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# EFFECT OF PLASTICIZERS ON WORKABILITY AND COMPRESSIVE STRENGTH OF CONCRETE

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## ABSTRACT

Worldwide, a great deal of research is currently being conducted concerning the use of plasticizers in increasing the workability and strengthening of reinforced cement concrete and plain cement concrete members. Use of plasticizer application is a very effective way to increase workability, decreasing the water cement ratio and finally increasing the compressive strength of concrete.

First of all in this thesis work literature review based on workability and compressive strength of concrete as experimental investigations are studied and need of the study is included. In the first phase of the study concrete mix design procedure is adopted for M30 and M35 grade of concrete. For the determination of mix design various properties of concrete ingradients is conducted in the laboratory and results are recorded. In the second phase two sets of concrete cubes were casted for this experimental test program. In set A 36 cubes were casted of M30 grade out of which 18 cubes are made with keeping water cement ratio as 0.4 and remaining 18 cubes are made with keeping water cement ratio as 0.5 with variations in the amount of plasticizers. In set B again 36 cubes were casted of M35 grade out of which 18 cubes are made with keeping water cement ratio as 0.4 and remaining 18 cubes are made with keeping water cement ratio as 0.5 with variations in the amount of plasticizers. Lastly the cubes are tested for Workability and Compressive strength using slump cone test apparatus and compression testing machine. Effect on workability and strength with variation in the dosage of plasticizers are studied from experimental data obtained for 7 days and 28 days. Finally it has been concluded that use of plasticizers as admixtures results in improvement in workability and finally an increase in compressive strength of concrete. This leads to a step ahead in durability of the concrete and in turn is a durability of the structure.

**KEYWORDS:** Silica fume, High strength concrete, High performance concrete, Strength. Slump. Plasticizer.

## INTRODUCTION

The concrete is the most important construction material, which is manufactured at site. It has the advantage of being formed into any desired shape most conveniently. As it is artificially manufactured at site it has wide uses in various construction works. Worldwide, a great deal of research is currently being conducted concerning the use of plasticizers in increasing the workability and strengthening of reinforced cement concrete and plain cement concrete members.

Use of plasticizer application is a very effective way to increase workability, decreasing the water cement ratio and finally increasing the compressive strength of concrete. Concrete is a composite product obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone. The distinguishing property of the concrete is its ability to harden under water. The ingredients of the concrete can be classified into two groups namely active & inactive group. The active group consist of cement, water & admixtures, where as inactive group comprises of fine &coarse aggregate.

Although all materials that go into concrete mixture are essential, the cement is very often the most important because it is usually the delicate link in the chain. The function of cement is to bind all the materials & to fill up the voids to form a compact mass. The cement constitutes about 20% of the volume of concrete, which affects the cost of construction. Being an engineer our duty is to economize the construction without affecting the strength & stability the structure Now a day's various admixtures are available to modify various properties of concrete such as, rate of

hydration, setting time, workability, dispersion & air entrainment. These admixtures are generally added in a relatively small quantity. A degree of control must be exercised to ensure proper quantity of admixtures, as an excess quantity may be detrimental to the properties of the concrete.On the other hand in some cases where the section are narrow or heavily reinforced or contains inaccessible parts or when the spacing of reinforcement makes the placing & compaction difficult, higher workability is required to achieve full compaction with reasonable amount of effort. In such cases also the amount of water is to be increased to achieve the desired workability and so in turn to affect the strength. To increase the water to improve the workability is not a proper approach because increase in water will result in increase in water cement ratio, which will adversely affect the desired strength. Therefore to have desired strength cement also will have to be increased to maintain water cement ratio i.e. strength of concrete.

On the basis of the recent trends in development in concrete types and use the following objectives becomes the part of study in the dissertation

1. To determine workability for different water cement ratio including the variation in the dosage of plasticizers.
2. To determine compressive strength for different water cement ratio including the variation in the dosage of plasticizers.
3. To study a comparison between different grades of concrete for improvement in workability of concrete.
4. To study a comparison between different grades of concrete for improvement in compressive strength of concrete.
5. To draw graphical comparisons between different grades of concrete for improvement in workability and compressive strength of concrete.
6. To draw conclusions about improvement in the workability and strength of concrete.
7. To draw inferences for further scope in this direction.

## NEED OF THE STUDY

1. Conventional concreting methods
2. Poor Concrete character in use
3. Standard mix in practice
4. Quality improvement

## EXPERIMENTAL INVESTIGATION

### PROPERTIES OF MATERIALS

**Cement**

JK SUPER CEMENT (fly ash based) PPC

a) Setting Time Initial setting time 30 min Final setting time 600 min
b) Compressive Strengths 07 days 40 N/mm2 28days 55 N/mm2

### SIEVE ANALYSIS

**Grading of Fine aggregate**

*TABLE (1)*

| S.NO . | Sieve No. | Mass Retained (gms) | % Retained | Cumulative % Retained | % Passing |
|---|---|---|---|---|---|
| 1. | 4.75 | 7 | 0.7 | 0.7 | 99.3 |
| 2. | 2.36 | 19 | 1.9 | 2.6 | 98.1 |
| 3. | 1.18 | 81 | 8.1 | 10.7 | 91.9 |
| 4. | 600 | 223 | 22.3 | 33 | 77.7 |
| 5. | 300 | 549 | 54.9 | 87.9 | 45.1 |
| 6. | 150 | 93 | 9.3 | 97.2 | 7.0 |
| 7. | Pan | 25 | | | |
| | | | | ∑C = 232.1 | |

a) Fineness Modulus 2.321
b) Free Water (during rains) 7%
c) Water Absorption 2.15%
d) Specific Gravity 2.60

e) Silt Content 0.2%

**Grading of Coarse Aggregate**

*TABLE (2)*

| S No | Sieve No | Mass Retained (gm) | % Retained | Cumulative % Retained | % Passing |
|---|---|---|---|---|---|
| 1 | 40 | 0 | 0 | 0 | 100 |
| 2 | 20 | 1.584 | 31.68 | 31.68 | 68.32 |
| 3 | 10 | 2.970 | 59.40 | 91.08 | 8.92 |
| 4 | 4.758 | 0.440 | 8.8 | 99.88 | 0.12 |
| 5 | Pan | 0.006 | 0.012 | 99.892 | 0.108 |
| | | | | ∑C =320 | |

a) Fineness Modulus 3.2
b) Impact value 8.8%
c) Specific gravity 2.90
d) Water Absorption 1.6%
e) Free water (during rains) 3.25%

**Mix Design Compute Target Mean Compressive Strength:**

$F_{ck}$ = $f_{ck}$ + ( k× S)

$F_{ck}$ = Target Mean Compressive Strength at 28 days in N/Sq.mm
$f_{ck}$ = Characteristic Compressive Strength at 28 days in N/Sq.mm
S = Standard Deviation in N/Sq.mm
K = A Statistic, depending on accepted proportion of low results.

*TABLE (3)*

| Accepted proportion of low results | k |
|---|---|
| 1 in 5, 20% | 0.84 |
| 1 in 10, 10% | 1.28 |
| 1 in 15, 6.7% | 1.50 |
| 1 in 20, 5% | 1.65 |
| 1in 40, 2.5% | 1.86 |
| 1 in 100, 1% | 2.33 |

**Assumed Standard Deviation** (Table 8, IS: 456-2000)

*TABLE (4)*

| Grade of Concrete | Assumed Standard Deviation (N/Sq.mm) | |
|---|---|---|
| | **Good Site Control** | **Fair Site Control** |
| M10, M15 | 3.5 | 4.5 |
| M20, M25 | 4.0 | 5.0 |
| M30, M35 M,40,M45 M50 | 5.0 | 6.0 |

From Is 456:2000, k=1.65

S = 6

**FOR M30 GRADE**

$F_{ck}$ = 30+ (1.65×6)

$F_{ck}$ =40 N/mm2 value of s has taken from table no. 10.25 (CT ml gambhir)

**FOR M35 GRADE**

$F_{ck}$ = 35+ (1.65×6)

$F_{ck}$ =45 N/mm2 value of s has taken from table no. 10.25 (CT ml gambhir)

**Water-Cement ratio of trial mix from experience**

*TABLE (5)*

| S.No. | Concrete Grade | Minimum expected W/C |
|---|---|---|
| 1 | M10 | 0.9 |
| 2 | M15 | 0.7 |
| 3 | M20 | 0.55 |
| 4 | M25 | 0.50 |
| 5 | M30 | 0.45 |
| 6 | M35 | 0.40 |
| 7 | M40 | 0.35 |
| 8 | M45 | 0.30 |

**Water content per cubic metre of concrete from table2 of I.S: 10262-2009.**

*TABLE (6)*

| Maximum size of Aggregate (mm) | Water Content per cubic metre of concrete (Kg) |
|---|---|
| 10 | 208 |
| 20 | 186 |
| 40 | 165 |

**Compute the quantity of cement as follows.**

$$\text{Cement} = \frac{\text{Water content}}{\text{W/C Ratio}}$$

1. Cement = 186 / 0.5
   = 372 kg

2. Cement = 208 / 0.5
   = 416 kg

**Quantities of Fine & Coarse aggregate by absolute volume method.**

$$V = (W+C/S_c+(1/p) \times (fa/S_{fa}))\times(1/1000)$$
and
$$V = (W+C/S_c+(1/(1-p))\times(ca/S_{ca})) \times (1/1000)$$

**Mix proportion-**
**FOR M30 GRADE OF CONCRETE-**

*TABLE (9)*

| | Water | Cement | Fine Agg. | Coarse Agg. |
|---|---|---|---|---|
| **Qty.** | 160 kg | 380 kg | 711 kg | 1283 kg |
| **As ratio** | 0.4 | 1 | 1.87 | 3.37 |

**FOR M35 GRADE OF CONCRETE-**

*TABLE (10)*

| | Water | Cement | Fine Agg. | Coarse Agg. |
|---|---|---|---|---|
| **Qty.** | 160 kg | 400 kg | 704 kg | 1271 kg |
| **As ratio** | 0.4 | 1 | 1.76 | 3.17 |

## PLAN OF WORK

**Work was planned as follows**

a) Mix proportion to be studied- M35 and M30
b) Dose of plasticizer to be used-0.5% and 1% (by wt. of cement ).
c) To study the effect of plasticizer on workability,7 days strength and 28 days strength of concrete.

So it was planned to cast about 72 nos, of concrete cubes of size 15 × 15 × 15cm. In some cases water correction could be incorporated when there was no relative change in free water of aggregates. In this way in present work the mix proportion of M30 was constant, i.e. 1:1.87:3.37 and M35 1:1.76:3.17 .The water cement ratio get changed as explained above resulting in change in strength. However, the doses of plasticizer were varied as planned above.

## TESTING OF CONCRETE CUBES

On the basis of mix design, the mix proportion of concrete was kept as 1:1.87:3.37 for M30 (cement : sand : aggregate ) and 1:1.76:3.17 for M35. Keeping a water cement ratio of 0.4 and 0.5, In all 72 nos. of cubes of sizes 15 × 15 × 15 cm were cast in a group of 12 sets. In each set 6 nos. of cubes were cast.

For each sets weight batching of material was adopted. The quantity of materials required for casting of 6 cubes of M30 with 0.4 water cement ratio were calculated as:

**Cement - 7.4 kg**
**Water - 2.96 lts.**
**Aggregate - 24.94 kg**
**Sand - 13.84 kg**

The quantity of materials required for casting of 6 cubes of M30 with 0.5 water cement ratio were calculated as

**Cement - 7.4 kg**
**Water - 3.7lts.**
**aggregate - 24.94 kg**
**Sand - 13.84 kg**

The quantity of materials required for casting of 6 cubes of M35 with 0.4 water cement ratio were calculated as

**Cement - 9.3 kg**
**Water - 3.72lts.**
**Aggregate - 29.48 kg**
**Sand - 16.34 kg**

The quantity of materials required for casting of 6 cubes of M35 with 0.5 water cement ratio were calculated as

**Cement - 9.3 kg**
**Water - 4.65 lts.**
**Aggregate - 29.48 kg**

**Sand - 16.34 kg**

Hand mixing was adopted for casting of the concrete cubes and thus 12 sets of cubes were formed with varying percentage of plasticiser. The fresh concrete was then tested for workability using slump apparatus before filling in the cube. Cubes so formed in the set of 6 cubes were marked as per the casting date. On the next day of casting the cubes were kept submerged in a water tank for curing.

After 7 days of curing 3 cubes from each set were tested for compressive strength in a compression testing machine.Similarly after 28 days of curing remaining cubes of each set were tested for compressive strength of 28 days.

## RESULTS

In present work all 72 cubes were cast in different sets. Result consist of measurement of workability during casting and cube compressive strength at 7 days and 28 days. Results are tabulated in table 11 Dose of plasticizer, w/c ratio and average Compressive strength is also reported in table 11

It has already been reported in previous that for whole work following two parameters were constant,

Consumption of cement per cum of work - kg/cum

Mix proportion -1:1.87:3.37

Mix proportion- 1:1.76:3.17

***TABLE -11***

| S No. | Sample Mark | W/C Ratio | % Dose Plasticizer | Slump (mm) | Average Compressive Strength in Kg/Sq cm | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 7 Days | 28 Days | Avg of 7 | Avg of 28 |
| 1 | M-30-5F | 0.4 | NIL | 110 | 210,225,220 | 260,300,310 | 215 | 285 |
| 2 | M-30-7F | 0.4 | 0.5 | 110 | 240,220,250 | 270,310,315 | 235 | 295 |
| 3 | M-30-12F | 0.4 | 1.0 | 140 | 235,270,250 | 325,290,310 | 255 | 310 |
| 4 | M-30-14F | 0.5 | NIL | 130 | 215,235,240 | 295,310,340 | 236 | 320 |
| 5 | M-30-21F | 0.5 | 0.5 | 140 | 245,265,280 | 295,345,375 | 270 | 345 |
| 6 | M-30-23F | 0.5 | 1.0 | 180 | 280,290,295, | 345,360,385 | 295 | 370 |
| 7 | M-35-25F | 0.4 | NIL | 135 | 330,305,315 | 315,385,360 | 320 | 355 |
| 8 | M-35-27F | 0.4 | 0.5 | 160 | 375,360,380 | 390,385,395 | 370 | 395 |
| 9 | M-35-3M | 0.4 | 1.0 | 170 | 380,435,395 | 415,435,455 | 410 | 435 |
| 10 | M-35-5M | 0.5 | NIL | 140 | 385,315,360 | 395,425,380 | 350 | 400 |
| 11 | M-35-12M | 0.5 | 0.5 | 185 | 390,410,440 | 430,485,470 | 420 | 480 |
| 12 | M-35-14M | 0.5 | 1.0 | 200 | 425,435,455 | 470,510,535 | 450 | 510 |

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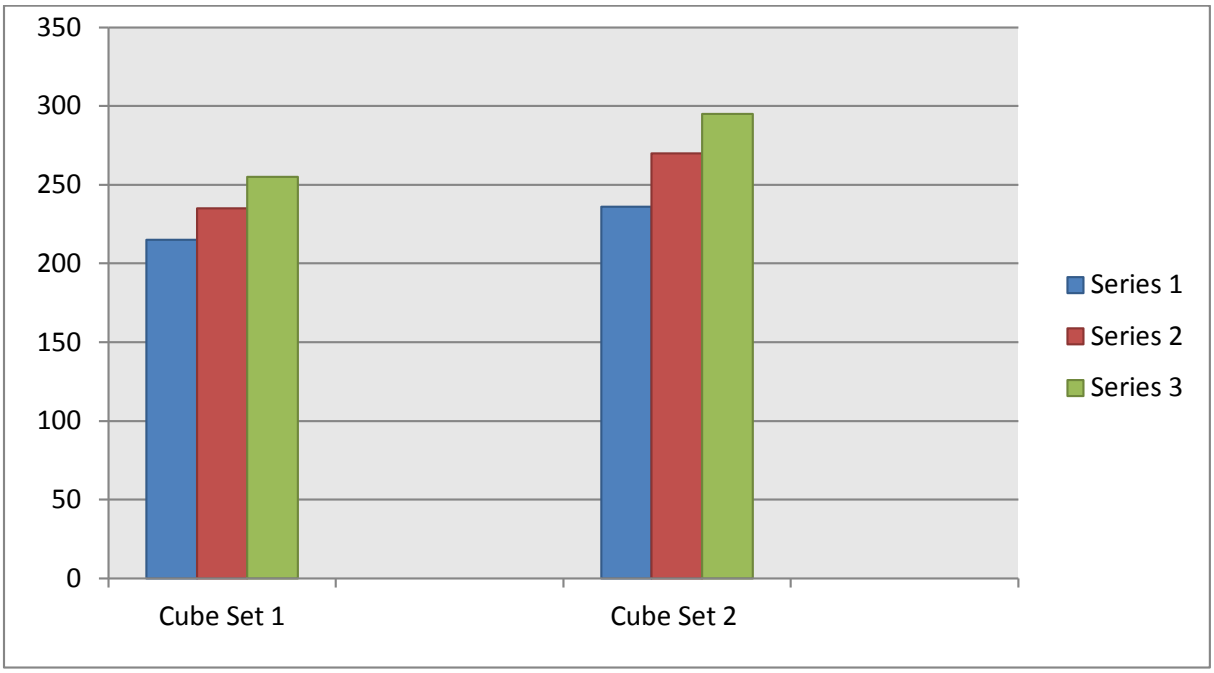
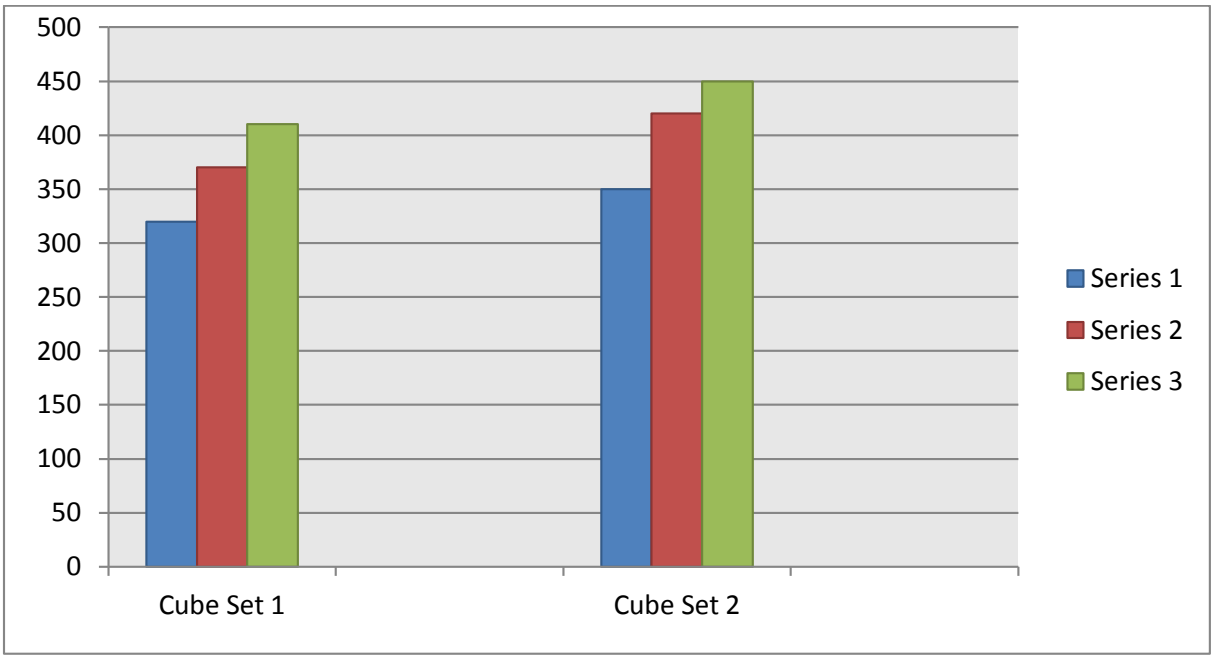
## GRAPHICAL RESULTS




***CUBE SET 1- 0.4 W/C RATIO*** ***PLASTICISER - NILL***
***CUBE SET 2- 0.5 W/C RATIO*** ***PLASTICISER – 0.5%***
***PLASTICISER – 1%***

## CHARACTERISTIC COMRESSIVE STRENGTH AFTER 7DAYS




***CUBE SET 1- 0.4 W/C RATIO*** ***PLASTICISER - NILL***
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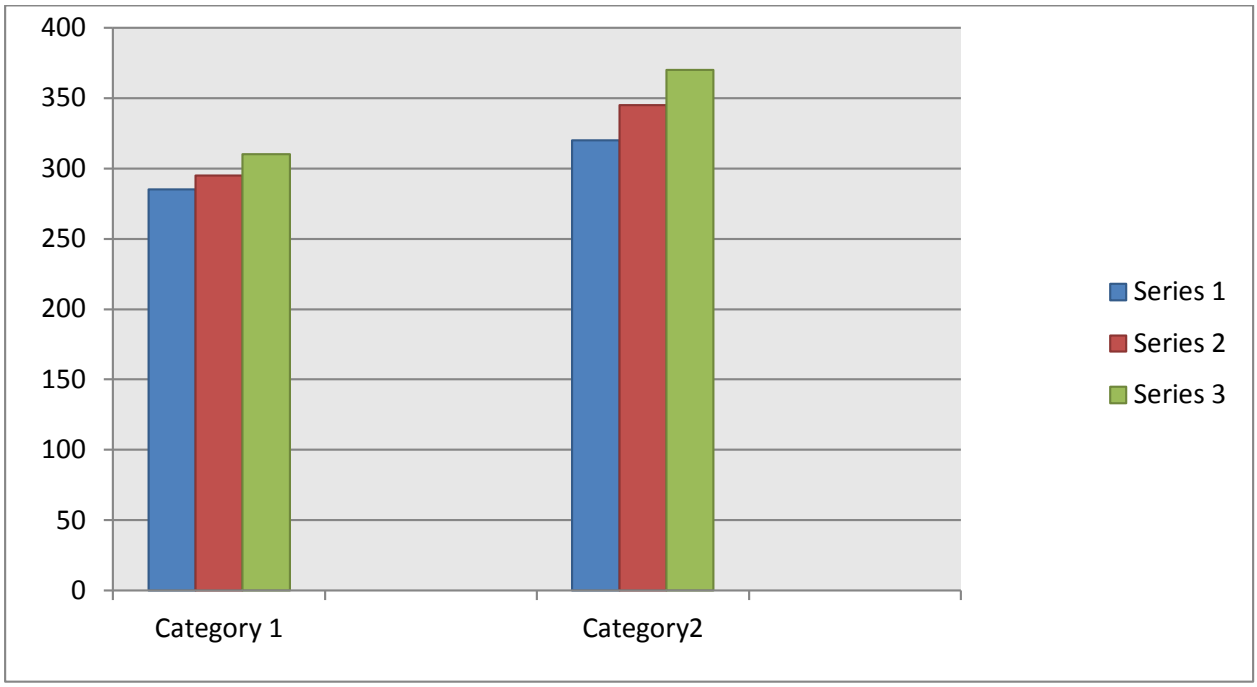
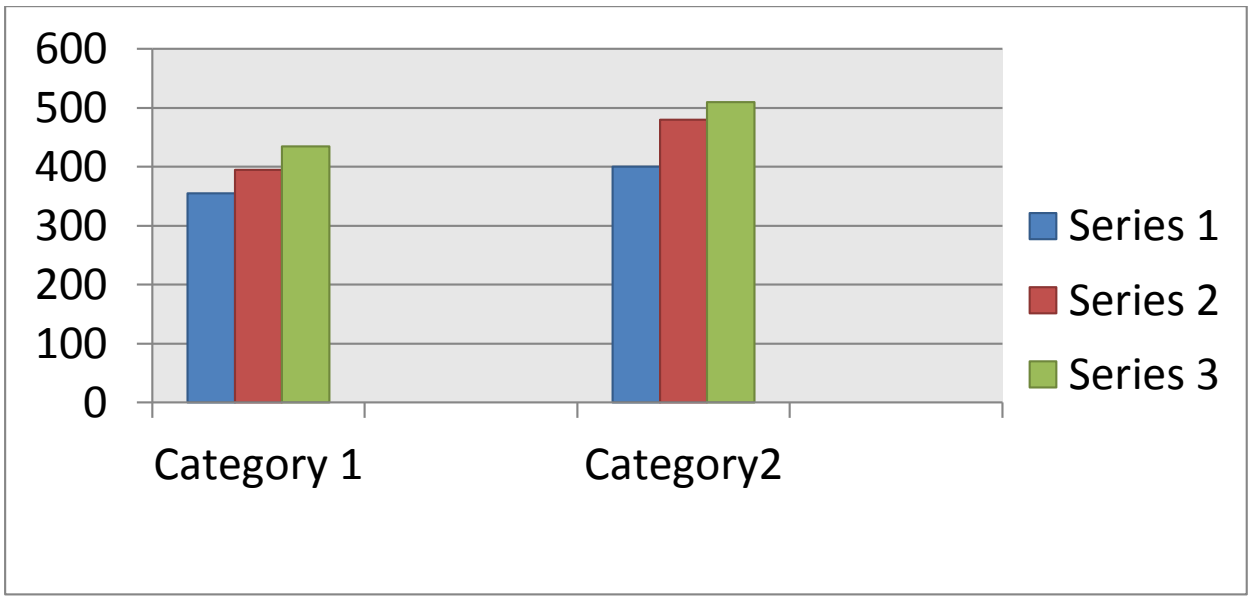
**CHARACTERISTIC COMRESSIVE STRENGTH AFTER 7DAYS**




*CATEGORY 1- 0.4 W/C RATIO* *PLASTICISER - NILL*
*CATEGORY 2- 0.5 W/C RATIO* *PLASTICISER – 0.5%*
*PLASTICISER – 1%*

**CHARACTERISTIC COMRESSIVE STRENGTH AFTER 28 DAYS**




*CATEGORY 1- 0.4 W/C RATIO* *PLASTICISER- NILL*
*CATEGORY 2- 0.5 W/C RATIO* *PLASTICISER – 0.5%*
*PLASTICISER – 1%*

**DISCUSSIONS**

As discussed earlier our plan was to study the effect of plasticizer on compressive strength and workability of concrete. This study was to be made on two concrete mixes i.e. M35, M30. But work cannot be executed as per planning, because of the rapid changes in season and heavy rains during work. Sometimes material was very bad sometimes dry and very dry. Though in some cases water correction was made for free water in aggregates however, it is not be assessed in some cases prior to mixing due to sudden rains . As a result of this situation W/C ratio get varied resulting in change in strength of concrete. Following observations are made from the study of result tabulated in table 11 Results are referred with their serial numbers.

- S. No.1 & S. No. 4 shows that for same grade of mix and different water cement ratio the average compressive strength of concrete increases due to increase in water cement ratio.
- S.No2 & S.No8 shows that for different grade of mix and same water cement ratio and same percentage dose of plasticizer. The average compressive strength increase to a higher value i.e. for higher grade of concrete strength use of plasticizer is helpful in increasing the strength of concrete.
- S.No.3 & S.No.9 shows that the different grade of mix and same water cement ratio with percentage dose of plasticizer also when increased, the average compressive strength increase much more than earlier this shows that for higher grade of concrete use of plasticizer increase the strength .
- S. No. 6 & S.No.12 shows that for different grade of mix and higher value of water cement ratio and increased dose of plasticizer the variation in strength of concrete is up to a great extent . This shows that plasticizer should be used to modify the strength in concrete.
- S.No1,4,7& S. No. 10 shows that without addition of percentage dose of plasticizer the variation in strength of different mix grade is not much. The variation is only due to change in mix grade.

## CONCLUSIONS

A mix proportion which makes a concrete of strength 410 kg/sq.cm **.** may result in a concrete having compressive strength as 370-510 kg/sq.cm, if less water cement ratio is kept by making concrete workable with the use of plasticizers. It may be stated that , M30 grade of concrete may be improved grade of concrete, at the cost of plasticizer which is very less as compared to the cost of cement saves.

1. From the results of the study the workability of concrete can be increased by addition of plasticizer. However, very high dosages of plasticizer tend to impair cohesiveness of concrete.
2. Slump loss can be reduced by using the chemical admixtures. However, effectiveness is higher for plasticizer concrete. Compressive strength is improved by plasticizer compared with control; On the other hand, even its ultimate strength is higher than the desired characteristic strength.

## FURTHER SCOPE

On the basis of results and discussions the following scope which can be involved in further studies are suggested as follows:

1. Use of Plasticizers with high grade of Concrete can be explored.
2. Different Plasticizers and polymers effects can be a part of study and exploration.

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