Study on various ultra-high strength concrete with steel fiber

[1] Nihar Dabhi, [2] Prof. M. G. Vanza, [3] Dr. Major C. S. Shangvi

[1]PG student Master of engineering, [2]Associate Professor, [3] Prof. & Head, Applied Mechanics Department,
[1]Applied Mechanics Department,
[1]LDCE, Ahmedabad, Gujarat.

Abstract: Use of Ultra High Strength Concrete in structures such as nuclear power plant, high rise buildings, Bridges which are generally subjected to higher dead load and live loads is increasing due to its superior mechanical properties such as compressive strength and tensile strength over the conventional concrete. In addition to mineral admixture and super plasticizers use of steel fiber is increasing mainly due to its effect on tensile strength of concrete and improvement in ductility. This study is concerned with developing optimum mix design of Ultra High Strength Concrete of grade 90MPa, 100MPa and 110MPa. Three variation of Ultra high strength are prepared :(i) UHSC with maximum aggregate size of 10mm (ii) UHSC with maximum aggregate size of 20 mm (iii) UHSC with maximum aggregate size of 20mm with addition of 1% and 2% of steel fiber. The effect of varying % of steel fiber and maximum size of aggregate on different grade of concrete is studied and their mechanical properties such as compressive strength, Split cylinder tensile test are analyzed.

Index Terms - Ultra High Strength Concrete, steel fiber, super plasticizers.

I. INTRODUCTION

Ultra high strength concrete is a composite which comprises of cement, fine and coarse aggregate, mineral admixtures such as fly ash, GGBS, Microsilica, Metakaolin in addition of super plasticizers such as high range water reducing composites. Also various types of fibers such as steel fiber, Polypropylene fiber, Asbestos fiber, Glass fiber, carbon fiber and organic fibers are added to gain the increase in ductility and tensile strength. Generally the water – cementations material ratio in ultra-high strength concrete is below 0.25.Imposes unnecessary load: The thickness of the coba is maintained at about 125 mm to 150 mm, which adds unnecessary dead load on the slab.

In the present study an attempt is made to prepare an optimum design mix for ultra-high strength concrete with varying input parameters such as different maximum size of coarse aggregate and different percentage of steel fiber on the mechanical properties such as compressive strength and split cylinder tensile test of the ultra-high strength concrete.

For the above mentioned comparison three types of variations are prepared and their results are analyzed. Three prepared variations are: (i) UHSC with maximum aggregate size of 10mm (ii) UHSC with maximum aggregate size of 20 mm (iii) UHSC with maximum aggregate size of 20mm with addition of 1% and 2% of steel fiber.

II. LITERATURE REVIEWS

Zemei Wu, Kamal khayat, Caijun shi, Zemei Wu. investigated the effect of silica fume content, ranging from 0 to 25%, by mass of cementitious materials, on rheological, fiber-matrix bond, and mechanical properties of non-fibrous UHPC matrix and UHPC made with 2% micro-steel fibers.

R. Yu, P. Spiesz, H.J.H. Brouwers. R. Yu. Addressed the development of an eco-friendly Ultra-High Performance Concrete (UHPC) with efficient cement and mineral admixtures such as Fly ash, GGBS and Lime stone. This study implies that the relatively high cement amount is not helpful for producing UHPC with small environmental impact. It should be also noted that when the cement amount is relatively high, the cement hydration degree is smaller and the cement efficiency is lower, compared to the concrete with low cement amount.

Weina Meng, Mahdi Valipour, Kamal Henri Khayat, Weina Meng, prepared a mix design method for ultra-high performance concrete (UHPC) prepared with high-volume supplementary cementitious materials and conventional sand.

High-volume replacement of cement with sustainable additional cementitious materials (SCMs), such as ground granulated blast furnace slag (GGBS), fly ash, and silica fume (SF), can be performed to reduce cement content

III. RESEARCH GAP AND OBJECTIVES OF WORK:

The superior mechanical property of ultra-high strength concrete makes it usable for structures exposed to high dead and live load. Use of ultra-high strength concrete in high rise structure, bridges and nuclear power plants is increasing due its higher mechanical properties such as compressive strength and tensile strength.

However the Effect of different maximum aggregate size and different percentage of steel fiber on the properties of Ultra high strength can be studied to provide better understanding regarding material selection for preparing UHSC concrete in future.

Objectives of Work:

To prepare optimum design mix for ultra-high strength concrete (UHSC) having compressive strength of 90 Mpa, 100 Mpa and 110 Mpa and to understand the effect of varying input parameters such as maximum aggregate size and steel fiber on the mechanical properties of prepared concrete design mix.

IV. STUDY OF BASE MATERIAL

The base materials used in experiment are natural river sand, coarse aggregate, grit, OPC cement Grade 53, Fly ash (Class-C), Microsilica, High range water reducing super plasticizer. These materials have been obtained from nearby construction sites

Study of various properties of Natural River Sand:

Fineness Modulus: F.M. = 2.74, Zone – II

Specific Gravity: 2.66

Study of various properties of Coarse Aggregate:

Sieve Analysis: F.M. = 8.136

Specific Gravity: 3.15

Water Absorption = 0.83%

Properties of Cement: Ultratech OPC 53

Table 1.1: *Physical properties of OPC 53 grade cement*

Sr.No.	Requirement	Requirement as per (IS 269:2015)	Result obtained
1	Fineness	Not < 225 M2/kg	350
2	Soundness		
	Le-chatelier Method Expansion	Not > 10mm	1.0
	Auto Clave Test Expansion	Not > 0.8%	0.050
3	Setting Time		
	Initial Setting Time In Minutes	Not < 30	135
	Final Setting Time In Minutes	Not > 600	170

Properties of Microsilica: ELKEM Microsilica 920 D

Table 1.2: *Physical and chemical properties of Microsilica*

Property	Unit	Value
Sio2	%	Minimum 8 5
H20	%	Maximum 3
Retained on 45µm sieve	%	Maximum 10
Loss on ignition	%	Maximum 6
Specific surface area	M2/g	Minimum 15
Pozzolonic activity index	%	Minimum 105

Properties of Fly ash Class C: Sio2+Al2O3+Fe2O3, Min% 50

Sulfur Trioxide SO3, max% 5

Moisture content, max% 3

Loss on ignition, max% **6**

Properties of Steel fiber:

Table.1.3: *Physical properties of Steel fiber*

Property	Dia.	UTS N/mm2	Length
Acceptable limit	0.25mm	2200-2850	8mm + 1mm
Result	0.25	2200	8mm

Properties of High range water reducing admixture: Master Glenium sky 8777 (Polycarboxilic ether polymers)

V. Experimental Program

Mix design:

Table.1.4: *Mix design for Various Grade of concrete*

Sr.No.	Mix Design	M90 (10 mm)	M100 (10 mm)	M110 (10 mm)	M90 (20 mm)	M100 (20 mm)	M110 (20 mm)
1	Cement (kg/m3)	450	500	525	450	500	525
2	Fly ash (kg)	150	125	135	150	125	135
3	Microsilica (kg/m3)	50	75	90	50	75	90
4	Water (kg/m3)	150	150	150	150	150	150
5	Fine aggregate (kg/m3)	663.93	771.4	758.1	663.93	399	524.16
6	Coarse aggregate (kg/m3)	1048.32	812	798	524.16	812	798
7	Chemical admixture (kg/m3)	5.2	5.6	6.75	5.2	5.6	6.75
8	w/cm	0.23	0.214	0.20	0.23	0.214	0.20

Ultra-high strength concrete mix designation

Designation for the different variations of ultra-high strength concrete is given below in table as well as the total no of specimens prepared are also shown. In this table A1 represents Mix having max. Size of aggregate 10mm, A3 represents max. Size of aggregate 20mm. Number after the represents percentage of steel fiber in concrete mix.

Table.1.5 *Mix designation*

Mix	Designation	No. of cube cast	No. of cylinder cast
M90-A1-0	Control concrete, Max agg. Size 10mm (M90)	6	3
M90-A1-0 (0.8%, 0.9%, 1.0%)	M90, Max agg. Size 10mm	18	9
M90-A3-0	Control concrete, Max agg. Size 20mm (M90)	6	3
M90-A3-0 (0.8%, 0.9%, 1.0%)	M90, Max agg. Size 20mm	18	9
M90-A3-1(0.8%, 0.9%, 1.0%)	M90, Max agg. Size 20mm (Fiber – 1%)	18	9
M90-A3-2(0.8%, 0.9%, 1.0%)	M90, Max agg. Size 20mm (Fiber – 2%)	18	9
M100-A1-0	Control concrete, Max agg. Size 10mm(M100)	6	3
M100-A1-0(0.8%, 0.9%, 1.0%)	M90, Max agg. Size 10mm	18	9

Workability test:

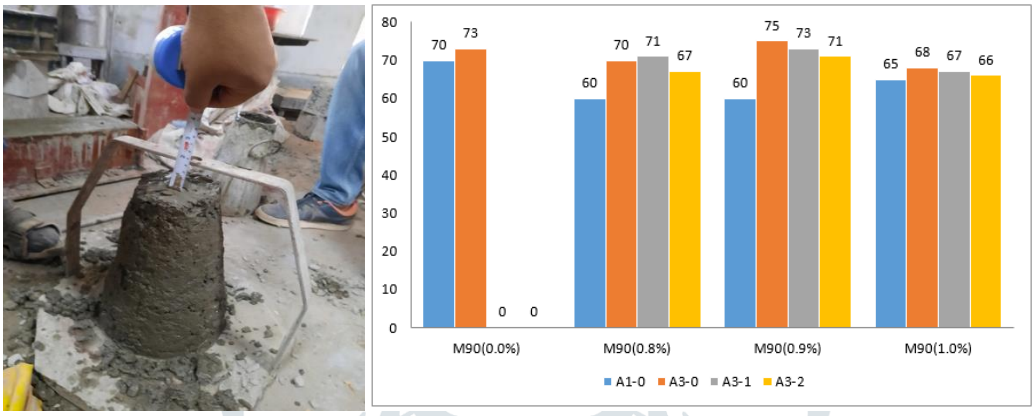

Fig.1.1: *Slump test results for M90 grade*

Compression test:

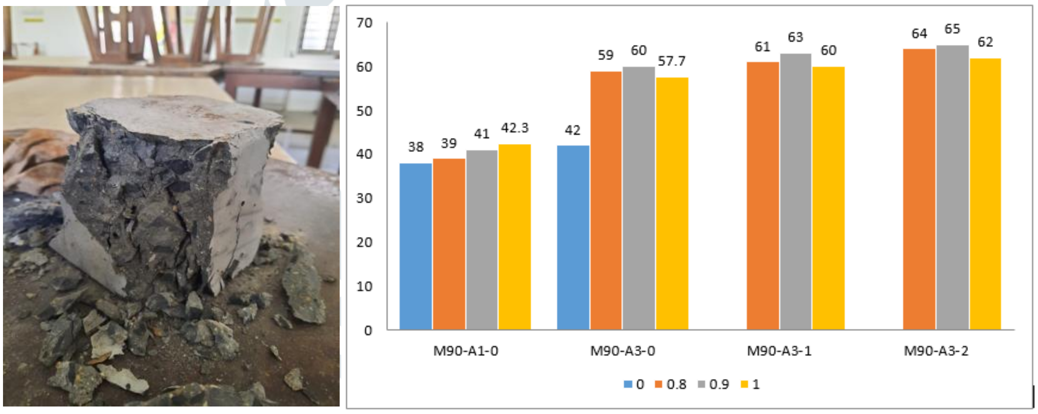

Fig.1.2: *Day Compressive test results for M90 grade*

Split cylinder tensile test:

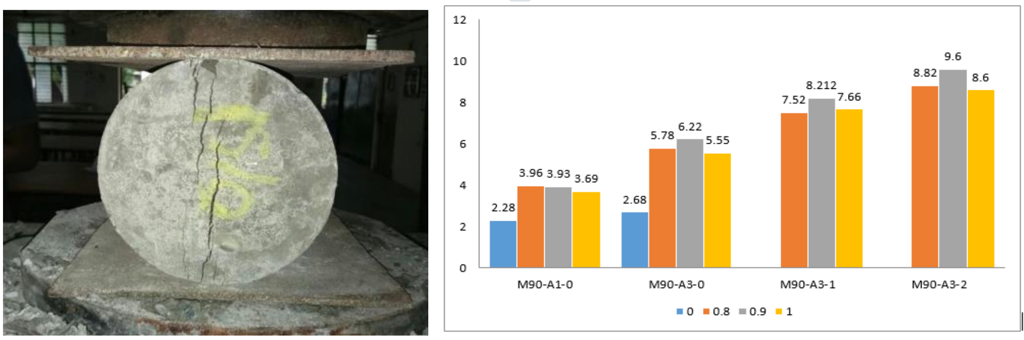

Fig.1.3: *Split cylinder tensile test*

VI. CONCLUSION

It can be seen from the comparison of slump value that the influence of the maximum aggregate size on the workability of concrete of higher grade (i.e. 110) is more than in the concrete of grade M90 and M100.

It was also shown that by addition of fiber by 1% slump flow of concrete was decreased by about 5% but by increasing the amount of steel fiber 2% shown significant reduction of about 10% in the slump, It can be attributed to the fact that inclusion of steel fiber increases the friction between the particles and stop them from sliding one over another.

An increase of about

- Increase of around 40% in mix A3, and 13% in mix A1 was observed than the control sample in the strength of concrete for M90 grade of concrete.
- Increase of around 25% in mix A3, and 13% in mix A1 was observed than the control sample in the strength of concrete for M100 grade of concrete.
- Increase of around 40% in mix A3, and 45% in mix A1 was observed than the control sample in the strength of concrete for M110 grade of concrete.
- We can conclude that generally an increase in the strength of concrete was observed by increasing the maximum size of aggregate in concrete to 20mm rather than just using 10mm aggregate.
- An increase of about 5.5-6% and an increase of about 8-9% was observed in strength of concrete by inclusion of steel fiber of 1% and 2% respectively in the design mix A3.
- An increase of about 4-6% and an increase of about 7-11% was observed in strength of concrete by inclusion of steel fiber of 1% and 2% respectively in the design mix A3.

VII. References

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