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Assessment of Use of Pozzocrete on Strength of Concrete

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Abstract: ***Concrete demand has increased to satisfy the need of infrastructural development facilities. Tremendous amount of natural resources and energy is consumed for production of ordinary Portland cement. It also emits substantial quantity of carbon dioxide into the atmosphere. Therefore, it has been need of the hour to find out alternatives for making eco-friendly concrete. Many siliceous and alumnio-siliceous material are available which possess little or no binding values. But these materials in finely divided forms when come in contact with moisture, they chemically react with calcium hydroxide to form compounds those have binding properties. In the current studies when research was conducted on pozzocrete in laboratory it was well established that when pozzocrete is used in concrete, it increases the strength of concrete. Pozzocrete being finer than cement, gives more specific surface, fills the voids, increases workability of concrete and also reduces the problem of shrinkage in concrete.***

In the current study, the behavior of pozzocrete with cement concrete is reported. Percentage variation of pozzocrete in cement concrete to replace cement is tested to achieve economy as well as higher strength of RCC structural members. An experimental investigation was carried out on pozzocrete in reinforced cement concrete. Weigh batching method was used for 10% to 30% replacement of cement by pozzocrete in M20 grade concrete. It was found out that 30% replacement of cement with pozzocrete gave most acceptable results in flexural behavior. Workability and ductility of concrete was also found to be increased with increase in flexural strength.

Keywords: Eco-friendly, Silicious, pozzocrete, Weigh batching, Workability, Ductility

I. INTRODUCTION

One of the most widely used material in construction is plain cement concrete, which has the benefit of casting in any shape required. Concrete has very low tensile strength as compared to its compressive strength which is very high. Achieving concrete with crushing strength more than 40 N/mm2 is not a difficult task, but with replacement of cement with pozzocrete in concrete, about 50% increase in strength of concrete can be achieved.

Combustion of pulverized bituminous or sub-bituminous materials at power stations lead fly ashes. Processing of this fly ash gets high efficiency pozzolanic material called pozzocrete. It is also one of the cheapest available pozzolanic materials with high production capacity and also checked with strict quality control. Much research has been carried out on different types of pozzolanic materials and its properties with various parameters such as water cement ratio, effect on strength parameters of concrete are well established now.

Precast concrete members are used widely to accelerate the construction process and also to maintain proper quality control in concrete production. Casting of these precast concrete members is also a very tedious job which involves difficult and intricate patterns. Pozzocrete mix concrete can help pre-casters solve challenges in many areas of production. Precast members also require accelerated curing to achieve early age concrete strength so that they can bear handling stresses. While the pozzocrete have been too slow for early strength gain characteristics, conditions are changing towards the use of pozzocrete in the applications. Where the high strength concrete mixtures are found to be dry and harsh to use, pozzocrete is used beneficially to increase the workability of concrete. Pozzocrete used in pre-cast concrete products improves the workability, resulting in product with sharp, distinctive corners and edges.

II. OBJECTIVE & METHODOLOGY

A. Objective

Current study is aimed at to Determine

1) Flexural stresses by using single point loading flexure testing machine.
2) Compressive stresses by using compression testing machine.

B. Methodology

The current study has been divided into following steps –

1) Determination of properties of natural aggregates, sand, water and cement.
2) Preparing concrete mix design following I.S. code method.
3) Collection of pozzocrete and its properties from the supplier.
4) Casting standard cube (150 x 150 x 150mm) and beams and RCC beams (150 x 150 x 1000mm).
5) Testing in laboratory and interpretation of results.

III. MATERIALS & MIX PROPORTION

A. Pozzocrete 63

1) General Information

a) Presentation - Finely divided dry powder
b) Color - Light grey
c) Bulk Weight - 1.0 tonne / m^3
d) Sp. Density - 2.3
e) Particle Size - <50 micron
f) Particle Shape - Spherical
g) Package - 50kg bags

2) Chemical composition of pozzocrete 63

a) $Al_2O_3 + Fe_2O_3$ - 32.5%
b) SiO_2 - 64%
c) MgO - 1.2%
d) SO_3 - 1.6%
e) Na_2O - 0.7%
f) Surface area > 4,000

B. Cement

1) Type of Cement - OPC 53 grade
2) Fineness of cement - 4.577
3) Sp. Gravity - 3.12
4) Consistency - 32%

C. Sand

1) Particle Size < 4.75mm
2) Sp. Gravity - 2.84
3) Free moisture - NIL

D. Coarse Aggregate

1) Particle Size - 60% passing 20mm & retained on 10mm 40% passing 10mm & retained on 4.75mm
2) Sp. Gravity - 2.77
3) Free moisture - NIL

Table I: Concrete Mix

Mix I	Mix II	Mix III	Mix IV	Mix V	Mix VI	Mix VII
M20 Grade Concrete	Concrete with 10% Reduction in Cement	Concrete with 20% Reduction in Cement	Concrete with 30% Reduction in Cement	Concrete with 10% Replacement of cement with pozzocrete	Concrete with 20% Replacement of cement with pozzocrete	Concrete with 30% Replacement of cement with pozzocrete

The details of mix design for concrete mix I to VII are given in table II and III below:

Table II: For cubes

Ingredient	Mix I	Mix II	Mix III	Mix IV	Mix V	Mix VI	Mix VIl
Cement (gms)	1200	1080	960	840	1080	960	840
Pozzocrete (gms)					120	240	360
Sand (gms)	2304	2304	2304	2304	2304	2304	2304
Aggregate (gms)	4360	4360	4360	4360	4360	4360	4360
Water (ml)	696	626	556	487	696	696	696

Table III: For beams

Ingredient	Mix I	Mix II	Mix III	Mix IV	Mix V	Mix VI	Mix VIl
Cement (gms)	8000	7200	6400	5600	7200	6400	5600
Pozzocrete (gms)	--	--	--	--	800	1600	2400
Sand (gms)	15360	15360	15360	15360	15360	15360	15360
Aggregate (gms)	29040	29040	29040	29040	29040	29040	29040
Water (ml)	4640	4176	3712	3248	4640	4640	4640

IV. LABORATORY TESTING & CALCULATION

The specimens were tested for compression, flexure & shear tests in laboratory. All the specimens were casted with proportion of 1 : 2 : 3.75 with w/c ratio of 0.575. The cement was replaced with pozzocrete, percentage varied from 0% to 30% with every 10% increase.

A. Compression Test

Compressive strength is performed on casted cubical specimens of size 150 x 150 x 150mm. Most characteristics of hardened concrete are related to its compressive strength hence it is the most common test conducted on concrete. It is also the easiest test to perform on concrete. Compressive strength is the maximum load the concrete cube can bear at failure. Compressive strength is ratio of max load at failure to the cross sectional area of concrete.

B. Flexural Test

Tensile strength of concrete is evaluation by conducting flexural test. Concrete structures need to resist tensile stresses induced due to externally applied loads. It is not possible to measure the tensile strength of concrete by direct means. Beam tests are found to be suitable for measuring the flexural strength of concrete. RCC concrete beams of size 150 x 150 x 1000mm are tested with single point loading at the center. The flexural strength is evaluated from:

$$F_b = \frac{P.L}{b.d^2}$$

Where, P = maximum applied load in N
L = length / span in mm
b = average width of specimen in mm
d = average depth of specimen in mm.

C. Shear Test

The shear strength of concrete beam of size 150 x 150 x 1000mm is evaluated from :

$$T_v = \frac{V}{b\,.\,d}$$

Where, V = maximum shear force = $P/2$
b = average width of specimen in mm
d = average depth of specimen in mm

V. RESULTS AND DISCUSSIONS

1) *Compressive Strength:* Compressive strengths at 3 days, 7 days and 28 days for concrete mixes I to VII are tabulated in ***Table I*** below. Comparing the results, it was found that increase in compressive strength of concrete is achieved at 28 days with 20% and 30% replacement of cement with pozzocrete as compared to that of standard M20 grade concrete.

Table IV: Results of Cube Compression Test for Concrete Mixes 1 to 7

Concrete Mix	Compressive Strength N/mm^2		
	3 Days	7 Days	28 Days
I	12.34	12.76	25.12
II	11.45	12.40	22.82
III	11.61	12.08	20.92
IV	7.66	9.25	18.18
V	9.22	13.63	20.35
VI	12.92	15.75	25.14
VI	14.00	16.90	27.12

Change in compressive strength of standard cube for M20 Grade concrete and for percentage replacement of cement with pozzocrete is shown in Figure 1 below -

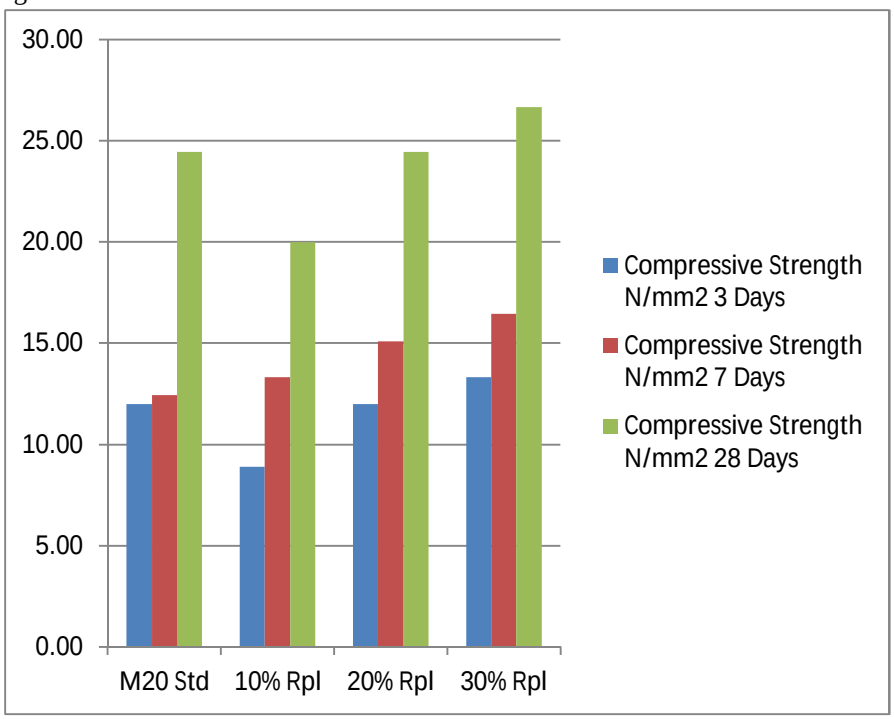

Figure 1: Compressive Strength of Concrete.

2) Flexural Strength: Flexural strengths for beams at 3 days, 7 days and 28 days for concrete mixes I to VII are tabulated in ***Table V*** below. Comparing the results, it was found that increase in flexural strength of concrete is achieved at 28 days. Pozzocrete in 10% replacement of cement lead to app. 22% increase, 20% replacement lead to app. 9% increase and 30% in replacement of cement lead to app. 38% increase in flexural strength of concrete, when compared to standard M20 grade.

Table V: Results of Flexural Strength for Concrete Mixes 1 to 7

Concrete Mix	Flexural Strength N/mm^2		
	3 Days	7 Days	28 Days
I	13.11	13.18	12.65
II	14.14	12.86	13.70
III	14.61	13.27	12.48
IV	13.97	13.47	13.60
V	14.05	12.20	14.75
VI	14.80	13.72	13.74
VI	14.43	13.70	17.32

Changes in flexural strength of beams for M20 Grade concrete and for percentage replacement of cement with pozzocrete are shown in figure 2 below -

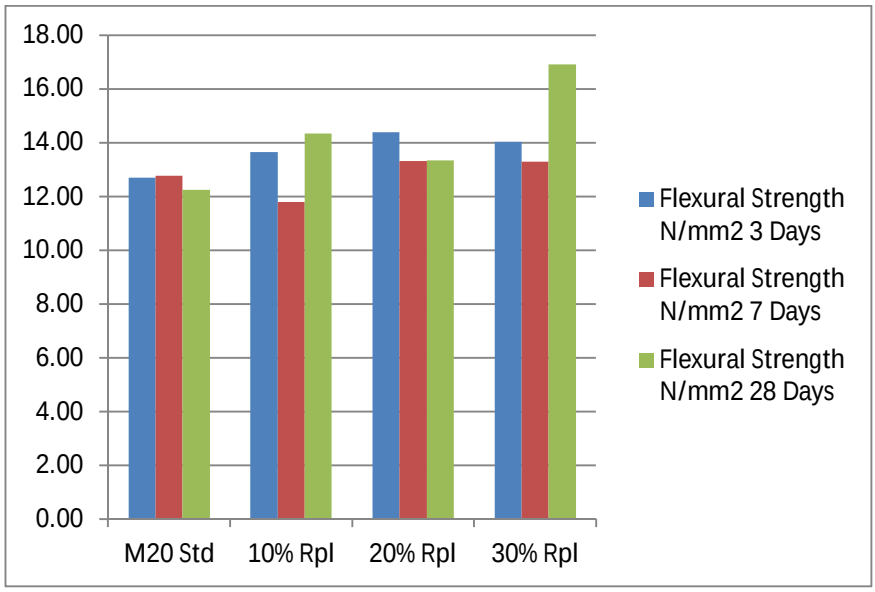

Figure 2: Flexural Strength of Concrete.

3) Shear Strength: Shear strengths for beams at 3 days, 7 days and 28 days for concrete mixes I to VII are tabulated in ***Table:VI*** below. Comparing the results, it was found that increase in flexural strength of concrete is achieved at 28 days. Pozzocrete in 10% replacement of cement lead to app. 21% increase, 20% replacement lead to app. 8% increase and 30% in replacement of cement lead to app. 38% increase in shear strength of concrete, when compared to standard M20 grade.

Table VI: Shear Strength of Concrete for Mix I to VI

Concrete Mix	Flexural Strength N/mm^2		
	3 Days	7 Days	28 Days
I	1.10	1.11	1.14
II	1.19	1.36	1.15
III	1.23	1.11	0.98
IV	1.17	1.13	1.14
V	1.18	0.96	1.28
VI	1.24	1.15	1.15
VI	1.21	1.15	1.45

Changes in shear strength of beams for M20 Grade concrete and for percentage replacement of cement with pozzocrete are shown in figure 3 below -

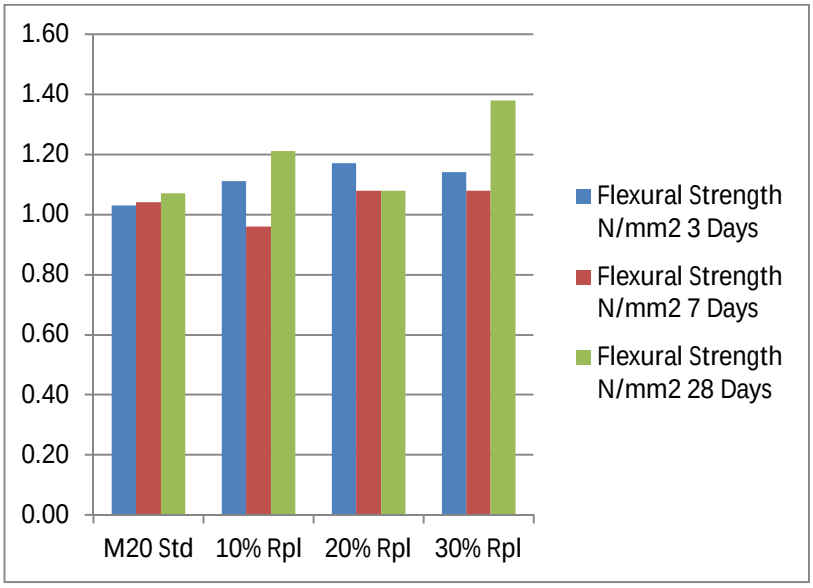

Figure 3: Shear strength of concrete.

VI. CONCLUSION

The use of pozzolanic materials in concrete increases its fineness which is turn increase workability, reduces shrinkage. The characteristics strength of concrete has found to increase with the increasing percentage of pozzolana in concrete. Following conclusions can be drawn from the experimental investigation that was carried out on concrete with replacement of cement with pozzocrete –

1) Increases in economy upto certain percentage replacement of cement with pozzocrete.
2) Increase in characteristic strength viz., compressive, flexure and shear strength upto 30% replacement of cement with pozzoncrete.
3) Reduction in water demand due to improved workability of concrete.
4) Slower rate of setting, reducing risk of cold joints.
5) Ease in surface finishing.

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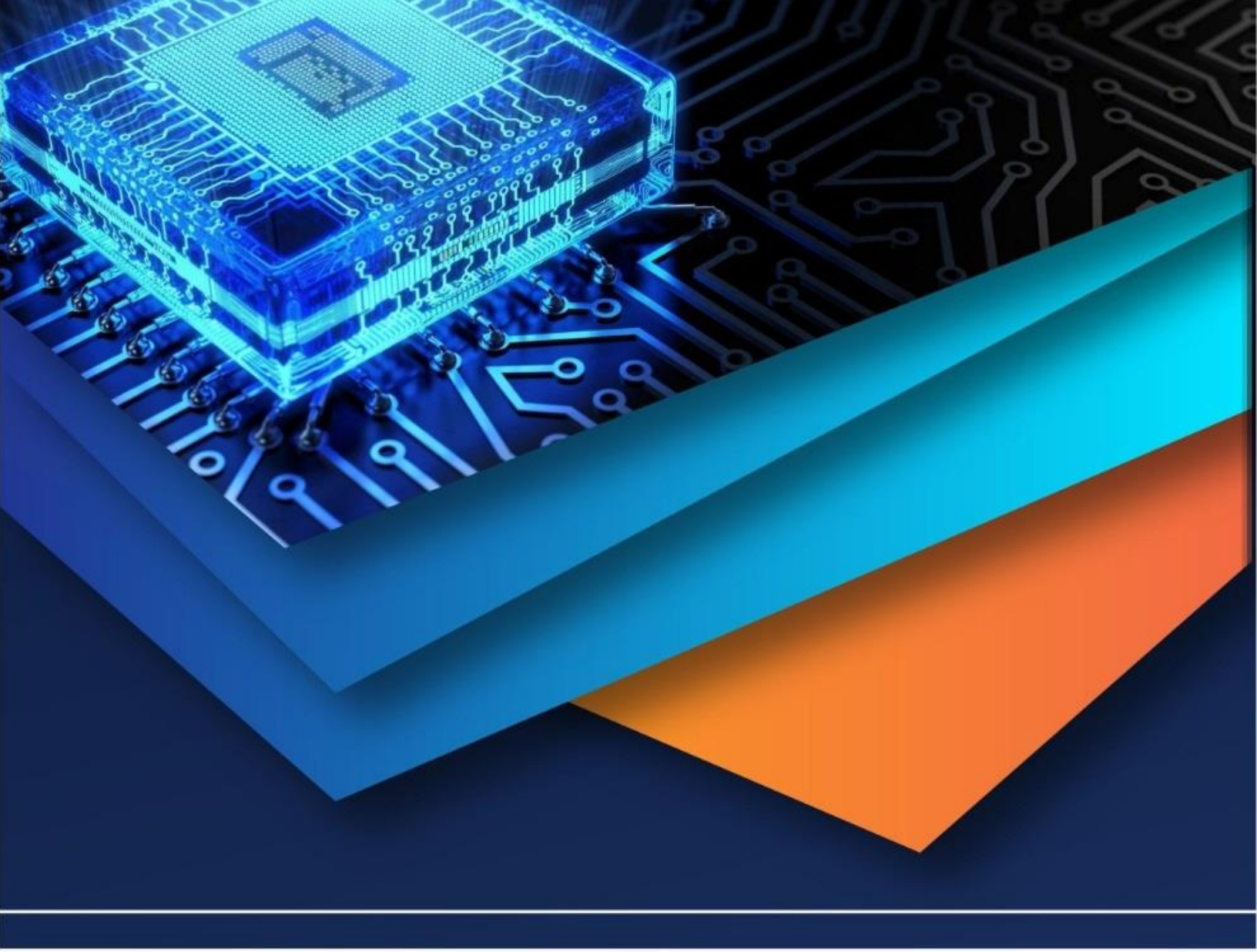

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