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Analysis on Mix Design of High Strength Concrete [M55 & M70]

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Abstract— **This research paper is based on study in performance improvement of high-strength concrete. Initially, a conventional concrete of three cube specimens of size 150mm x 150mm x 150mm of M55 grade with water cement ratio of 0.35 were casted and tested after 28 days of curing, yielding an compressive strength of 43.11 MPa, 43.6 MPa, 42.88 MPa and average compressive strength of 43.19 MPa, which is lower than target strength. So to overcome this, a modified mix design of M70 grade concrete with water cement ratio 0.27 was made by adding silica fume 5% and fly ash 15% as a supplementary cementitious material. Together, two cube specimen of size 150mm x 150mm x 150mm and two beam specimen of size 150mm x 150mm x 700mm were casted using modified mix. The 7-day and 28-day compressive strength of cube comes out to be 43.6 MPa and 79.9 MPa, exceeding the target strength, indicates increase in mechanical properties. Flexural strength tests were conducted on overhanging beam under centre point loading, and result of beam comes out to be 6.98 MPa and 10.46 MPa, the average flexural strength of two beam was 8.72 MPa. Further, comparison of the two beam was carried using structural analysis software SAP 2000, and support reaction, shear force, bending moment, deflection diagram were made. Most of the results were in accordance with the standards but as experimental test provides real behavior, and software analysis predicts theoretical results so both the results have some deviations.**

Keywords— High strength concrete; Silica fume; Fly ash; Compressive strength; Flexural strength; SAP 2000.

I. INTRODUCTION

High strength concrete has a compressive strength greater than 55 MPa having water cement ratio (w/c) ranging from 0.35 to 0.27 or even less. Due to low w/c ratio it requires mineral admixtures such as silica fumes and fly ash as a partial replacement of cement, it also requires a polycarboxylate ether based super plasticizer such as aura-mix 300 to improve workability, reduce water content, and enhance strength. For high strength concrete (M 55 or above) mixes, generally OPC-53 grade cement is used. In this study, mix design for M55 concrete cube specimen and M70 concrete cube and beam specimen are carried out. Then, the cube was tested on compressive testing machine and beam with centre point loading on flexural testing machine after 7 and 28 days of curing. Thereafter, on the basis of centre point loading, the failure load of two beams were analysed and compared in software SAP 2000 and getting the values of support reaction, shear force, bending moment, and deflection.

High strength concrete can be used for various applications such as pre-cast railway sleeper, high rise buildings, bridge construction etc.

II. MATERIALS AND METHODS

A. Materials used

1. Cement-In this study, Ultra Tech OPC 53 grade cement is used and color of cement is grey. Specific gravity of the cement is 3.15.
2. Fine aggregate- River sand is used as fine aggregate. Specific gravity of the fine aggregate is 2.65.
3. Coarse Aggregate- Stones made from Crushed rocks are used as coarse aggregate. Specific gravity of the coarse aggregate is 2.74.
4. Silica Fume- Sika Fume DS is used. It is dark grey to greyish black powder in color with specific gravity of 2.20.
5. Water- The curing tank or while casting of specimens the water should be free from any dirt or harmful chemicals. As, water cement ratio is important for strength evaluation of concrete.
6. Fly ash- Fly ash used was procured from a local brick manufacturing unit. It is dark grey to almost black in colour with specific gravity of 2.20.
7. Superplasticizer- Auramix 300 (polycarboxylate ether based) manufactured by Fosroc chemicals India Pvt. Ltd is used, is a high range water reducing admixture used to improve workability without increasing water content with a relatively low dosage 0.5% by cement weight with specific gravity of 1.08 is used.

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B. Procedure

1. Initially 3 cubes of size 150 x 150 x 150 mm of conventional high strength M55 grade is casted without mineral admixture and put for 28 days of curing.
2. Thereafter, 2 cube and 2 beam specimen of size 150 x 150 x 700 mm were casted by adding 5% silica fume and 15% fly ash. The cube specimen was tested after 7 and 28 days of curing and beam after 28 days of curing.

The steps are shown in following figures-

Fig.1 Mixing of concrete

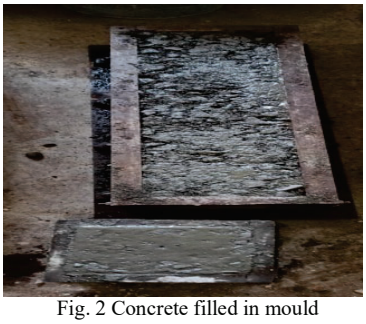


Fig. 2 Concrete filled in mould

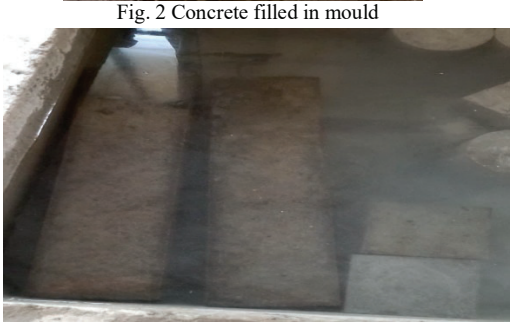


Fig. 3 Curing for 7 and 28 days

C. IX DESIGN

1. Mix design for conventional M 55 and modified mix M70 grade. For the calculations of the quantities and mix design different research paper and literature review were used.

Table 1. Mix design for M 55 and M70

Ingredients	**F r 3 cubes M55**	**For 2 cubes + 2 beams M70**
Cement	4.17 Kg	16.36 Kg
Water	1.46 L	5.39 L
Fine Aggregate	6.69 Kg	22.52 Kg
Coarse Aggregate	12.66 Kg	46.61 Kg
Chemical Admixture	20 Ml	84.11Ml
Silica fume	—	1.02 Kg
Fly Ash	—	3.061 Kg
Water / Cement Ratio	0.35	.27
C : FA : CA	1 : 1.60 : 3.03	1 : 1.37 : 2.84

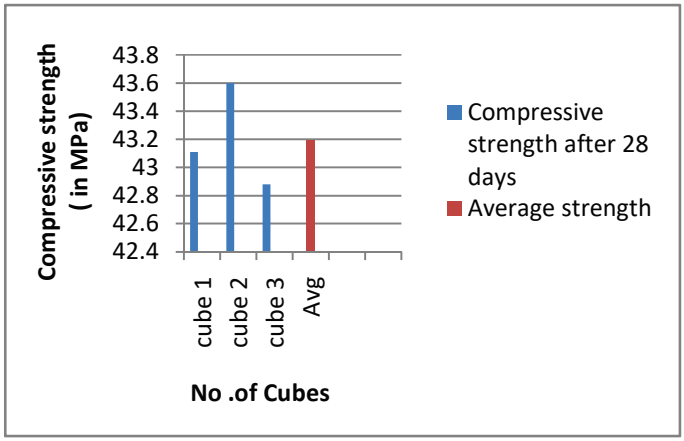
III. TEST AND RESULTS

A. The 28-day compressive test result for conventional M55 grade concrete was shown in following table and graph:

Table 2. Compressive test result M55

Age in days		**28**
No of Cubes		3
Cube Strength in MPa	**Cube 1**	43.11
	Cube 2	43.6
	Cube 3	42.88
Average compressive strength in MPa		43.19

Graph 1. Compressive strength comparison M55



B. The 7 and 28 day compressive test result for modified mix M70 grade concrete was shown in following table and graph:

Table 3. Compressive test result M70

Age in days		**7**	**28**
No of Cubes		1	
Cube strength in MPa	**Cube 1**	43.6	—
	Cube 2	—	79.9
Average compressive strength in MPa		43.6	79.9

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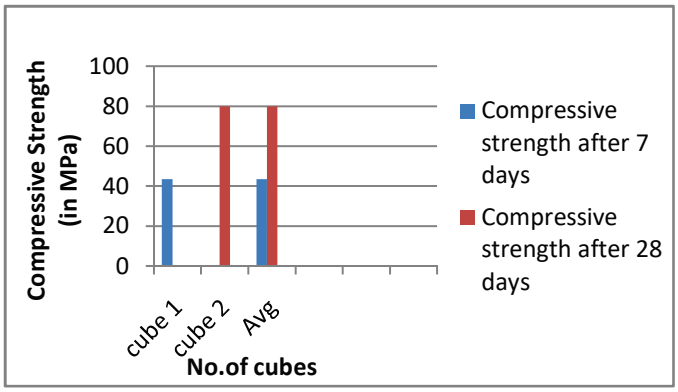
Graph 2. Compressive strength comparison M70



C. The 28 day flexural strength of 2 beams under centre point loading were shown in following tables and graph:

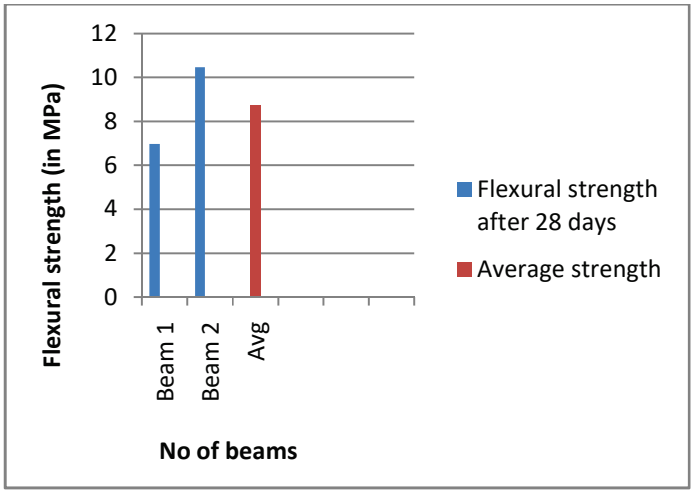
Table 4. Beam experimental data

Beam No	Dial Reading, 1 Division =1000kg	Weight (Kg)	Span length L(mm)	Width and depth b, d (mm)
1		39	400	150
2	6	39.2	400	150

Table 5. Beam flexural test result

Load at failure P (KN)	Flexural strength , F_b (MPa) $F_b = 3PL / 2bd^2$	Average strength (MPa)
39.24	.98	8.72
58.86	0.46	

Graph 3. Flexural strength comparison



D. Software analysis SAP 2000 result:

1) Beam 1 (at centre point load 39.24 KN)

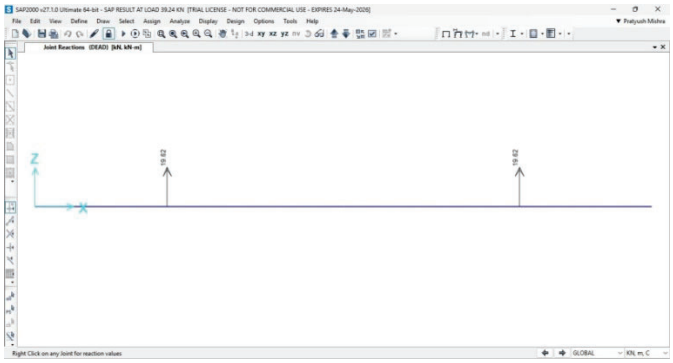


Fig. 4 Support reaction beam 1

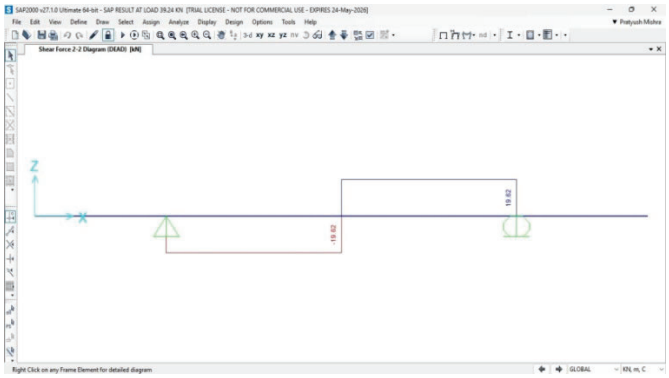


Fig. 5 Shear force beam 1

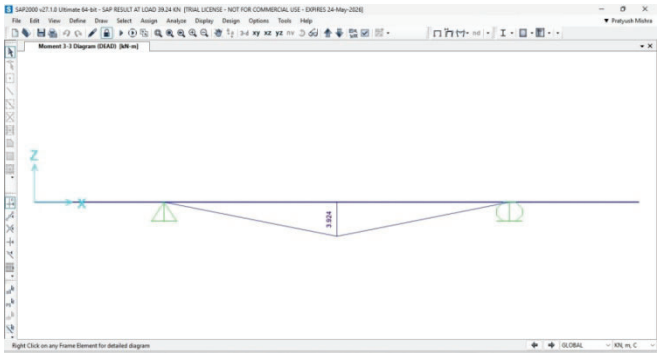


Fig. 6 Bending moment beam 1

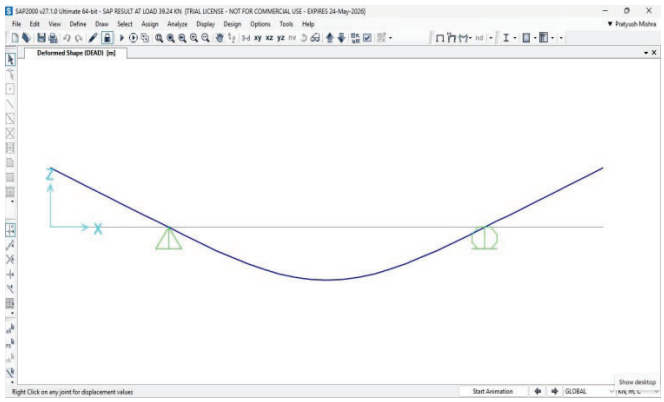


Fig. 7 Deflection beam 1

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Fig. 8 SFD, BMD, Deflection maximum beam 1

2) Beam 2 (at centre point load 58.86 KN)

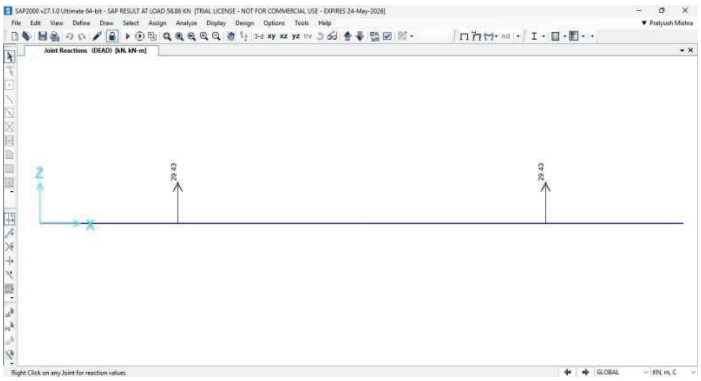

Fig. 9 Support reaction beam 2

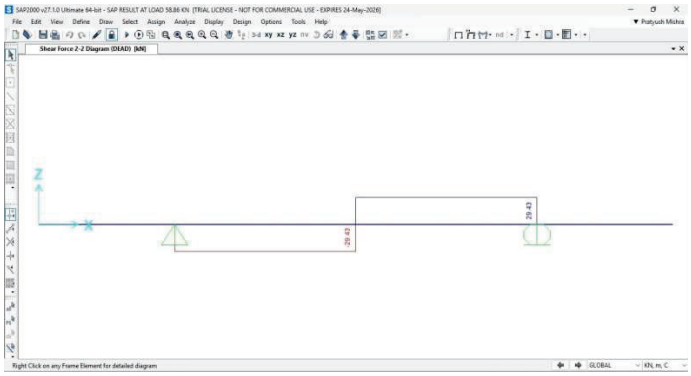

Fig. 10 Shear force beam 2

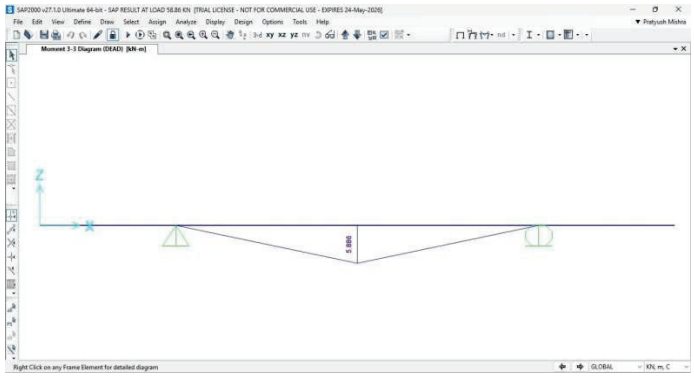

Fig. 11 Bending moment beam 2

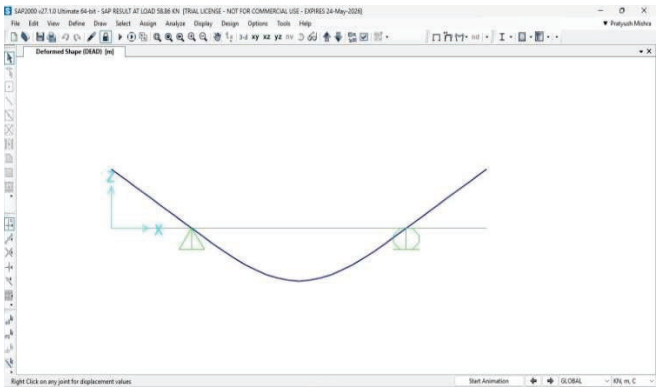

Fig. 12 Deflection beam 2

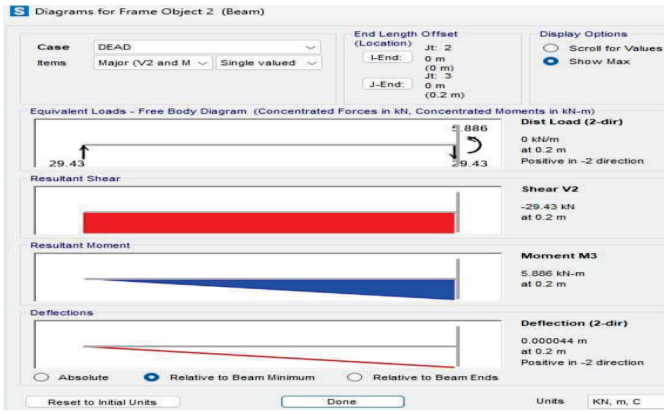

Fig. 13 SFD, BMD, Deflection maximum beam

IV. CONCLUSION

The average compressive result of cube after 28 days for M55 and M70 grade was 43.19MPa and 79.9 MPa and flexural result of 2 beams was 8.72 MPa. It shows that M55 mix is insufficient for high strength concrete as it is lower than target strength, whereas modified mix M70 shows excellent performance in terms of compression and flexural. Analysis of SAP 2000 indicates that maximum bending moment and deflection occurs at mid span of the beam.

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