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Mechanical Properties Assessment of Ultra High Performance Fibre Reinforced Concrete (UHPFRC)

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Abstract - The present paper is aimed to assessment of UHPFRC the conventional concrete is replaced by UHPFRC, an Advanced Cement based Super plasticised concrete with high workability and low water cement ratio. The constituents are optimised in granular packing such as Portland cement, silica fume, sand, quartz sand, high range water reducer admixture, steel fiber, with an improved form of homogeneity and compactness, durability, the research work is carried out to achieve enhanced target compressive strength 150 N/mm^2. The optimised effort to reach strengths in compressive, split tensile and flexural strengths. The influence of temperature on concrete was identified and highlighted.

Key words : Ultra high performance fiber reinforced concrete, mix-proportioning, temperature influence, steel fiber, silica fume, Quartz Sand, Super Plasticizer.

I. INTRODUCTION

The ultra high performance fiber reinforced concrete is a special type of material mixed with cement. The recipes are Silica fume, sand, quartz powder steel fibers, with reduced water cement ratio (w/c) to 0.22 to get high strength with low porosity. In recent years the UHPFRC products developed all over the world several researchers, namely R.yu., P-spiesz, HJH, Brouwers, srinivasan Allen, Katrin Habel, Jean, Philippe contributed for the new findings in UHPFRC. Improved durability and quality of the economical material for 30% replacement of cement yielding a good strength in concrete, workability, and cost efficiency, the strength achievement ranges between 150N/mm^2 to 200 N/mm^2 The new materials in particle packing and live influence on mechanical properties of UHPFRC permitted to design new concrete mixes, produced and more popular in these days. The UHPFRC is a combination of high strength concrete and fiber reinforced. According to Richard & Cheryrezy (1905) represents the highest development of HPC, its compressive strengths on the curing conditions. Ross (e) experimental study on mechanical behavior of UHPFRC. The design of concrete is based on densely compacted cementious matrix, normal sand is used. The UHPFRC serves several purposes in structural applications in Bridges, stadium panels, roads, power plant, rail bridges, airport runways, in-situ members, and seismic strengthening of existing structures.

II. RESEARCH SIGNIFICANCE

Now-a-days the increased strength in concrete is required in heavy structures to carry heavier loads for sustainability. The conventional concrete failed to fulfill the requirement. Hence more emphasis is put on durability to withstand heavier loads and aggressive environment conditions. The compressive strength can be enhanced by special materials such as Silica fume, Quartz Powder, fine sand, steel fibers, HRWRA with low water cement ratio. The concrete specimens are exposed to elevated temperature 120^{0}C; the research investigation was done to achieve targeting compressive strength 150N/mm^2.

III. OBJECTIVE

The principal objective of this experimental work is as follows.
To produce ultra high performance fiber reinforced concrete of above 150N/mm^2.
The influence of elevated temperature on compressive strength.

IV. MATERIAL AND METHODS

A. Cement

The ordinary Portland cement of 53 Grade conforming to IS-12269-1987 with a specific gravity of 3:15 used.

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B. Sand

The locally available natural sand with less than 2 mm size, having specific gravity 2.63 conforming to IS 650 specifications.

C. Silica Fume

The Silica Fume conforming to Grade 920-0 with a specific gravity 2.25 was used as mineral admixture

D. Quartz

The quartz sand was used from locally available source contained 99% silicon dioxide; the specific gravity of quartz sand is 2.59

E. Steel Fibers

The micro steel fibers of length 20 mm and diameter 0.16 mm with hooked ends having aspect ratio (a / r) =50 are used.

F. Super Plasticizer

The adequate work ability of concrete is improved by adding HRWRA admixture. The rheological behavior of concrete mix and its specific gravity is 1.00 confirms to ASTM - C494 type – F

G. Water

The pure, drinkable, free from chemical, mineral impurities used for mixing & curing.

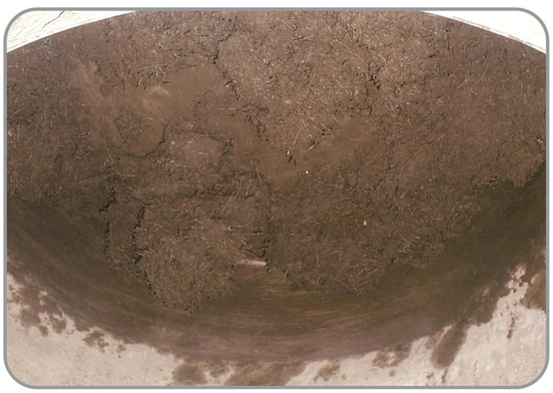

Fig. 1 UHPFRC Mix

Fig. 2 Specimens after Curing

Material	Cement	Silica Fume
CaO	63.49%	0.28%
SO_2	20.60%	96.60%
Fe_2O_3	4.75%	0.25%
Al_2O_3	5.40%	0.20%
MgO	1.84%	0.22%
SO_3	2.75%	0.12%
Na_2O	0.30%	0.20%
K_2O	0.50%	0.35%
Mn_2O_3	0.09%	--
TiO_2	0.25%	--

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Table 1.Minerological Composition of Cement and Silica Fume

Table2. Properties of material

Standard	Sl. No.	Material	Material I.D.	Property Analysis
IS-12269-1987	1	Cement	C	OPC-53 grade S.G.- 3.5
IS-3831970	2	Sand	NS	S.G.- 2.63
IS-383 1970	3	Silica Fume	SF	S.G.- 2.25
ASTM-C494 Type F	4	Steel fibers	ST F	L=20 m = 0.16,mm
ASTM-C 494 Type F	5	Super Plasticizer	SP	SG -1.00
--	6	Quartz	Q	SG.- 2-59

C=Cement ,NS=Normal sand, SF=Silica fume, STF=Steel fiber, SP=Super plasticizer
Q=Quartz sand

Table 3.UHPRRC Composition

Material	Kg/ m^3	% by Wt.
Cement	728	1.0
Fine Sand	965	1.32
Silica fume	195	0.20
Quartz	210	0.28
Steel fibers	156	0.2% / Vol.
HRWRA	30	0.04
Water	165(lit)	0.22

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GRADIATION CHART

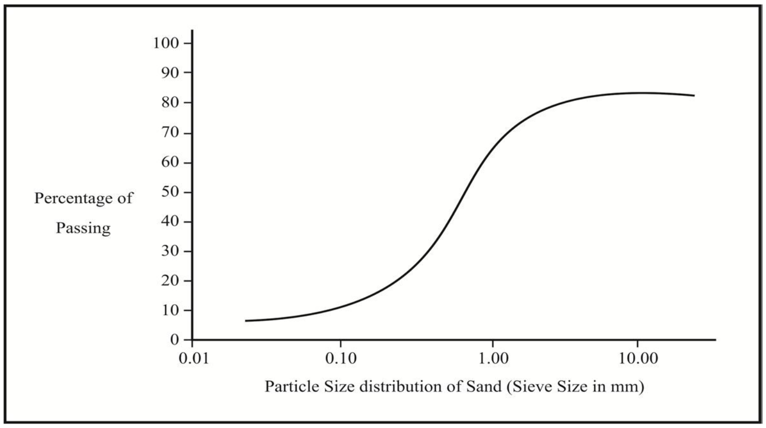

Fig. 6

V. EXPERIMENTAL INVESTICATION

In this experimental research programme: The concrete mixing is performed in a concrete mixture. The materials are weighed carefully mixing, Cement, sand, quartz sand, to obtain homogenous mix, followed by adding Silica Fume mix containing steel fiber mixing with water and Super Plasticizer. The compaction process is performed by means of a concrete needle vibrator distributed casting uniformly, after 24hrs the specimens are demoulded and allowed for drying. Then the specimens are subjected to Temperature in an electric oven to a temperature of 120^0 for 24hrs. The specimens are tested for compressive, split and tensile strengths.

Fig. 3 UHPFRC Hot Air Curing

Fig. 4 Test Setup Tensile Automatic CTM (3000 KN)

Fig. 5 UHPFRC Specimen after Testing

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EFFECT OF ELEVATED TEMPERATURE

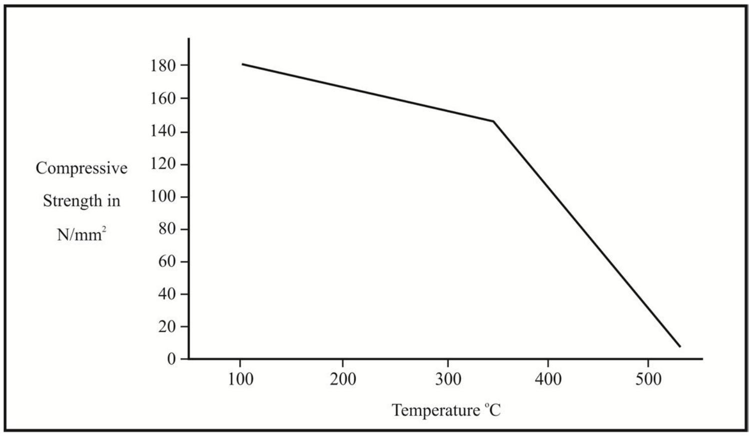

Fig. 7

VI. RESULT AND ANALYSIS

Day	Compressive strength in N/mm^2	Split tensile strength in N/mm^2	Flexural Strength in N/mm^2
3 day	58.25	9.75	12.15
7 day	85.44	11.05	14.50
14 day	122.52	13.45	24.75
28 day	148.25	17.50	26.25
90 day	155.30	21	29

VII. CURING REGIME OF UHPFRC

The thermal curing plays a vital role in strength up gradation. The acceleration of chemical process increases in faster curing in high temperature 120^{0}C. The specimens are exposed to hot air curing for 24 hours duration at the age 3 day to 90 day.

The elevated temperature condition may affect concrete structure. The testing samples were cured under temperature condition increases compressive strength significantly.

90 Days Compressive Strength of UHPFRC

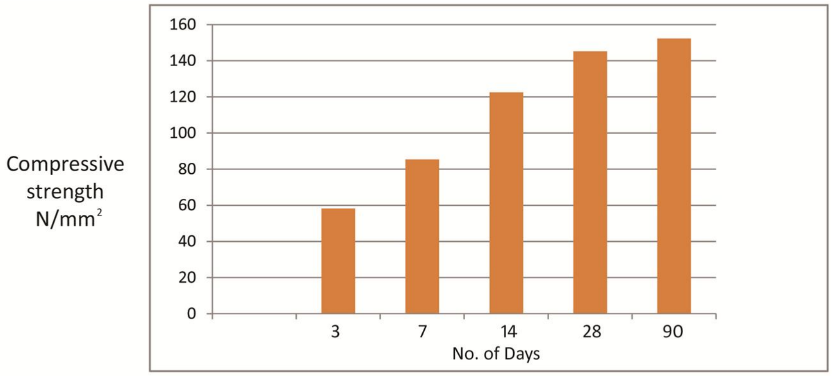

Fig. 8

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90 Days Split tensile Strength of UHPFRC

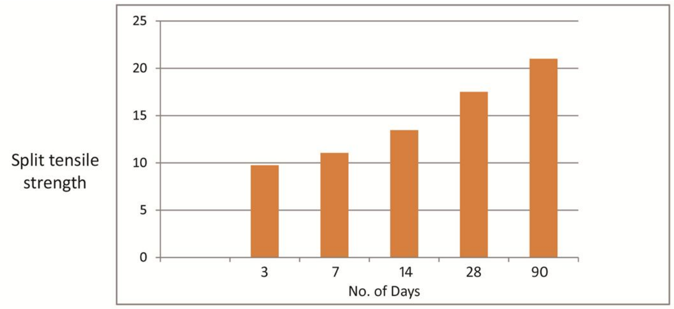

Fig. 9

90 Days Flexural Strength of UHPFRC

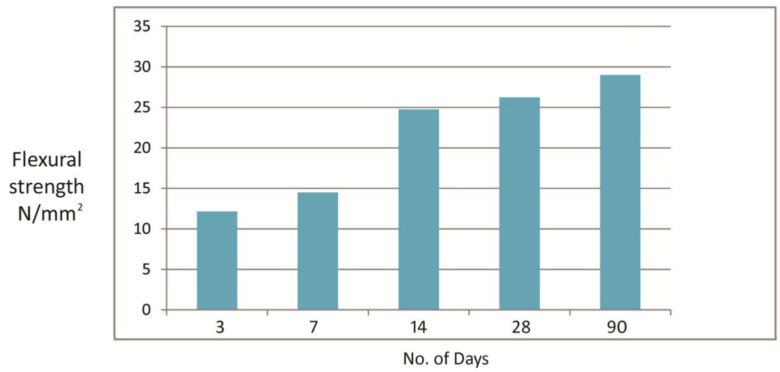

Fig. 10

VIII. CONCLUSIONS

The following conclusions are drawn based on the experimental work,

The mechanical properties determination and performance of the Higher strengths upto 180 N/mm^2 can be achieved by careful Mix proportioning and quality of material use.

The steel fiber enhance the strengths of concrete

The influence of elevated temperature 20% -25% strength can be increased

The pure, clean free from impurities and suitable proportion of super plasticizer use enhance the strengths.

The proper mixing, placing, curing influence on strength.

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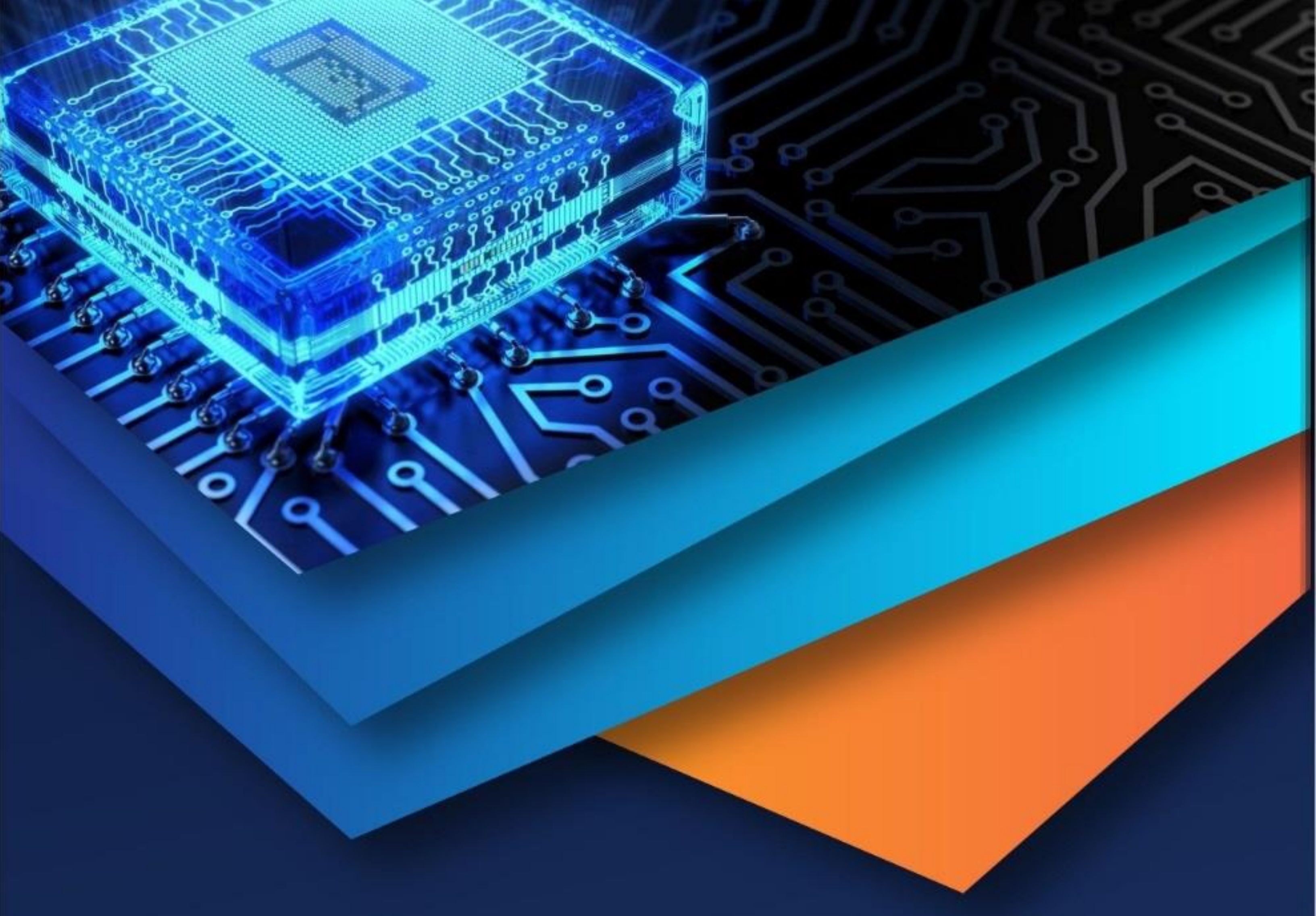

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