An Experimental Investigation for use of Calcite and Fly Ash as a Supplementary Cementitious Material in Concrete

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Abstract— The cement is one of the most demanding binding material in cement infrastructure industry since from its discovery it became very popular due its bonding and durable nature. The raw material required for production of cement is mine everyday, due to increase in demand of cement raw material they are in verge of exhaust which has an direct impact on price of cement and Indian economy. The use supplementary cementitious material (SCMs) like Fly ash and Calcite can be the innovative approach to develop concrete without any side effect on its properties. Fly ash is a waste generated from thermal power station which contain high amount of SiO_2 and Calcite which is reach in $CaCO_3$, experimental investigation shows that, it enhances the physical and mechanical properties of concrete.

Key words: Cement, Fly ash, Calcite, SCMs, Concrete

I. INTRODUCTION

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. Due to continuous increasing demand of cement raw material lead to think for the alternative materials for concrete composition. The principal objective of using alternative material is to optimize the mix to make best use of available raw materials. A range of calcareous raw material can be used for cement manufacture, but limestone, chalk or marble predominant. In most cases other calcium-bearing sources occur in sufficient large deposits or amount to be used as alternative partly.

Use of calcite in concrete is sustainable approach to evaluate the effect on mechanical properties of concrete. The construction industry is the primary consumer of calcite in the form of limestone and marble.

A. Natural and Synthetic Calcite

Calcite is a mineral, which contains calcium carbonate ($CaCO_3$). This is an abundant mineral on the earth surface. Calcite can form rocks, and they may grow up to large sizes. They are found in all three types of rocks, which are sedimentary, igneous and metamorphic rocks. The amount of calcium carbonate containing in the rock can vary. Sometimes, there are calcite minerals, which contain about 99% calcium carbonate. Rajasthan has the largest share (50%) of calcite resources, followed by Andhra Pradesh (42%) and Madhya Pradesh (6%). The remaining resources are located in Karnataka, Gujarat, Haryana, Tamil Nadu and Uttar Pradesh. [1]

B. Fly Ash

Fly ash (FA) is a by-product of the combustion of pulverized coal in electric power generation plants. When the pulverized coal is ignited in the combustion chamber, the carbon and volatile materials are burned off. However, some of the mineral impurities of clay, shale, feldspars, etc., are fused in suspension and carried out of the combustion chamber in the exhaust gases. As the exhaust gases cool, the fused materials solidify into spherical glassy particles called fly ash. The fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. Generally any coal based thermal power station may have the following four kinds of ash like Fly ash, Bottom Ash Pond ash, Mound Ash. As per the Bureau of Indian Standard IS: 3812 (Part-1) all these types of ash is termed as Pulverized Fuel Ash (PFA).The total number of thermal power station in Maharashtra is 16, Generation of fly ash in Maharashtra from year 2011-12 is about 12.596 million tonnes which rise in year 2012-13 is about 13.9107 million tonnes. The total utilization of fly ash in Maharashtra in year 2011-12 is 55.62% and which was increase in year 2012-13 about 63.36%. on account of fly ash utilization across the country in year 2011-12 was 58.48% and usage hike up to 61.37% in year 2012-13. [2]

II. PROPERTIES OF CONCRETE INGREDIENT

The material used for carrying out the experimental work of project is as, Cement (Grade 53), Coarse Aggregate, Fine Aggregate, Calcite and Fly Ash. The chemical and physical properties of concrete ingredient as follows,

A. Chemical Properties

Sr. No.	Chemical Composition	Cement (53 grade)	Calcite	Fly ash
1	$SiO_2 + Al_2O + Fe_2O_3$	---	---	89.91
2	CaO (Lime)	60-67	48.2	---
3	SiO_2 (Silica)	17-25	4.50	58.34
4	Al_2O_3 (Alumina)	3-8	1.10	---
5	Fe_2O_3 (Iron oxide)	0.5-6	1.50	---
6	MgO (Magnesia)	0.1-4	3.10	0.5
7	Alkalies	0.4-1.3	---	1.05
8	Sulphur	1-3	---	0.4

Table 1: Chemical properties of Cement, Calcite and Fly ash

B. Physical Properties

Material	Test	Result
Sand	Specific gravity	2.6
	Fines modules	2.51
	Zone	II
Coarse Aggregate	Specific gravity	2.65
	Fineness modulus	7.238
	Max. Size Aggregate (MAS)	20

Table 2: Physical properties of concrete ingredient

III. MIX PROPORTION

A. Mix Proportion for M25 Grade Concrete Mix (IS10262:2009)

Sr. No.	Material	Quantity	Proportion
1	Cement	359.09 kg/m3	1
2	Sand	697.45 kg/m3	1.94
3	Coarse aggregate	1210.38 kg/m3	3.37
4	Water	----	0.44
5	Super plasticizer	1%	----
6	Slump	75 - 100	----

Table 3: Mix proportion for M25 grade concrete

IV. COMBINATION OF MATERIAL

In this experimentation, cement was partially replaced by combinations of Fly ash (FA) and Calcite powder. Test was started with control concrete of M25 grade. Following table shows the percentage variations of cement, Fly Ash and Calcite powder.

Sr. No	Nomenclature	Cement (%)	Fly ash (%)	Calcite (%)
1	Conventional (M25)	100	0	0
2	CF 1	75	20	5
4	CF 2	70	20	10
5	CF 3	65	20	15
6	CF 4	60	20	20

Table 4: Nomenclature of samples

V. TESTING ON CONCRETE

A. Fresh Concrete

The workability was tested by slump cone test on conventional (M25) mix and different combination with Fly ash and Calcite powder and found that with the addition of Calcite and Fly ash increases workability in concrete mix, It may be because of fineness of Calcite and Fly ash.

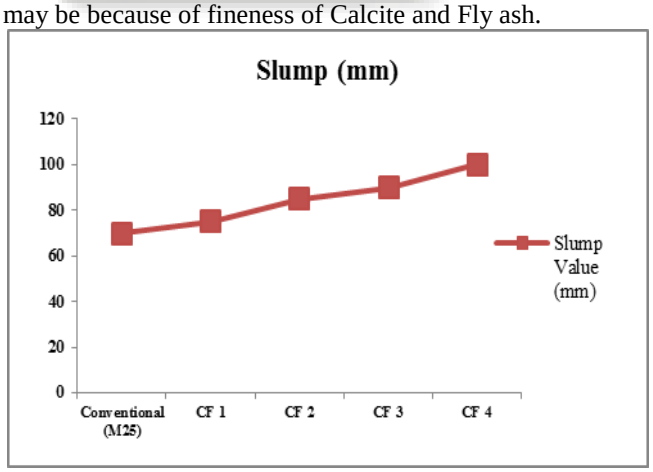

Fig. 1: Graph no. 1 Slump value of different samples.

B. Hardened Concrete

1) Compressive Strength

The compressive strength was measured on three cubes of 150mm at the age of 7, 14 and 28 days and mean value were reported on strength. At testing age, samples were removed from the curing tank and weighed. The samples were centrally placed in a compression testing machine the strength development results are shown in Graph no. 2 for reference, M25 and CF1 to CF4 mixtures.

The early strength of every sample is less as compared to conventional concrete. The 14 day strength of sample CF1 and CF2 is 5% more than the conventional concrete, but the strength of CF3 and CF4 decreases as the percentage of calcite increase. the 28 days strength of sample CF1 and CF2 is more with respect to conventional concrete and CF3 and CF4 strength decreases drastically.

Compressive strength (N/mm^2)			
Type	**7 Days**	**14 Days**	**28 Days**
Conventional (M25)	17.93	20.2	29.5
CF 1	15.41	20.42	30.37
CF 2	16.2	21.29	31.39
CF 3	16.28	17.51	25.58
CF 4	9.01	11.63	15.55

Table 5: Result of Compressive strength

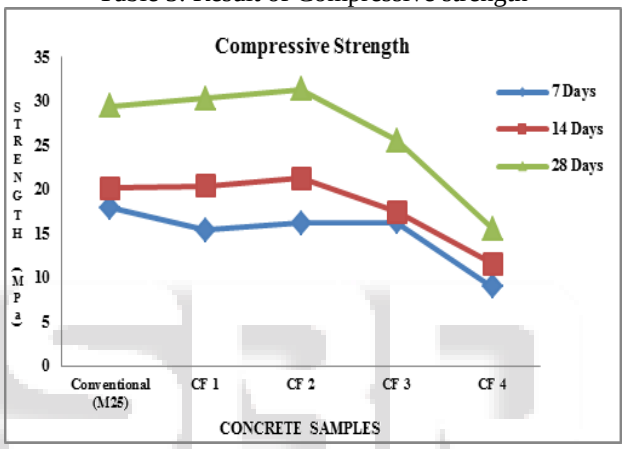

Fig. 2: Graph no. 2 Result comparison of Compressive strength

2) Split Tensile Strength

The split tensile strength of concrete done on three cylinder having size 150×300 mm at the age 7, 14 and 28 days and by taking mean of three cylinder it show the split tensile strength which is reported on compression testing machine. The strength development results are shown in Graph no. 3 for reference, M25 and CF1 to CF4 mixtures.

The early strength of sample CF1, CF2, CF3 is found more than the conventional concrete but the strength of sample CF4 is less. The 14 days strength of every sample is more than conventional concrete. 28 days strength of sample CF1, CF2 and CF3 is found more.

Split Tensile strength (N/mm^2)			
Type	**7 Days**	**14 Days**	**28 Days**
Conventional (M25)	1.73	2.2	2.87
CF 1	1.85	2.27	2.91
CF 2	2.13	2.34	3.24
CF 3	2.17	2.24	3.15
CF 4	1.62	2.08	2.13

Table 6: Result of Split tensile strength

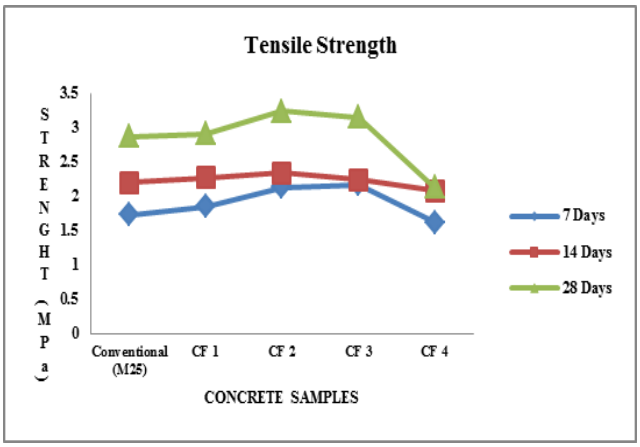

Fig. 3: Graph no. 3 Result comparison of Tensile strength

3) Flexural Strength

The flexural strength of concrete was measured on three beam having size of 150×150×700 mm at the age 7, 14 and 28 days and mean value was reported on strength on universal testing machine. The strength development results are shown in Graph no. 4 for reference, M25 and CF1 to CF4 mixtures

The 7 and 14 days strength of sample CF1, CF2, and CF3 is increased with respect to conventional concrete but the CF4 strength found to be decrease. The 28 days strength of sample CF1 and CF2 is more than the conventional concrete but the strength of sample CF3, and CF4 is less with respect to conventional concrete.

Flexural strength (N/mm^2)			
Type	**7 Days**	**14 Days**	**28 Days**
Conventional (M25)	1.53	1.83	2.19
CF 1	1.56	1.86	2.25
CF 2	1.65	2.02	2.22
CF 3	1.64	1.98	2.12
CF 4	1.19	1.61	1.71

Table 7: Result of Flexural strength

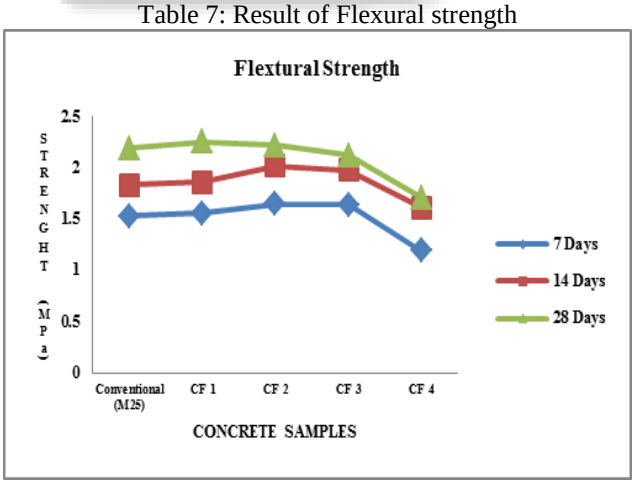

Fig. 4: Graph no. 4 Result comparison of Flexural strength

VI. CONCLUSION

1) The workability of concrete found to be gradually increasing with the addition of Calcite and Fly ash in cement.
2) Early strength of Calcite and Fly ash concrete mix with respect to the conventional concrete is found to be less.
3) 14 days compressive strength of CF1 and CF2 mix is found to be 5% more than conventional concrete.

But in concrete mix CF3 and CF4 compressive strength is drastically reduced with respect to conventional concrete.

4) 28 days compressive strength of CF1 and CF2 mix is found to be 10% more than conventional concrete.
5) The flexural strength of 7, 14 and 28 days concrete sample CF1 and CF2 is found to be more than conventional concrete.
6) Split tensile strength of 7, 14 and 28 days concrete sample CF1, CF2 and CF3 is found to be 15% more than conventional concrete.

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