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"ENHANCING CONCRETE PERFORMANCE WITH SUPERPLASTICIZER:A MIX DESIGN STUDY"

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ABSTRACT -

In this world, concrete is the most alternate hand material used after water. It contains concrete, sand, coarse totals and water. Alongside these materials different admixtures can likewise be employed which can upgrade the properties of cement and reduce the water content in mixture. In our design work we aim to examine the similarity and variation between concrete mix design by using the IS method, also to intimate suitability of mix design through experimental investigation by using Superplasticizer. In this exploration work53 grade of Pozzolona Portland Cement, locally available fine aggregate and coarse aggregate and superplasticizer (FOSROC SP 430) were named, based on IS 456-2000 and IS 10262-2019 norms for determining quantities and proportion of concrete having grade M25, M30, M40. Compressive strength was determined at 7 days, 14 days and 28 days curing period and eventually, compare the results by checking strength and durability criteria.

Concrete Mix Design using Superplasticiser is a popular technique in the construction industry to produce high-performance concrete with improved workability and strength. Super plasticisers are chemical admixtures that are added to the concrete mix to improve its flowability and reduce the amount of water required, without compromising the strength or durability of the concrete. Fosroc SP430 is a commonly used super plasticiser that can help to reduce the cement content of concrete mixtures, resulting in cost savings and a reduced environmental impact. This abstract paragraph will focus on the topic of concrete mix design using Fosroc SP430 super plasticiser and the potential benefits of reducing cement content, including improved sustainability and reduced costs. The application of Fosroc SP430 in concrete mix design can lead to the creation of high-performance, environmentally friendly concrete with reduced carbon footprint, making it a popular choice among designers and contractors.

Keywords- Mix design, IS method, Compressive strength, Fosroc SP 430

1. INTRODUCTION

Concrete is a homogeneous mixture of cement, aggregate and water, which is used in the various civil engineering fields. The basic building material is most popular because of good strength, durability and provident in use.

Concrete blend design styles are substantially based on graphs, charts, tables and on empirical relations which is developed by using available materials through trials and examinations.

For altitudinous structures and pre-stressed concrete, use of higher grades of concrete is necessary to achieve the maximum strength. According to IS 456-2000 for durability considerations, we use highest grade of concrete for more severe exposure conditions. To increase the strength and durability of concrete we use the chemical admixtures such as Air Entrainers, Water Reducers, Set Retarders, Set Accelerators, Superplasticizers

For Ordinary and Standard grades of concrete only IS system is used for different placing condition, for the specified depression(slump) value that ranges from 25mm to 150mm. Predicted on the nominal maximum size of aggregate, elect the maximum water content for range of 25 to 50 mm slump by using I.S. 10262:2009 (table 2). Quality material gives better strength and continuity to the concrete. Quality is a trip, not a destination, it is a nonstop improvement.

2. LITERATURE REVIEW

This task includes the assessment on experimental examination of blend design method of concrete by using IS 10262-20149 & IS 456-2000

1. Abdul Aziz and A Ramakrishnaiah (*2019*)

This study look into for resolving the most suitable concrete blend in order to achieve the target mean strength. In this exploration work 43 grades of ordinary Portland cement, sand and aggregate were selected based on IS:456- 2000 and IS 10262-2009 standard for determining amounts and proportions for concrete having grade M25. The instance having size 150mm × 150mm × 150mm was tested at the age of 7 and 28 days of curing period.

2. Ozuzun and Uzal (2021)

Superplasticizers (SPs) play a significant part in the sustainable growth of the concrete assiduity due to the combinations' dropped water and Portland cement content. It is necessary to develop eco-efficient indispensable types of superplasticizers . In comparison to lignosulfonate- (LS) and naphthalene-grounded amalgamation, the plasticizing performance of a humic-acid grounded superplasticizer generated from leonardite as a natural organic matter and its influence on hydration & characteristics of Portland cement were deliberate. Through the use of isothermal calorimetry and thermo-gravimetric proportions of toughened pastes, the result of LHA on the hydration of Portland.

3. METHODOLOGY

3.1 Objectives of Mix Design

The desire of concrete blend design is to make sure the most optimum proportions of the element accoutrements to fulfil the requirement of the structure being erected. Ensuing objectives mst be considered while mix designing:-

a) To achieve the asked plasticity in the plastic stage, minimal strength in the toughened stage

b) Durability in the given terrain conditions.

c) To produce concrete as economically as possible.

3.2 Basic Considerations

For design of concrete blend following key points must be followed

a) Price- The price of concrete is made up of

- Material price
- Outfit price
- Labour price

b) Identification -For designing concrete mixes saturation point should be kept in mind:-

- Compressive strength required must be minimum
- water/ cement ratio should be minimum
- To avoid less cracks maximum cement content should be there.
- Maximum aggregate/ cement ratio

c) **Plasticity –** While designing concrete composites following points must be kept in minds for better workability

- The thickness of concrete should no further than that necessary for placing, compacting and finishing.
- Further workable concrete means lower strength which is depends on water cement rate.

d) **Firmness and continuity-** It is depends on only water cement rate, to achieved maximum strength use suitable admixtures and quality paraphernalia.

3.3 Materials Used: The following materials were used in concrete mixed design

i) Cement:- Ambuja PPC 53 grade of cement was used.

ii) Coarse Aggregate:- Coarse Aggregate of 20 mm & 12.5 mm were used which was passing through 20mm and 12.5 sieve was used in design.

iii) Fine Aggregate:- Sand which was passing through 2.36 mm sieve was used in design.

iv) Admixture:- Conplast SP430 is a chloride free, superplasticising admixture based on selected sulphonated napthalene polymers. It is funished as a dark brown(colour) solution which instantly disperses in water. 0.5-2% by weight of cement can be added in mix design according to brouchre of SP 430

v) **Water**:- Potable (drinkable) water was used having Ph 6.5.

4. PROCEDURE

We have performed various tests for concrete Mix Design.

1. Sieve analysis of Fine Aggregate:-

To determine the gradation of sand and in which zone it is coming. In the practical we performed, sand was present in Zone I.

Fig- 1: Sieve Analysis

2. Specific Gravity of Coarse Aggregate:-

Specific gravity will show whether something will float or sink & in identification of stone. In our practical specific gravity of coarse aggregate was found to be 2.66.

3. Specific Gravity of Fine Aggregate:-

It is used to calculate the solid volume & percentage of voids in aggregates in computations of yield. Specific Gravity of fine aggregate was found to be 2.74.

4. Specific Gravity of Cement:-

Specific gravity unrelate bad particles which are lighter than other particles. To determine the solid volume of all aggregates in concrete mix design, we determine the specific gravity of cement. To determine the test we require cement, gavel, water. 2.85 is the specific gravity which we have determined

Fig- 2: Specific Gravity of Cement By Le'chatliers Method

5. Specific Gravity of water:-

Specific Gravity of Water is 1.

6. Water Absorption of Coarse And Fine Aggregate:-

Water absorption gives an suggestion to determine strength of aggregate. Aggregates are porosive in nature if it has more water absorption and are generally we considered them as unfit unless they are found to be tolerable based on strength, jolt and hardness tests. Water absorption of coarse aggregate and fine aggregate was found to be 1.86% and 2.72% respectively.

Fig-3: Water Absorption In Oven @110° C

7. Moisture Content of Coarse Aggregate and Fine Aggregate:-

The moisture content in aggregate is used to decide the envelope content for HMA during manufacture of the mixture in a plant. To obtained familiar quantity of aggregate some policy must be required like, the aggregate must be warmed up to withdraw the moisture in air, and the percentage of moisture determined. Moisture content of Coarse aggregate & Fine aggregate was found to be 1.21% & 2.04% respectively.

Fig- 4: Moisture Content In Oven @110° C

8. Marsh Cone Test:-

This test can be used incontinently to identify the variations which are to be made in the superplasticizer lozenge. The saturation point is the point at which no lozenge can be added beyond its point as further addition of superplasticizer does not increase fluidity. significantly but could affect in segregation the achromatism lozenge can be taken as the optimum superplasticizer lozenge for a given cement paste. In our practical, we have got effective results at 1.5% by weight of cement and min time was taken at that point.

Fig- 5: Marsh Cone Test

9. Slump Cone Test:-

To perform this test, we have to ensure that same concrete batches are of persistent standard and strength. Concrete gets weaker & weaker as more water is added to it. We need to increase the cement content if client need a higher workability or more flaccid concrete (a higher slump result) to ensure the concrete still reaches its target strength. To ensure the quality of concrete this is one of the test we performed. Water is the foe when it comes to concrete strengths. In our performance of slump cone test we have assumed the slump to be 100 mm, 100mm & 75 mm for CMD with admixture for M40, M35, M25 respectively and we got the results as 110mm, 100mm, 80 mm.

Fig- 6: Slump cone test

5. CONCRETE MIX DESIGN USING IS METHOD:-

- Design **M25** concrete based on the provisions of IS-10262-2019 for the following data.

a) Type of cement-PPC 53
b) Exposure condition-Moderate
c) Maximum size of C.A-20mm
d) Specific gravity of cement-2.85
e) Specific gravity of C.A -2.66
f) Specific gravity of F.A -2.74
g) Type of Admixture - Superplasticizer
h) Sieve analysis zone –I
i) Method of concrete placing-normal
j) Degree of supervision –good

Step 1) Target mean strength of concrete

$F_{ck}= f_{ck}+ks$ $= 25+1.65\times5 = 33.25$ N/mm^2

Refer IS-10262-2019, table 1, Standard deviation S=5

Step 2) Water cement ratio selection

Refer IS- 456-2000, table 5 For M-30 concrete, maximum w/c ratio=0.5

Step3) Water content selection

Refer IS 10262-2019, table 4
For 20 mm aggregate, Maximum water content is=186k g/m^3 (for slump 25 to 50mm)We have to increase 3% of water content for every 25mm slump range
To attain maximum of 75 mm slump range =3% increase in water content

Estimated water content for 75 mm slump=$186+\frac{3}{100}\times 186$ = 191.58 kg/m^3

Assuming water reduction as 20% by adding superplasticizer (SP430) = 191.58 – 20/100 x 191.58
= 153.26 kg/m^3

Step 4) Cement content calculation

Water cement ratio=0.44

cement content= 153.36/0.44=348.32
kg/m^{3}According to IS-456-2000
For Moderate exposure condition, Minimum cement content =300
kg/m^{3}300 kg/m^3 < 348.32 kg/m^3,Hence Ok.

Step5) Volume of CA and FA content

IS 10262-2019, table 3, volume of CA corresponding to 20mm size aggregate andFA (Zone I), & after correction according to cl.5.5.1
Volume of CA = 0.612, Volume of FA= 1-0.612 = 0.388

Step 6) Mix calculation

(a) Vol of concrete =1m^3
(b)Vol of entrapped air = 0.01 m^3

(c)Vol of cement = $\frac{\text{mass of cement}}{\text{specific gravity of cement}} \times \frac{1}{1000} = \frac{348.32}{2.85} \times \frac{1}{1000}$

= 0.122 m^3 (for w/c ratio-0.44)

d)Water vol = $\frac{\text{mass of water}}{\text{specific gravity of water}} \times \frac{1}{1000} = \frac{153.26}{1} \times \frac{1}{1000}$

= 0.1532 m^3

(e)Vol of Chemical admixture (1.5% by weight of cement) = 1.5/100 x 348.32

= 5.22 kg

= $\frac{5.22}{1.2} \times \frac{1}{1000}$

= 0.00435 m^3

(f)Vol of total aggregate = ((a-b)-(c+d+e)

= ((1-001)-(0.122+0.1532+0.00435)

= 0.710 m3

(g)Mass of coarse aggregate

= (f)× Volume of coarse aggregate× specific gravity of coarse aggregate ×1000)

= 0.710 × 0.612 × 2.66 × 1000

= 1155.82kg

(h)Mass of fine aggregate

= ((f)× Volume of fine aggregate× specific gravity of fine aggregate ×1000)

= 0.710 x 0.388 x 2.74 x 1000

= 754.81kg

Step 7) Mix Proportion on adjustment in water, coarse aggregate & fine aggregate (if the coarse and fine aggregate is in dry condition, water absorption and moisture content correction)

(a) Cement = 348.31 kg/m^3
(b) Fine aggregate = 749 kg/m^3
(c) Coarse aggregate = 1147.55 kg/m^3
(d) Admixture = 5.22 kg/m^3
(e) Water = 164.65 kg/m^3
(f) w/c ratio = 0.44

NOTE:- Coarse Aggregate of 20 mm & 12.5 mm are used in the 60:40 respectively.

In this way, Similarly M30 & M40 Grade was designed according to IS456-2000 & IS 10262-2019.

Table No-01- Test materials required for concrete mix design with admixture(if coarse & fine aggregate is in dry condition)

Sr. No	Grade of concrete	w/c ratio	Maximum water content (kg/m³)	Cement (kg/m³)	Admixture (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)
1.	M25	0.44	164.65	348.31	5.22	749	1147.55
2.	M30	0.42	168.6	375.54	5.63	727.21	1134.33
3.	M40	0.36	169.53	438.13	6.57	680.37	1118

Table No-02- Test materials required for concrete mix design (if coarse & fine aggregate is in dry condition)

Sr. No	Grade of concrete	w/c ratio	Maximum water content (kg/m³)	Cement (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)
1.	M25	0.48	203.20	416.52	695.89	1048.18
2.	M30	0.47	208.436	443.06	674.79	1029.25
3.	M40	0.44	202.67	435.40	693.76	1061.81

6. RESULTS

Compressive strength of various grades of concrete was tested at 7 days, 14 days and 28 days curing period. Following experimental test results were obtained.

6.1 Compressive strength

To determine compressive strength of various grades of concrete specimen by using digital compression testingmachine (CTM).

Table No-03- The following results were obtained from compressive strength test of mix design using admixtures.

Sr. No.	Method of mixdesign	Curingperiod	Concrete grades	Specimen1	Specimen2	Specimen3	Avg Compressive Strength (MPa)
1	IS	7 days	M25	18.9	18.6	23.8	20.43
			M30	20.3	22.3	19.2	19.56
			M40	26.4	29.2	32.3	29.3
2	IS	14 days	M25	25.58	25.18	32.24	27.66
			M30	27.48	30.19	26	27.89
			M40	35.74	39.53	43.73	39.66
3	IS	28 days	M25	28.43	27.98	35.80	30.71
			M30	30.53	33.54	28.88	30.98
			M40	39.71	43.92	48.59	44.07

Table No-04- The following results were obtained from compressive strength test of mix design without using admixtures.

Sr. No.	Method of mixdesign	Curingperiod	Concrete grades	Specimen1	Specimen2	Specimen3	Avg Compressive Strength (MPa)
1	IS	7 days	M25	20.42	17.01	16.74	18.05
			M30	18.27	20	17.25	18.50
			M40	23.76	26.10	28.16	26.00
2	IS	14 days	M25	21.65	21.69	23.01	22.11
			M30	24.73	23.4	27.17	25.1
			M40	33.02	35.57	35.16	34.58
3	IS	28 days	M25	24.51	25.2	24.8	24.83
			M30	28.0	29.64	30.18	29.27
			M40	39.6	39.52	38.98	39.36

Fig7: Determining Compressive Strength Under Digital Compression Machine

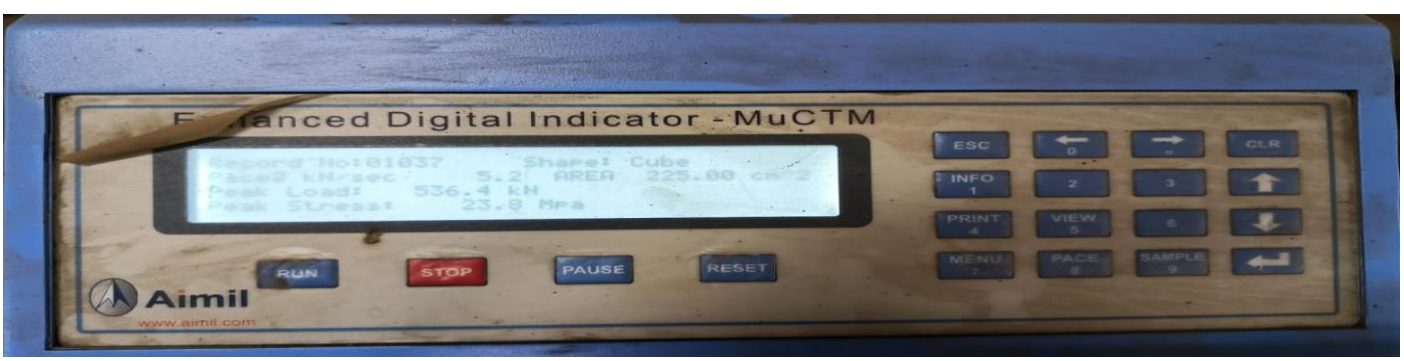


Fig - 8: Compressive Strength Of M25 cube 7th day testing

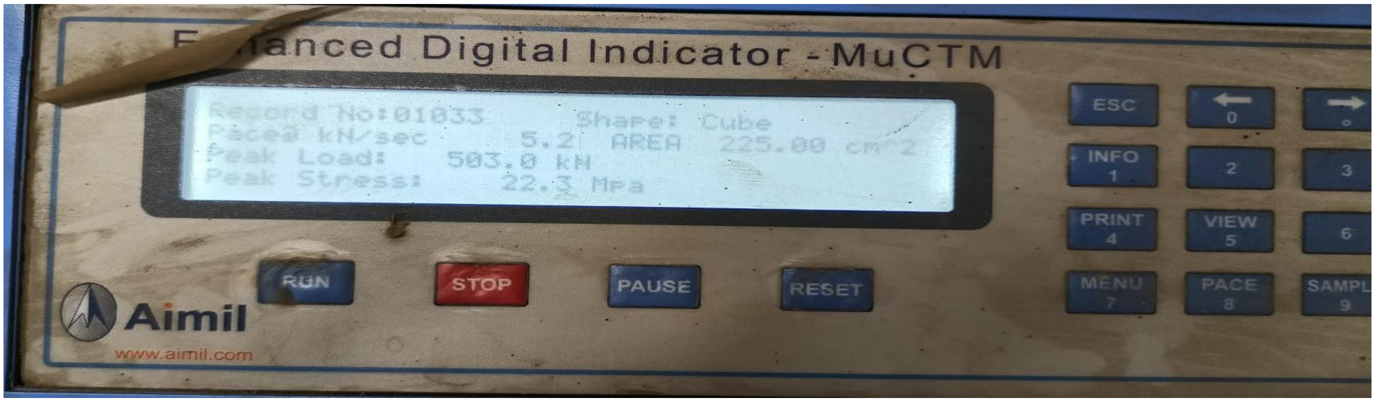


Fig - 9: Compressive Strength Of M30 cube 7th day testing

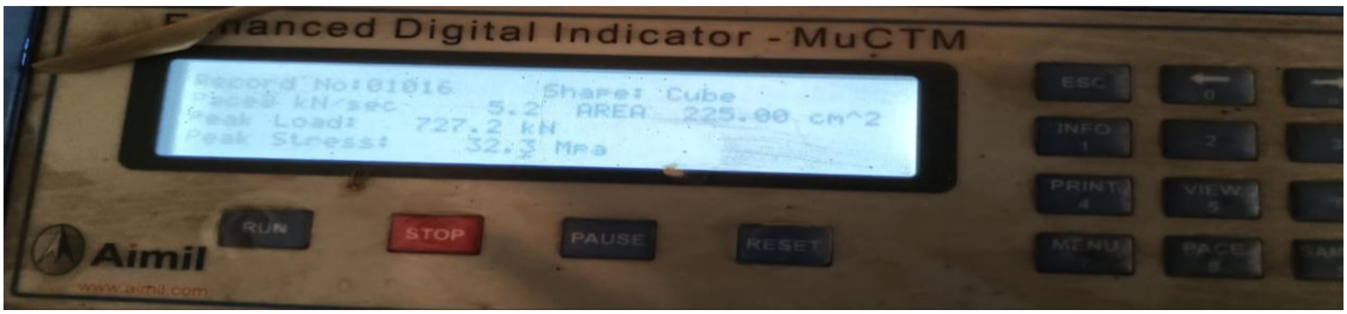


Fig - 10: Compressive Strength Of M40 cube 7th day testing

Chart 1- Test Results for Compressive Strength using admixtures

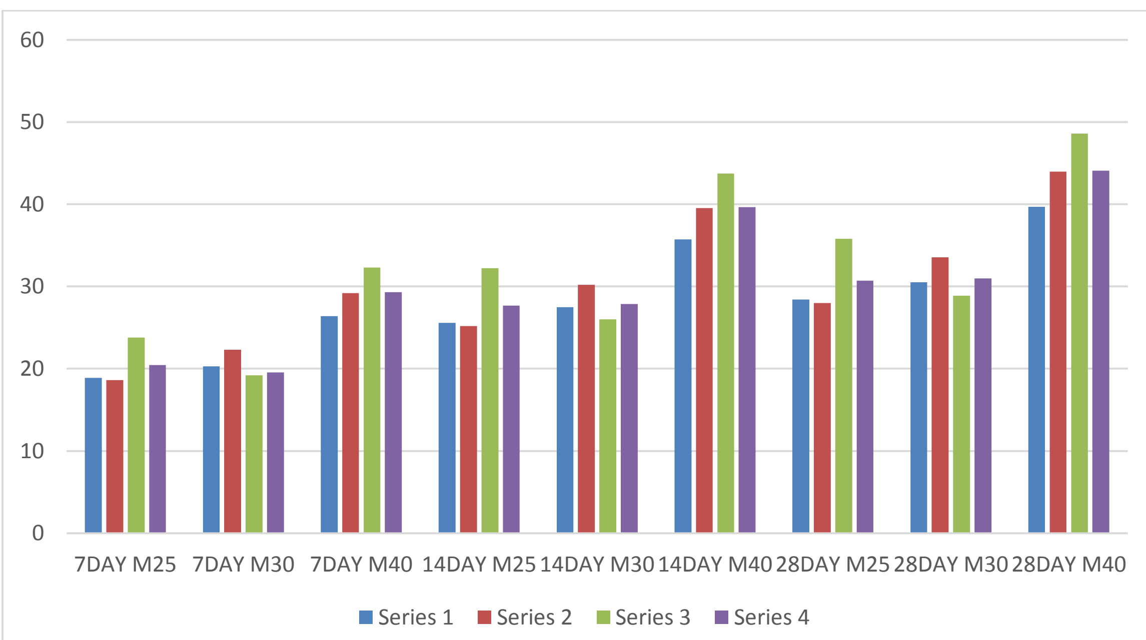
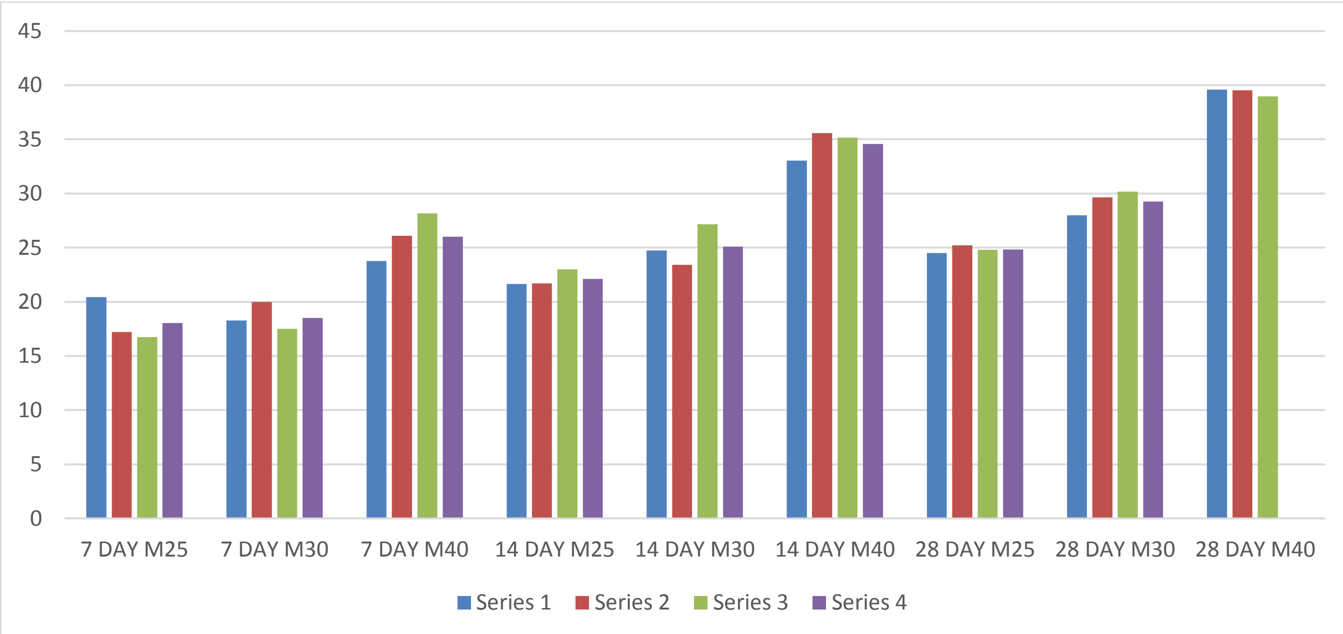


Chart 2- Test Results for Compressive Strength without admixtures



7. CONCLUSIONS:-

The following conclusions were drawn from the investigation.

- The strength of a concrete mix using Super Plasticiser Fosroc SP430 is comparable or even higher than traditional concrete mixes.
- The use of Fosroc SP430 superplasticizer in concrete mix design allows for a reduction in the water-cement ratio, resulting in a denser and stronger concrete with improved workability.
- The superplasticizer's ability to improve the workability of the concrete mix without compromising its strength or durability means that high-performance concrete can be produced with less cement and water, reducing the overall carbon footprint and cost of the construction project.
- Studies have shown that concrete mixes using Fosroc SP430 superplasticizer have higher compressive and flexural strength than traditional concrete mixes.
- This is because of the denser, more homogeneous mixture with reduced porosity, which leads to improved strength and durability.
- Additionally, the reduction in water-cement ratio due to the use of the superplasticizer can lead to a reduction in shrinkage and cracking, further improving the long-term strength and durability of the concrete.
- This makes Fosroc SP430 a popular choice among designers and contractors who seek to improve the sustainability and cost-effectiveness of their construction projects while maintaining high-quality standards the use of Fosroc SP430 can lead to improved finishing of the concrete, as well as enhanced durability and resistance to chemical attack. Overall, the incorporation of Fosroc SP430 superplasticizer into concrete mix design represents a significant step forward in the construction industry.

- In conclusion, the use of Fosroc SP430 superplasticizer in concrete mix design offers several advantages over traditional concrete mixtures as per IS10262:2019

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