
CASE B	32.28	53.19	67.85
CASE C	20.27	34.87	52.56
CASE D	29.21	42.75	54.06
CASE E	22.38	37.82	59.78
CASE F	29.06	43.17	62.55

Split tensile strength

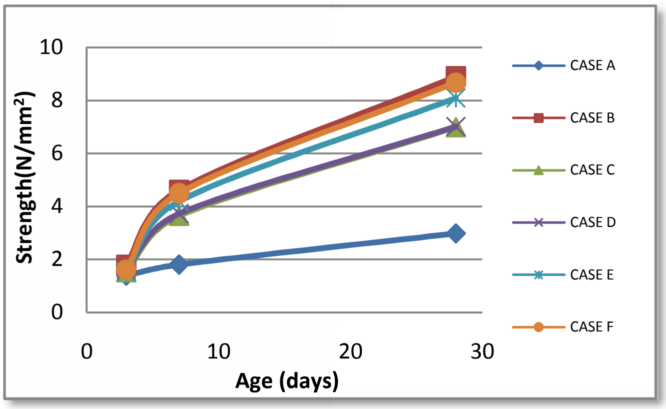
This is an indirect test for tensile strength of concrete. The test for determining split tensile strength for concrete employs cylindrical specimen of 150mmX300mm size, casted ,cured and tested at 3, 7, and 28 days. The results of split tensile strength test are tabulated.



Graph 1. Comparison of Compressive Strength with age (days) on different cases

Table 4. Split Tensile Strength test Results for different cases

Concrete type	3day strength (N/mm^2)	7 days strength (N/mm^2)	28 days strength (N/mm^2)
CASE A	1.39	1.80	2.98
CASE B	1.75	4.61	8.92
CASE C	1.51	3.64	6.99
CASE D	1.61	3.7	7.02
CASE E	1.54	4.10	8.09
CASE F	1.62	4.50	8.67



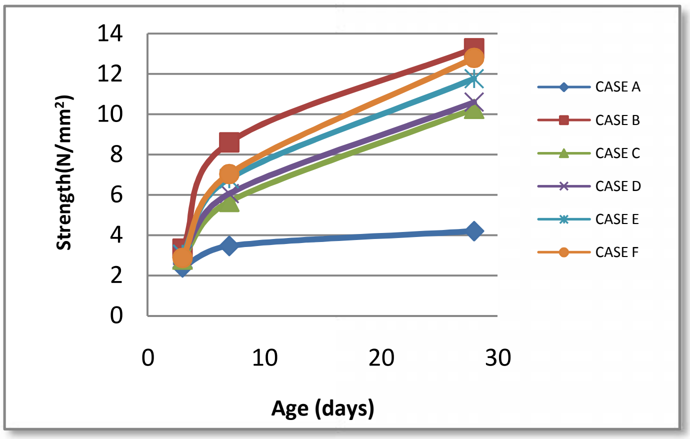
Graph 2. Comparison of Split Tensile strength with age (days) on different cases

Flexural strength test

Table 5. Flexural Strength Results for different cases

Concrete type	3 day strength (N/mm^2)	7 days strength (N/mm^2)	28 days strength (N/mm^2)
CASE A	2.40	3.467	4.20
CASE B	3.33	8.60	13.27
CASE C	2.80	5.66	10.27
CASE D	3.00	6.06	10.60
CASE E	3.06	6.80	11.76
CASE F	2.86	7.03	12.80

The flexural strength for concrete was studied on prism of size 100mm X 100mm X 500mm ,were tested at 3, 7, and 28 days. The results of flexural strength test are tabulated.



Graph 3. Comparison of Flexural strength with age (days) on different cases

Conclusion

Compressive strength

The rate of gain of 28 days Compressive Strength is highest for Case F layered specimen in comparison with other concrete matrices used in this investigation. The compressive strength of Case F is 176%more than that of 28 days strength of M20 grade of concrete (control) and also it is nearer to the M60 grade concrete (control).

Split tensile strength

For Split-Tensile Strength, 28 days strength is highest for Case F layered specimen in comparison with other concrete matrices used in this experimental investigation. The Split Tensile Strength of Case F is 191% more than that of 28 days strength of M20 grade of concrete (control) and also it is nearer to the M60 grade concrete (control).

Flexural strength

Incase of Flexural Strength, it has been observed that 28 days strength is highest for Case F layered specimen in comparison with other concrete matrices used in this investigation. The Flexural Strength of Case F is 205% more than that of 28 days strength of M20 grade of concrete (control) and also it is nearer to the M60 grade concrete (control). Therefore, based on the above conclusions, it is evident that case F (Upper layer made of HPC (0.30d) M60, middle layer made of (0.35d) M20 and bottom layer made of (0.35d) M60 grade concrete) is the most effective mix and shows a significant increase in the mechanical properties of layered concrete matrix.

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