Experimental Investigation on Hot Weather Concrete using Cera Plast

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Abstract— Concrete is widely used in structural engineering with its high compressive strength, low cost and abundant raw material. But common concrete has some shortcomings, for example, low tensile and flexural strength, poor toughness, high brittleness, and so on that restrict its application. To overcome these deficiencies, additional materials are added to improve the performance of concrete. The main purpose of this experimental investigation is to study the behaviour of Hot Weather Concrete (HWC). In this investigation HWC was manufactured by usual ingredients such as cement, fine aggregate, coarse aggregate, water and mineral admixtures such as Fly ash at replacement level of 5 % by weight of cement and manufacture sand is 50 % replaced by fine aggregate. The amount of CERA PLAST Super Plasticizer is added in the concrete is in the range of 0.25 %, 0.5 % and 1.0 % by volume of concrete. The water cement ratio adopted is 0.45. Specimens such as cubes, cylinders and prisms were cast and tested for above mixes viz. The mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength of concrete is tested at 7, 14 and 28 curing days.

Key words: Hot Weather Concrete, Fly Ash, CERA PLAST, Super Plasticizer

I. INTRODUCTION

Concrete is more preferable material in India for construction of engineering structures. India has a hot and cold weather condition places and in hot places the demand of water is increased so that the usage of water is reduced in construction work also.

The use of super plasticizers in concrete is an important milestone in the advancement of concrete technology. Since there is interaction in the early 1960 in Japan and in the early 1970 in Germany. It is widely used all over the world. India is catching up with the use of super plasticizers in the construction of high rise buildings, long span bridges and recently it has become popular in Ready Mix Concrete Industry. Common builders and Government departments are also started using this useful material.

In this project we replace a 5 % of fly ash for cement and 50 % of manufacture sand for fine aggregate to achieve strength of concrete. We specially add a CERA PLAST as super plasticizer for increasing a setting time and strength of concrete and also decreasing the water cement ratio of concrete. The water cement ratio is 0.45 is adopted. It is more economical compared to normal conventional concrete.

II. SUPER PLASTICIZERS IN CONCRETE

The super plasticizers are more powerful as dispersing agents and they are high range water reducers. It is the use of super plasticizers which has made it possible use of water cement ratio as low as 0.25.

Super plasticizers can produce:

1) At the same w/c ratio much more workable concrete than plain ones
2) For the same workability, it permits the use of lower w/c ratio
3) As a consequence of increased strength with lower w/c ratio, it also permits a reduction of cement content

The Super plasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and building.

III. CERA PLAST IN CONCRETE

CERA PLAST is a new generation, high grade and superior performance retarding super plasticiser which has several advantages such as:

1) Reduction in water-cement ratio of the order of 20-25 per cent
2) High early strength enabling early removal of form work
3) Increased ultimate strength
4) High quality concrete of improved durability, reduction in heat of hydration even with very high strength cements
5) Easy pumpability
6) Compatibility with mineral admixtures
7) Improved water tightness and durability

IV. SELECTIONS OF MATERIALS

In general concrete is a composite material of cement, fine aggregate, coarse aggregate and water. In this project, we have added CERA PLAST super plasticizer in the concrete in various percentages in the weight. The strength properties of those materials are arrived and compared with conventional concrete by conducting laboratory tests.

The selection of materials depends on various physical and chemical properties, such as particle size, specific gravity, purity, etc., Also, the compatibility and performance in the presence of other materials need to be established which may help in short listing of materials when two or more types are available.

V. MATERIALS USED

- Cement
- Water
- Coarse aggregate (20 mm)
- Fine aggregate
- Fly ash
- Manufactured sand
- CERA PLAST (Super plasticizer)

A. Cement:

Cement is one the binding materials used especially in concrete to bind all materials used in concrete and form a single substance. Ordinary Portland Cement (OPC) of 43 grade is used in this investigation. Strength is not less than 43 N/mm2 for 28 days.

Ordinary Portland cement of 43 grade in one lot was procured and stored in air tight container. The cement was fresh i.e used within three months of manufacture. It should satisfy the requirement of IS 12262. The properties of cement are determined as per IS 4031: 1968 & are tabulated below:

S.NO	PROPERTIES	VALUES
1	Fineness	10 %
2	Initial Setting Time	27 minutes
3	Final Setting Time	9.50 hours
4	Standard Consistency	29 %
5	Soundness	8 mm
6	Specific Gravity	3.15

Table 1: Properties of Cement

B. Fine Aggregate:

Natural sand is used as a fine aggregate from the day of introduction of concrete which makes the quality of concrete better when it consists of round shaped grains rather than angular shaped. Only river sand is used as fine aggregate in concrete but not sea since it consists of more amount of salt which destroys the quality of concrete also corrosion of reinforcement take place. In this research study we have used river sand after sieve analysis as per IS 383-1970.

1) Specific Gravity Test:

S.No	Weight of empty pycnometer (W1) "g"	Weight of sample + pycnometer (W2) "g"	Weight of sample + pycnometer + water (W3) "g"	Weight of water (W4) "g"	Specific gravity
1	375	774	1333	1081	2.70
2	376	775	1335	1083	2.70
3	375	775	1333	1082	2.69
			Average value		2.70

Table 2: Specific Gravity of Fine Aggregate

Specific gravity of fine aggregate = 2.70

2) Sieve Analysis Test:

Size of sieve "mm"	Weight of sand retained in "g"	Percentage of weight of sand retained (%)	Cumulative percentage of weight of sand (%)	Percentage of sand passing through sieve (%)	IS 383 Zone III confirmation of sand
10	-	-	-	-	100
4.75	12	1.2	1.2	98.8	1.2
2.36	62	6.2	7.4	92.6	7.4
1.18	260	26	33.4	66.6	66.6
0.6	120	12	45.4	54.6	45.4
0.3	280	28	73.4	26.6	73.4
0.15	214	21.4	94.8	5.2	94.8
<	52	5.2	100	0	100
0.15					

Table 3: Sieve Analysis of Fine Aggregate

C. Coarse Aggregate:

1) Crushing Value Test:

Sample	Weight of aggregate taken (W_1) "g"	Weight of aggregate left (W_2) "g"	Weight of aggregate passing through sieve, (W_3) "g"	Aggregate crushing value in percentage (%)
1	5000	1032	632	15.92
2	5000	1034	630	15.88
3	5000	1030	634	15.96
		Average value		15.92

Table 4: Crushing Value for Course Aggregate

Aggregate Crushing Value = 15.92 %

2) Impact Value Test:

Sample	Weight of aggregate taken (W_1) "g"	Weight of aggregate left (W_2) "g"	Weight of aggregate passing through sieve,(W_3) "g"	Aggregate impact value in (%)
1	1000	310	116	16.81
2	1000	313	118	17.11
3	1000	315	114	16.64
		Average value		16.85

Table 5: Impact Value for Coarse Aggregate

Aggregate Impact Value = 16.85 %

3) Aggregate Abrasion Test:

Sample	Weight of aggregate taken (W_1) "g"	Weight of aggregate left (W_2) "g"	Aggregate impact value in percentage (%)
1	5000	4455	10.91
2	5000	4450	11.00
3	5000	4452	10.96
		Average Value	10.95

Table 6: Abrasion Value of Coarse Aggregate

Aggregate Abrasion Value = 10.9 %

D. Flakiness Index Test:

Sieve Number in "mm"	Aggregate Retained in "IS Sieve" mm	Weight of Aggregate in "g" (∑)	Thickness of Slot in "mm"	Weight of aggregate through slot in "g" (∑W)
45	37.5	-	40 – 50	-
37.5	26.5	45	31.5 – 40	45
26.5	19	3697	25 – 31.5	1993
19	13.2	1984	16 – 25	1013
13.2	9.5	260	12.5 – 16	70
9.5	6.5	11	10 – 12.5	4
		∑ = 5997		∑W = 3125

Table 7: Flakiness Index Value of Coarse Aggregate

Flakiness Index of aggregate = 52.109 %

E. Water:

The major factor controlling strength, everything else being equal, is the amount of water used per bag of cement. Maximum strength is obtained by using less amount of water is required for the complete hydration of the cement. However, a mix of this type may be too dry to be workable. Concrete mix always contains more water than the amount required attaining maximum strength. The amount of excess water decreases the strength of concrete. The specified water-cement ratio is the perfect medium between the maximum possible strength of the concrete and the necessary minimum workability requirements. The degree of cement hydration increased with time and temperature, but the increase beyond 28 days was not significant. The p^H value of water is 6.8.

F. Fly Ash:

Fly ash is a finely divided residue particle. It is manufacture from combustion of powdered coal and transported by the flue gasses and collected by electrostatic precipitator. The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control.
The various properties of fly ash is as follows:

- Low water content
- Reduce heat of hydration
- Continuous pozzolanic reaction
- Low carbon content
- High fineness
- High resistivity
- More resistance to the corrosion of reinforcement

G. Manufacture Sand:

Manufacture sand is also known as"crusher sand". It is produced by modern crushers specially designed for producing cubical, comparatively smooth textured, well graded sand and good enough to replace natural sand. Maximum particle size of manufacture sand is finer than 75 micron. Manufactured sand is provided with a proper shape and surface texture. It minimizes voids content in concrete. Manufacture sand also gives a highly workable mix.

H. CERA PLAST:

CERA PLAST is a new generation super plasticizer, it highly increases strength of concrete, reduces water content in concrete and increases the setting time of concrete. The properties and composition of CERA PLAST is explained below:

1) Composition of CERA PLAST:

The various ingredients present in the CERA PLAST is tabulated:

INGREDIENT	CONTENT
Quartz (silica crystalline)	<0.1%
Calcium sulphate hemihydrates	>60%
Calcium carbonate	<10%

Table 8: Composition of CERA PLAST

2) Properties of CERA PLAST:

PROPERTIES	SIGNIFICANCE
Appearance	Brown
Odour	Slight Odour
Specific gravity	2.6 - 2.7
Solubility (water)	0.2 %

VI. MIX DESIGN

A. Requirements of Concrete Mix Design:

The requirements which form the basis of selection and proportioning of mix ingredients are:

1) The minimum compressive strength required from structural consideration
2) The adequate workability necessary for full compaction with the compacting equipment available.
3) Maximum water-cement ratio and/or maximum cement content to give adequate
4) durability for the particular site conditions
5) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

B. Concrete Design Mix Ratio:

Water	Cement	F A	C A
191.61	383	569.44	1188.6
0.50	1	1.48	3.1

The mix ratio is 1: 1.48: 3.1

From the mix design the water cement ratio is 0.50. But we had added the water cement ratio is 0.45 because of the addition of CERA PLAST super plasticizers.

VII. EXPERIMENTAL PROCESS AND TEST RESULTS

A. Compressive Strength:

The test was conducted as per IS 516-1959.The cubes of size 150 mm x150 mm x150 mm casted to find the compressive strength of concrete. Specimens are placed on the Compressive Testing Machine of capacity 200 tones without eccentricity and a uniform rate of loading of 140 Kg/cm^2 per minute was applied till the failure of the cube

Fig. 1: Compression Strength Test for Cube

MIX 1	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
CUBE 1	17.70	19.82	21.23
CUBE 2	16.95	20.65	22.20
CUBE 3	18.40	21.24	22.03
Average Value	17.65	20.50	22.02

Table 11: Compression Strength for MIX 1 Cubes

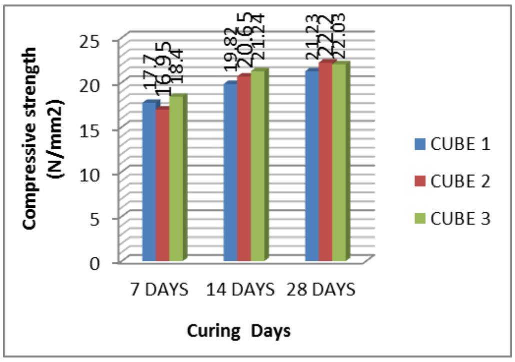

Fig. 2: Chart For Compressive Strength of MIX 1 Cubes

The compressive strength of MIX 1 concrete increases with the use of limited percentage of super plasticizers, but decreases when exceeds the limit. The average compression strength of cubes at 7 days curing is 17.65 N/mm^2, 14 days curing is 20.50 N/mm^2, and 28 days curing is 22.02 N/mm^2. The variations in the strength of cubes are shown in figure 5.

MIX 2	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
CUBE 1	22.83	24.31	25.87
CUBE 2	20.82	23.32	24.88
CUBE 3	21.81	22.29	26.89
Average Value	21.82	23.30	25.88

Table 12: Compression strength for MIX 2 cubes

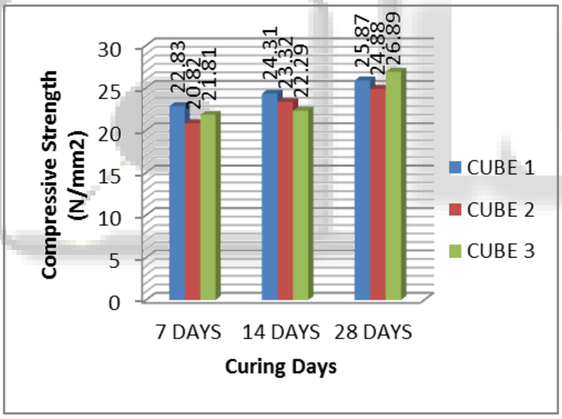

Fig. 3: Chart for Compressive Strength MIX 2 Cubes

The compressive strength of MIX 2 concrete increases with the use of limited percentage of super plasticizers, but decreases when exceeds the limit. The average compression strength of cubes at 7 days curing is 21.82 N/mm^2, 14 days curing is 23.30 N/mm^2, and 28 days curing is 25.88 N/mm^2. The variations in the strength of cubes are shown in figure 6.

MIX 3	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
CUBE 1	21.63	24.80	27.68
CUBE 2	23.62	25.81	29.65
CUBE 3	22.64	26.78	28.65
Average Value	22.63	25.79	28.66

Table 13: Compression Strength for MIX 3 Cubes

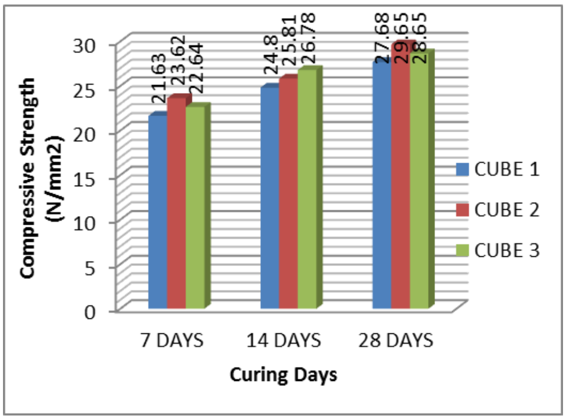

Fig. 4: Chart for Compressive Strength of MIXES 3 Cubes

The compressive strength of MIX 3 concrete increases with the use of limited percentage of super plasticizers, but decreases when exceeds the limit. The average compression strength of cubes at 7 days curing is 22.63 N/mm^2, 14 days curing is 25.79 N/mm^2, and 28 days curing is 28.66 N/mm^2. The variation in the strength of cubes is shown in figure 7.

MIX 4	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
CUBE 1	22.02	26.23	28.00
CUBE 2	21.02	25.23	27.02
CUBE 3	20.05	24.22	26.01
Average Value	21.03	25.22	27.01

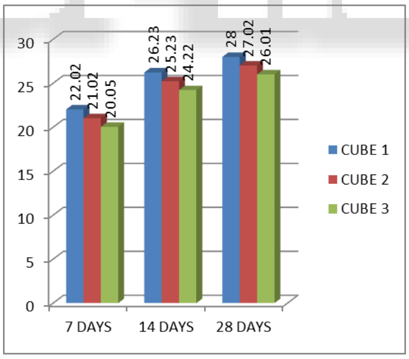

Figure 5: Chart for Compressive Strength of MIX 4 Cubes

The compressive strength of MIX 4 concrete increases with the use of limited percentage of super plasticizers, but decreases when exceeds the limit. The average compression strength of cubes at 7 days curing is 21.03 N/mm^2, 14 days curing is 25.22 N/mm^2, and 28 days curing is 27.01 N/mm^2. The variations in the strength of cubes are shown in figure 8.

MIX	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	28 DAYS (N/mm^2)
MIX 1	17.65	20.50	22.02
MIX 2	21.82	23.30	25.88
MIX 3	22.63	25.79	28.66
MIX 4	21.03	25.22	27.01

Table 15: Average Compression Strength of Cubes

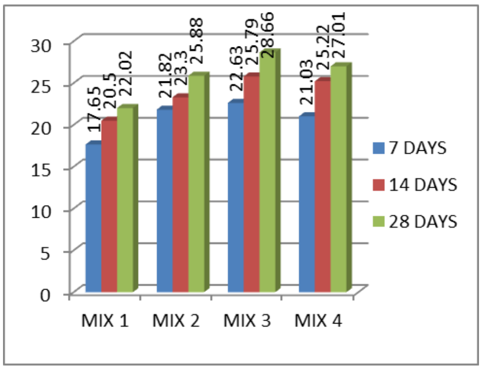

Fig. 6: Chart for Average Compressive Strength of Cubes

The compressive strength of concrete increases with the use of limited percentage of super plasticizers, but decreases when exceeds the limit. Optimum percentage of super plasticizers obtained in our experimental project is 0.5% for compressive strength.

A gradual decrease is noticed when the super plasticizers content exceeds 0.50 % is shown in figure -9

B. *Split Tensile Strength:*

Fig. 7: Split Tensile Strength Test for Cylinder

MIX	MIX 1 (N/mm^2)	MIX 2 (N/mm^2)	MIX 3 (N/mm^2)	MIX 4 (N/mm^2)
CYLINDER 1	3.96	4.13	4.18	4.16
CYLINDER 2	3.98	4.15	4.20	4.14
CYLINDER 3	4.00	4.17	4.24	4.13

Table 16: Split Tensile Strength of Cylinders

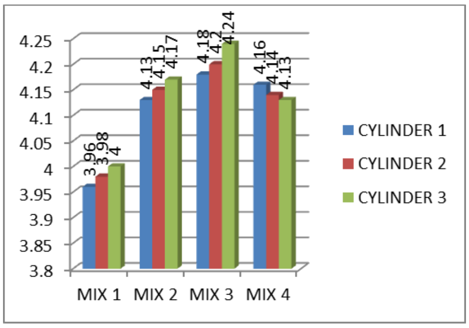

Fig. 8: Chart for Split Tensile Strength of Various Mix of Cylinders

When we consider the split tensile test results, the tensile strength is more in 0.50 % and decreased as the percentage increases. The curing time of a cylinder is 28 days. The comparison between the various mixes of cylinders are shown in figure – 10

C. *Flexural Strength:*

Fig. 9: Flexural Strength Test for Prism

MIX	MIX 1 (N/mm^2)	MIX 2 (N/mm^2)	MIX 3 (N/mm^2)	MIX 4 (N/mm^2)
PRISM 1	4.60	4.68	4.72	4.70
PRISM 2	4.62	4.68	4.71	4.69
PRISM 3	4.63	4.70	4.73	4.67

Table 17: Flexural Strength of Prisms

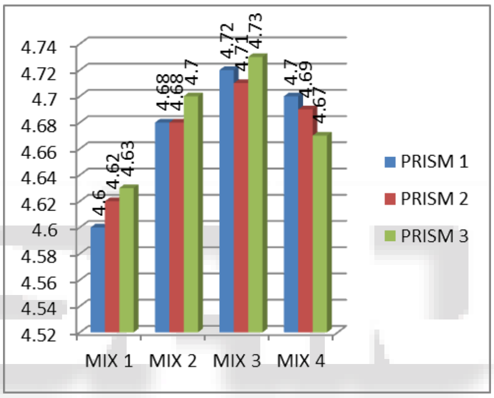

Fig. 10: Chart for Flexural Strength of Various Mix of Prisms

In flexural test, the curing period of prism is 28 days. The flexural strength of the prism is more in mix 3. The optimum percentage of super plasticizers is found to be 0.50 and the comparison between the various mixes is shown in figure -11.

VIII. CONCLUSION

The comparison between the conventional concrete and hot weather concrete gives the increase in the strength of concrete with 0.50 % of CERA PLAST used in the concrete mix and the strength is decrease with use of more than 0.50 % 0f CERA PLAST.

The hot weather concrete using CERA PLAST is increase the strength and setting time of concrete with low water content compared with conventional concrete. Cubes, cylinders and prisms are made for various testing of concrete. The 50 % replacement of manufacture sand for fine aggregate which reduces the cost and it makes the economical one. The 5 % replacement of fly ash for cement which gives the dense and fineness structure and also it will increase the strength of concrete.

Finally, hot weather concrete is suitable for a hot places, Ready Mix plant and Pumpable technique for multi-storied building.

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