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Mix Proportioning of M80 Grade Concrete using Mineral and PC Admixture

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ABSTRACT: Concrete makes up a significant part of any modern building's infrastructure. High strength concrete are used widely all over the world for increased durability, reducing self-weight, construction cost and time, creep and deflection of the structure. Studies have been carried out to produce high strength concrete with economical mix design by utilizing a broad range of materials as higher replacement materials for cement such as mineral admixture and superplasticizer in the production of concrete. This study investigated the strength properties of ground granulated blast furnace slag (GGBS), flyash, micro-silica, alccofine and metakaolin concrete in different proportions. High strength concrete of 10 different concrete mixture were casted and tested with different proportions of mineral admixtures (5%, 6.25%, 8%, 15%, 23% and 25%). The mix with aggregates size of 12.5mm gave the optimum results. The combination with 23% flyash and 6% micro-silica gave the desired high strength with economic mix design.

KEYWORDS: High strength concrete, mineral admixture, superplasticizer, Micro-silica, Alccofine, Metakaolin

I. INTRODUCTION

According to IS code 10262-2019, High strength concrete has a characteristic compressive strength of 65 N/mm² or more. High strength concrete is used globally where nuclear power plants, oil, gas and high rise buildings are among. High strength concrete is considered as superior structural performer, eco-friendly and energy conserving indicator. The demand for High Strength concrete is increasing rapidly due to this tremendous property.

Usually, for high strength mixes of concrete, mineral admixtures and super plasticizers are used along with that, low water-cement ratio is necessary. The procedure for proportioning of high strength concrete is similar to that of normal concrete. This procedure consists of steps that when followed, provides a good workability, durability and strength. To achieve high strength concrete optimum proportions shall be selected, such as cement and other cementitious materials, aggregate gradation, aggregate quality, admixture dosage, type and mixing. Flyash, ground granulated blast furnace slag (GGBS), micro-silica, alccofine and metakaolin are widely used as cementitious materials or mineral admixtures in high strength concrete. High strength concrete mixes usually have a low water-cement ratio (w/c). These low w/c ratios are generally attainable with high-range water-reducing admixtures. PCE type (Poly carboxylate ether based) super plasticisers are used which reduce water content by 30 percent or above at appropriate dosages.

II. RELATED WORK

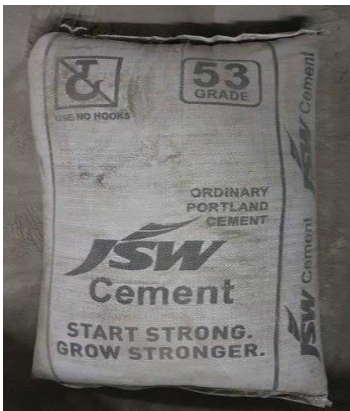
As our aim is to develop concrete which concerns on the strength and economic mix of concrete. So for this we need to go for the higher replacements of pozzolanic materials along with super plasticizer with having low water cement ratio. The use of silica fume, which has a better pozzolanic activity and is a good material for the production of high strength concrete. For developing an economic mix design, we have used GGBS and Fly ash to achieve the required strength of the concrete. In [1] M80 cubes were casted using combination of fly ash and ground granulated blast furnace slag in different percentages as replacement of cement. Then they casted concrete cubes and were cured for 28 days and compressive strength test was conducted. The maximum 28 days cube compressive strength of M80 grade with replacement in combination of 10% of FA and 30% of GGBS is 86.6 Mpa with replacement of 20% of FA and 20% of GGBS is 82.16 Mpa. In [2] Five trial mixes of M80 grade were conducted using different proportions of alccofine and fly ash to find the optimum range. After these mixes, It was observed that attempting different dose of alccofine and fly ash optimum result was obtained on 8% of alccofine and 16% of fly ash. In [3] An investigation on replacement of cement with mineral admixtures in some percentages was made to achieve target strength and to develop High strength concrete of M80 grade. Four trails of different mixes were conducted and it was observed that the max strength achieved at 28 days is 85.12 Mpa with replacement of mineral admixture 15% Fly ash + 5% Silica fume to cement. In [4] Fifteen cubes were cast. Silica Fume was replaced in the following proportions (5%, 10% 15% and 20%) by weight of cement while mixing concrete and cured for 28 days and found that the optimum replacement of Silica Fume is 10% which gives the maximum compressive strength. In [5] 25 numbers cubes were casted and the compressive strength was monitored at 56 days. Five specimens were tested with Coarse aggregate containing 10 mm and 20 mm of 40% and 60% Respectively which is classified as Type A and Type B aggregates and it was observed that use of Type A aggregates gave better results. In [6] The research work was carried out on M80 grade concrete with constant w/c ratio of 0.33 and partial replacements of fine aggregate by Glass Powder and cement by flyash with different percentages (i.e., 0%, 10%, 20%, and 30%). Compressive strengths for different proportions were tested by considering the replacement of fine aggregate and then followed by replacement of cement separately. Compressive strength for M80 grade concrete at 7 days and 28 days are studied. It was identified that the higher strength is achieved at partial replacement of cement by fly ash in 10% and river sand by glass powder in 30% individually. For M80 grade, maximum compressive strength obtained was 91.52 MPa. In [7] An experimental study was conducted on high strength concrete having a mean compressive strength determined at the age of 28 days of 100 MPa. 12 cubic samples were tested at the age of 28 days, the mean strength values obtained at 28 days is 107.60 [N/mm²]. Hence HSC can play a major role helping to reduce the amount of concrete needed for reinforced concrete structures, cutting down on initial costs and maintenance costs. In [8] Seven cubes of M80 grade with different proportions of silica fume and GGBS were casted and 7, 14 and 28 days compressive strength was tested. The results showed that the replacement of cement with silica fume 10% and 40% GGBS gave the maximum strength. In [9] 5 cubes each of grades M80 and M90 with different proportions of mineral and chemical admixtures were casted and cured for 7 and 28 days. For M80 grade the maximum compressive strength achieved at 28 days is 82.2 Mpa with 20% fly ash and 13.23% metakaolin. Similarly, for M90 grade concrete cubes the maximum strength achieved at 28 days is 92.4 Mpa with the combination of 33% fly ash and 15.13% metakaolin. In [10] the paper says that as the fly ash content increases, the compressive strength decreases at initial stages. The curing and ageing of concrete tends to change the behaviour of concrete replaced with 40% and 50% FA which showed an increase in strength compared to 30% FA on 28 days. Hence, it is concluded that fly ash increases long-term strength development of silica fume concrete. In [11] Seventeen trails were conducted with different proportions of BFS, PFA and SF as cement replacements on the mortar mechanical properties. From the results of the compressive strength test, it was found that all replacement levels of BFS resulted in higher compressive strength than that of the control mix at all ages. The hydration of BFS requires longer curing periods since BFS mortars reached their ultimate strength at ages beyond the 28-days age. In [12] the research says that the workability of concrete increased as the percentage of superplasticizer increased. Slump value of 0%, 0.5%, 1%, 1.5% and 2% super plasticizing admixture added concrete were 1.2 inch, 1.89 inch, 2.92 inch, 3.45 and 4.87 inch which were 36.5%, 58.9%, 65.21% and 75.35% higher than from reference concrete. e. After 28 days curing, highest compressive strength was obtained at 1% dosage of superplasticizer which was 42% higher than from reference concrete.

III. METHODOLOGY

The experimental project was designed for the compressive strength of concrete with M80 grade of high strength concrete. The project consists of casting and testing of total 90 cube specimens. The specimen of standard cube (150mm x 150mm x 150mm) were used to cast the concrete cubes. Compressive testing machine (CTM) was used to test all the specimens. Cement used in the experimental work is Ordinary Portland Cement (OPC) of 53 grade (JSW brand)

conforming to IS: 12269-1987. GGBS is produced by grinding Granulated Blast furnace Slag to a controlled fineness confirming to IS 12089:1987. Flyash is produced from thermal power plant in the form of dry powder confirming to IS 3812-1981. Vertical shaft impact crusher(VSI) aggregates were used for obtaining better results. The maximum size of the aggregates used was 20mm. Mineral admixtures ground granular blast furnace slag (GGBS), flyash(FA) and chemical admixtures like microsilica(MS), alccofine(AF), metakaolin(MK) is used. Polycarboxylic admixture Aura Mix 500 is used as a superplasticizer for obtaining better strength and workability.

The trail mixes were conducted with different proportions of mineral admixture and super plasticizers. A water cement (w/c) ratio of 0.23 was considered for the trails. Cement was kept constant in all the trails. A slump value of 120-125mm was obtained in all the mixes. A total of 10 trails were conducted with each trail consisting of 9 cubes and the cubes were casted by vibrating in 2 layers. The materials used is shown in the figure below.



Cement



GGBS



Flyash



Micro-silica



Alccofine



Metakaolin

(Source:#72, C H Building,2nd A main, 60 Feet Rd, Mallathahalli, Bengaluru, Karnataka 560056)



Aggregates

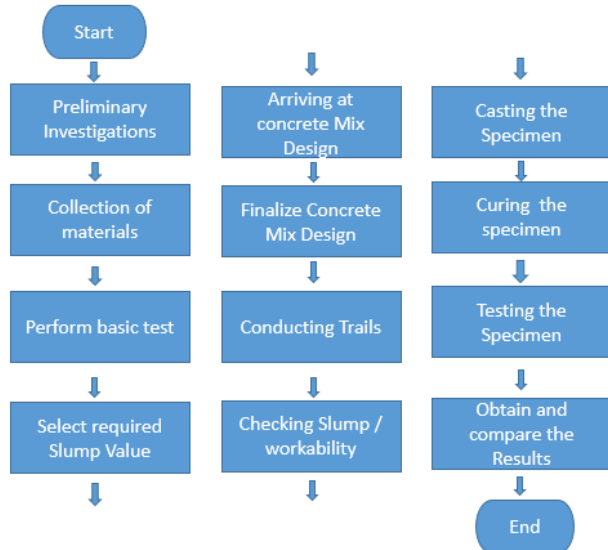
(Source: Jyothi Conmix, C-27, C-27, 1st Phase, Bengaluru, Karnataka 560074)



Polycarboxylic admixture

(source:forsroc)

After all the materials were gathered, Basic tests were conducted for each materials and the results were obtained in the range of specified values in the specified code book. The percentage of mineral admixture variations of 10 trails is shown in the below table 1.



No of Mix	% of GGBS	% of FA	% of MS	% of AF	% of MK
M1	23	0	8	0	0
M2	0	23	8	0	0
M3	23	0	5	0	0
M4	0	23	5	0	0
M5	23	0	0	8	0
M6	0	23	6	0	0
M7	0	23	0	8	0
M8	15	8	0	0	8
M9	23	0	0	0	8
M10	0	23	0	0	8

Table 1: Details of % of Mineral admixtures

Chart 1 :Methodology Chart



Vibrating in 2 layers



Conducting trails



Casted cubes

Compression strength test

The compression strength test on Concrete is done on the standard size of cube 150 x 150 x 150 mm. This test is performed after 7, 14 and 28 days of curing. The Compression strength is calculated as follows,

$$f_{ck} = P/A$$

Where, P = Load at Failure (N)

A = Cross sectional area (mm²)

f_{ck} = Compressive Strength (N/mm²)

The mean target strength that has to be achieved is calculated by the formula,

$$f'_{ck} = f_{ck} + 1.65 S$$

Where, f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days,

S = standard deviation

The value of S is taken from table 2 of IS code 10262-2019 that is S=6

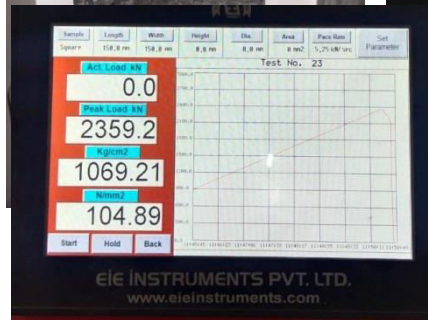
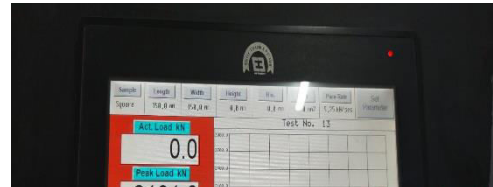
$$\begin{aligned}
 \text{Therefore, the mean target strength of M80 grade concrete is } f'_{ck} &= f_{ck} + 1.65 S \\
 &= 80 + 1.65 * 6 \\
 &= 89.9 \text{ N/mm}^2
 \end{aligned}$$

IV. EXPERIMENTAL RESULTS

It is observed that from the compression strength test of 10 mixes of M80 grade at 28 days age, the optimum results was obtained in Mix 6. That is, with the combination of 23% flyash and 6% microsilica. The compressive strength for 28 days was 93.43 N/mm². The 7, 14 and 28 days strength of all the 10 mixes are shown in the below Table 2.

Table 2: Compressive strength of concrete Testing cubes in CTM 28day Compressive strength of Mix 6

for different percentages of Mineral admixture

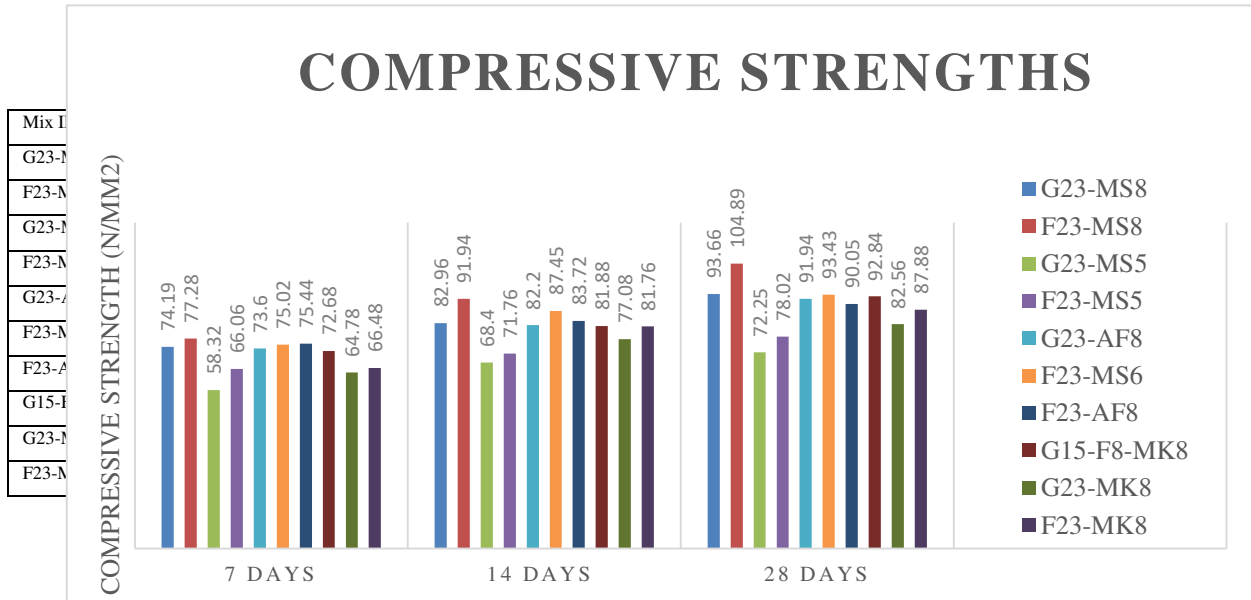


28day Compressive strength of Mix 1 28day Compressive strength of Mix 2 28day Compressive strength of Mix 5

By all the 10 trails, we observed that Mix 2 was overdesigned. For high strength and economic mix, Mix 6 is the best out of all the 10 mixes as the cost of fly ash is comparatively cheaper than the cost of GGBS. In some places where flyash is not available, Mix 1 can be chosen as it gives us the desired result. Hence, by the trails we can conclude that the optimum mix is obtained with 23% flyash and 6% micro-silica. It is observed that, out of all the chemical admixtures used, the mix with the combination of micro-silica gave the best results.

The following characteristics were observed in the project,

- The use of 8% micro-silica with 23% flyash gave the maximum 28days strength that is 104.89N/mm². Hence, it is concluded that this is an overbuilt design.
- Mix 3 and 4 with combination of 5% microsilica is under designed as required 28day strength is not achieved.
- The trail which consisted of only 12.5mm aggregates gave more strength than the trails which consisted of 20mm aggregates. Hence, for high strength concrete 12.5mm aggregates should be used.
- Use of PC admixture (Aura mix 500) superplasticier conforming to to IS 9103 in the mix increases the Workability of the concrete mix.
- Microsilica gave the highest strength of all the chemical admixture used.
- Use of Aura Mix 500 in the mix increased the strength of the concrete compared to other superplasticizers.



Graph 1: 7,14 and 28 days compressive strengths of the mixes.

V. CONCLUSION

Based on the experimental studies presented in this paper, the following conclusions may be drawn,

- The compressive strength is optimum in 2 mixes, one with the combination of 23% flyash and 6% micro silica and second with the combination of 23% GGBS and 8% microsilica.
- For High strength concrete 10 – 12 mm size coarse aggregate gives better results than 20 mm size aggregate.
- For high strength of concrete low w/c ratio is required.
- As w/c ratio is low superplasticizer is required for better workability.
- For economical mix, flyash can be preferred over GGBS.
- Out of all the chemical admixtures used, Micro silica gave the best results with required high strength.
- For high strength with economic mix, Mix 6 that is 23% flyash and 6% microsilica gave the best results with 28day strength as 93.43N/mm².

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