An Experimental Study on Compressive Strength of Concrete with Natural Pozzolana (Clay)

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***Abstract*— Cement is one of the most popular construction material in the present trends of construction. Either it be cast-on-site or precast or even Precast-prestressed structure, use of cement is everywhere. It can be predected that the use of cement will only increase in the days to come. With all the merits cement concrete possess, its few dimerits are neglected. When it is clubbed with a social cause of saving our environment it is becomes desirable in favour of future generations. Though cement is responsible for the strong bonding among the components of concrete. It has been observed that approximately 7% of the CO_2 emission worldwide is solely due to production of cement. Present study aim to partially replace cement with natural pozzolanic material i.e. clay. The 7 day, 21 day and 28 day compressive strength test performed on the specimens have shown encouraging results. Keeping the amount of water to be used is kept constant, the workability and compaction factor is checked. The observation have shown that the compressive strength is comparable to controlled specimens ant the result is quiet appreciable to be used in future construction techniques.**

***Keywords*— Cement, clay, compressive strength, workability.**

I. INTRODUCTION

Using heavy constructional materials are very much necessary to fulfill our engineering needs but it has also been observed that the environmental impact of construction materials have gone unaddressed for quite a long period. It has become the need of era that engineering community must actively pursue materials and technologies that are better for the environment and climate. Reports issued in 2007 by the United Nations Intergovernmental Panel on Climate Change (IPCC) assert that global warming, attributable to the build-up of greenhouse gases from man-made sources, is occurring at dangerous rate. Further, the IPCC warns that catastrophic changes to the environment are likely unless immediate steps are taken to reduce the atmospheric concentration of carbon dioxide (CO^2), and other greenhouse gases. NASA scientist, James Hansen and his colleagues conclude, "Pale climate evidence and ongoing global changes imply that today's CO^2, about 385 [parts per million (ppm)], is already too high to maintain the climate to which humanity, wildlife, and the rest of the biosphere are adapted". To achieve drastic cuts in carbon emissions worldwide, all major emitters including the manufacturers of industrial materials, must take the necessary action [6].

Cement has been one of the most commonly used construction material. It has larger advantages over its few disadvantages, which are therefore neglected. It gives high efficiency and easy construction mode with the desired strength. However cement production is an energy intensive process, which also has an important effect on the environment. Producing one ton of Portland cement releases about one ton of CO^2 greenhouse gas into atmosphere and as a result of this production 1.6 billion tons of CO^2 is released every year, which is estimated at about 7% of the CO^2 production worldwide [9].

II. EXPERIMENTAL MATERIAL

A. Cement

Ordinary Portland Cement of 43 Grades conforming IS: 8112-1989 is being used. The required tests were performed as per requirement and the results are compiled in Table I.

TABLE I. Properties of Cement.

Sl. No.	Property of cement		Obtained result for OPC 43 grade	Requirements as per IS:8112-2013
1.	Specific gravity		3.15	3.10-3.15
2.	Standard consistency		31.5	30-35
3.	Initial setting time (min)		64	30
4.	Final setting time (max)		185	600
5.	Compressive Strength N/mm^2	3 days	18	23
		7 days	25	33
		28 days	45	43
6.	Soundness by Le-Chatliers method (mm, max.)		8.5	10

B. Clay

The naturally available clay was used. The clay was tested for its chemical compositions and the results are compiled in Table II.

TABLE II. Chemical Content of Clay

Sl.No.	Chemical Compounds	Observed value (%)
1.	SiO2	44.2
2.	Na2O	0.013
3.	K2O	0.05
4.	Fe2O3	0.13
5.	Al2O3	39.7
6.	TiO2	1.32
7.	CaO	0.20
8.	MgO	0.03

C. *Crushed Aggregates*

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. Local available coarse aggregates were used conforming to IS: 383. The Flakiness and Elongation Index were maintained well below 15%.

D. *Fine Aggregates*

Fine aggregates are the aggregates whose size is less than 4.75 mm. For increased workability and strength is concerned, the fine aggregate should have a round shape. The fine aggregates are used to fill the voids in the coarse aggregate and to act as a workability agent. the sand we used was of zone III.

E. *Water*

Potable water is used for preparing samples. It should be a matter of high concern that the water should be free from any impurities for the desirable results. The pH value must not be more than 8 at any case.

III. MIX PROPORTIONS

Five mixture proportions were made. The first was control mix (i.e. without clay), and the other four mixes contained varying percentages of clay. The cement was replaced with clay by weight. The portion of cement being replaced ranged from 10% to 50%. The control mix without clay was proportionated for M-25 grade as per IS: 10262-2009. The mix proportions are given in Table IV.

TABLE III: Values of Specific Gravity

Sl. No.	Specific Gravity	Result
1.	Cement	3.15
2.	Clay	2.48
3.	Coarse Aggregate	2.73
4.	Fine Aggregate	2.58

TABLE IV: Mix for M-25 Grade (1:1:2)

Sl. No.	Mix Code	W/c Ratio	Water (Ltr)	Cement (kg)	Clay (kg)	F.A. (kg)	C.A. (kg)
1	M	0.43	2.3	5.0	0	5	10
2	M_1	-	2.3	4.5	0.5	5	10
3	M_2	-	2.3	4.0	1.0	5	10
4	M_3	-	2.3	3.5	1.5	5	10
5	M_4	-	2.3	3.0	2.0	5	10
6	M_5	-	2.3	2.5	2.5	5	10

IV. EXPERIMENTAL TESTS

After the mix proportions were made the test for workability, compaction factor and the compressive strength was carried on. For all the tests the water content is kept fixed from the control mix designed for M-25 grade as per Table IV.

A. *Compression test (IS 516:1959)*

For performing the Compressive strength tests on compression testing machine cube samples for each composition were prepared. Three samples per batch were tested and the average strength values reported in Table VI. The comparative study is done for concrete mix as per Table IV, with cement and without cement replaced by with clay in different proportions. The strength is measured in (MPa) and is commonly specified as a characteristic strength of concrete measured at 28 days of full submerged curing.

B. *Workability Test*

Workability test also known as the slump test was performed to determine the slump value. Keeping the water-cement ratio constant for all the mixes is Table IV the slump value was found following the procedure as per IS: 456-2000. The result of the test is compiled in table V.

C. *Compaction Factor*

The compacting factor for all the mixes from Table IV was performed. Compaction factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted. The result of the test is compiled in Table V.

TABLE V: Workability Test.

Sl. No	% Replacement of Cement	Mix Code	Slump Value (cm)	Compaction Factor
1	0	M	22	0.89
2	10%	M_2	19	0.81
3	20%	M_3	17	0.72
4	30%	M_4	15	0.70
5	40%	M_5	10	0.67
6	50%	M_6	9	0.61

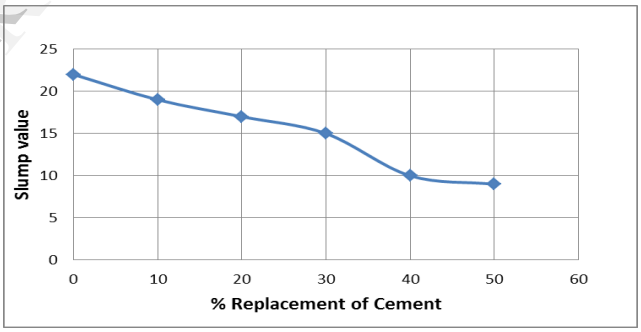

Fig 1. Plot of Slump value vs. % Replacement of cement

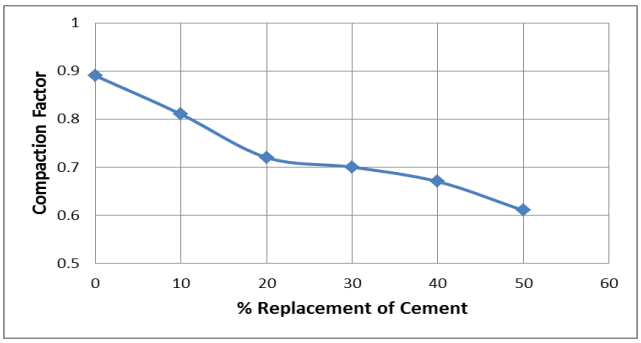

Fig 2. Plot of Compaction Factor vs. % Replacement of cement

TABLE VI. Compressive Strength Test.

Sl. No	% Replacement of Cement	Mix Code	Age of the specimen (days)		
			7	21	28
1	0	M	21.6	23.5	24.3
2	10%	M_2	20.2	22.3	23.1
3	20%	M_3	19.3	20	21.3
4	30%	M_4	22.1	24	26.7
5	40%	M_5	21.7	23.6	25.8
6	50%	M_6	20.6	22.1	23.9

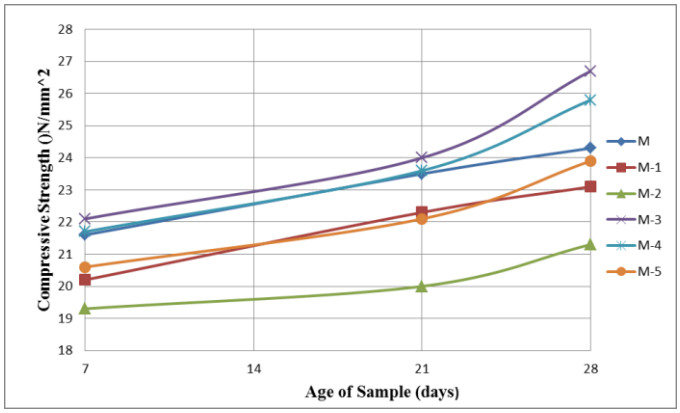

Fig 3. Plot of Compressive Strength vs. Age of sample.

CONCLUSION

- Workability as well as compaction factor decreases with increase in percentage of clay in the composition.
- Since the workability decreases the strength increases. This shows in addition of clay the concrete retains its basic properties.
- Replacement of 30% cement by natural shows increase in strength.
- Replacement of cement by natural clay up to 50% doesn't have any significant change in compressive strength.
- Hence the uses of cement can be reduced up to 30% without compromising with strength.

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