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Effect of Cementitious Materials on Properties of Mortar

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Abstract— The aim of this project work is to demonstrate the effect of cementitious materials on properties of mortar. For construction purposes Mortar mix is used as binding material. The most commonly used mortar ingredients to make different types of mortar are cement , sand, lime, water etc. It is known that the consumption of natural sand as fine aggregate in mortar production is very high and many developing countries are facing some problems in the supply of natural sand in order to achieve the increasing demands of construction development . For getting a good mortar mix, it is very important to use quality ingredients. Without good ingredients, it is not possible to get the desired quality of mortar mix. Therefore this study investigates the use of nano silica , fly ash , GGBS to form mortar. This study introduces a mode of construction by partially replacing the waste materials. Since these materials are obtained from waste products of various industries. By reviewing various literature we acquired the knowledge about mix designs .and by the result we get to know about effect of silica, fly ash and GGBS on properties of mortar. The expected results are that by adding these materials the compressive strength of mortar must increase and the consistency must increase with decrease in cement content.

Keywords— Mortar, Silica Fumes, Fly Ash, GGBS.

I. INTRODUCTION

In the last decade, the worldwide consumption of natural sand as fine aggregate and cement in mortar production is very high and many developing countries have encountered some problems in the supply of natural sand in order to meet the increasing demands of construction development. Due to decrease in the quantity of naturally available materials, one logical option to solve this problem is employing these materials as a part of cement in mortar. This paper presents an overview of studies and experiments carried out on properties of mortar by partially replacing cementitious materials such as GGBS, silica fumes and fly ash.

The sand which is being used in this project is typically called as **Ennore sand** which is originated from Madras. This sand was being used as per the IS specification. Composed of three grades (Grade I, Grade II and Grade III having the sizes 1 mm to 2 mm, 0.5 mm to 1 mm and 0.09 mm to 0.5 mm respectively).

FIGURE NO: 1.1.Weighing of Ennore Sand.

Mortar is a material used in masonry construction to fill the gaps between the bricks and blocks used in construction. Mortar is a mixture of sand, a binder such as cement or lime, and water and is applied as a paste which then sets hard. Usually mortar is produced by using binder material as cement. Here mainly mortar is being tested on the basis of its strength by replacing cementitious materials like GGBS, Silica fumes and fly ash. Various percentages of these cementitious materials are being replaced in cement content .

GGBS used is obtained from blast furnace slag, a by-product from the iron industry. It is obtained by quenching molten iron blast furnace slag immediately in water or stream, to produce a glassy granular product that is then dried and ground into a fine powder. Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready mixed or site-batched durable concrete. To protect against chloride attack, GGBS is used at a replacement level of 50%GGBS is also routinely used to limit the temperature rise in large concrete pours.

FIGURE NO: 1.2.GGBS and Silica Fumes.

SILICA FUMES are most often prepared in a multi-step process where an alkali-silicate solution is partially neutralized, leading to the formation of silica nuclei. The subunits of colloidal silica particles are typically in the range of 1 to 5 nm. The size of the particles influences the strength and surface smoothness, with a range from 5 to 200 nm being used in most studies. Use of silica fumes in concrete continues to increase despite its relatively high cost because of its pozzolanic behavior and its content of fine particles. These two features of the silica fumes confer some benefits to the concrete. Also, because of its small particle size, nano silica fills the voids between the cement particles this improves the packing and reduces the porosity.

FLY ASH is produced by coal-fired electric and steam generating plants. Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately ignites, generating heat and producing a molten mineral residue. the spherical shape of fly ash creates a ball bearing effect in the mix, improving workability without increasing water requirements. Fly ash also improves the pump-ability of concrete by making it more cohesive and less prone to segregation. The spherical shape improves the pump-ability by decreasing the friction between the concrete and the pump line.

In addition, some fly ashes have been shown to significantly decrease heat generation as the concrete hardens and strengthens. Fly ash, as do all pozzolanic materials, generally provide increased concrete strength gain for much longer periods than mixes with portland cement only.

FIGURE NO:1.3. 70.6 x 70.6 x 70.6 mm Cubes Moulds.

II. LITERATURE REVIEW

1. G. Ravi Teja, A. Narender Reddy, T. Meena [5]experimentally concluded that the use of Nano particles in cement gives improvement in the compressive properties of concrete. The results showed that there is an considerable improvement in the mechanical properties and durability properties by the addition of nano silica to tetranary blended concrete.

2. Zengqi Zhang, Bo Zhang, Peiyu Yan [6] did the Comparative study of effect of raw and densified silica fume in the paste, mortar and concrete. It was found out that silica fumes can make great contributions to the compressive strengths of paste, mortar and concrete at later ages. The increase of compressive strength is most significant in concrete and that in paste is the least.

3. Charuchandra Korde , Matthew Cruickshank, Roger P. West, Claudia Pellegrino [7] did the experimental study on the use of Activated slag as partial replacement of cement mortars. The activated slag used was Ground Granulated Blast furnace Slag also known as GGBS. It was concluded that the slower rate of strength development due to the use of GGBS is addressed to a certain extent by using admixtures and thermal activation.

PROPORTIONS OF MATERIALS USED:

These proportions are calculated by studying various research papers. Here GGBS is being replaced as 10, 20 and 30% respectively. Silica fumes being costlier than the other products are being used in the least quantity as 2 and 3%.

Whereas fly ash is being used as 5,10 and 15% of replacement to cement considering cement 100%. Using ratio 1:3 the quantities in grams were calculated.

TABLE NO :01.Quantities of Material.

Sr. No.	GGBS %	GGBS (grams)	Silica Fumes %	Silica Fumes (grams)	Fly Ash %	Fly Ash (grams)	Cement %	Cement (grams)
1	10	20	2	4	5	10	83	166
2	10	20	2	4	10	20	78	156
3	10	20	2	4	15	30	73	146
4	10	20	3	6	5	10	82	164
5	10	20	3	6	10	20	77	154
6	10	20	3	6	15	30	72	144
7	20	40	2	4	5	10	73	146
8	20	40	2	4	10	20	68	136
9	20	40	2	4	15	30	63	126
10	20	40	3	6	5	10	72	144
11	20	40	3	6	10	20	67	134
12	20	40	3	6	15	30	62	124
13	30	60	2	4	5	10	63	126
14	30	60	2	4	10	20	58	116
15	30	60	2	4	15	30	53	106
16	30	60	3	6	5	10	62	124
17	30	60	3	6	10	20	57	114
18	30	60	3	6	15	30	52	104

FIGURE NO:2.1.Cubes Casting.

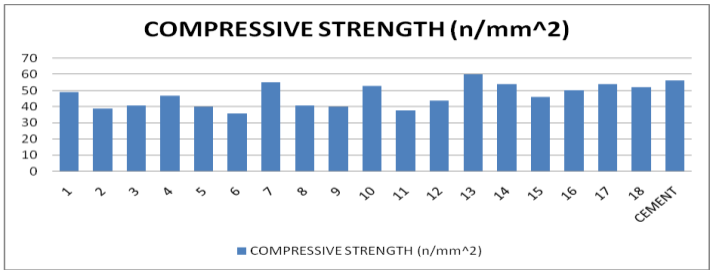
III. RESULT

- **COMPRESSIVE STRENGTH TEST**

TABLE NO : 2. Compressive Strength

Sample No.	Compressive Strength (N/mm^2)
1	48.98
2	38.78
3	40.82
4	46.94
5	39.80
6	35.71
7	55.10
8	40.82
9	39.80
10	53.06
11	37.76
12	43.88
13	60.19
14	54.17
15	46.15
16	50.16
17	54.17
18	52.17
CEMENT	56.12

FIGURE NO : 2.2.Compressive Strength of Cubes.



GRAPH NO:01.Compressive Strength of Different Samples

The compression strength test is arried out Mix The cement and sand in dry condition with a trowel for 1minitues and then add water. The quantity of water shall be (p/4+3)% of combined weight of cement and sand where, p is the % of water required to produce a paste of standard consistency determined earlier.Add water and mix it until the mixture is of uniform colour. The time of mixing shall not be less than 3 minutes & not more than 4 minutes. Immediately after mixing the mortar, place the mortar in the cube mould and prod with the help of the rod. The mortar shall be prodded 20 times in about 8 sec to ensure elimination of entrained air. If vibrator is used, the period

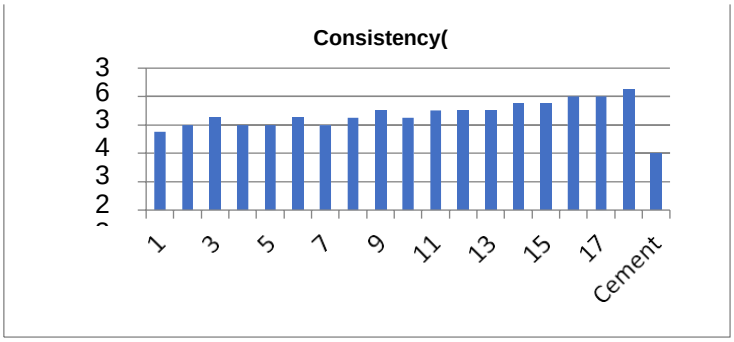
of vibration shall be 2 minutes at the specified speed of 12000 ± 400 vibrations /minutes. Then place the cube molds in temperature of 27±2° C and 90% relative humidity for 24 hours. After 24 hours remove the cubes from the mould and immediately submerge in clean water till testing. Take out the cubes from water just before testing. Testing should be done on their sides without any packing. The rate of loading should be 350 kg/cm^2/minute and uniform. Test should be conducted for 3 cubes and report the average value as the test result for 28 day compressive strength. Any Results from the above table whose values are above 53 N/mm^2 is a successful output than that of using OPC grade 53 cement. The 13th iteration has the highest of the compressive strength which contains 63% cement , 30% ggbs, 2% silica fumes and 5% fly ash.

- **Consistency Test**

TABLE NO : 03.Consistency Test Results.

Sample No.	Cement %	Silica %	Fly ash %	GGBS %	Consistency %
1	83	2	5	10	31.5
2	78	2	10	10	32
3	73	2	15	10	32.5
4	82	3	5	10	32
5	77	3	10	10	32
6	72	3	15	10	32.5
7	73	2	5	20	32
8	68	2	10	20	32.5
9	63	2	15	20	33
10	72	3	5	20	32.5
11	67	3	10	20	33
12	62	3	15	20	33
13	63	2	5	30	33
14	58	2	10	30	33.5
15	53	2	15	30	33.5
16	62	3	5	30	34
17	57	3	10	30	34
18	52	3	15	30	34.5

FIGURE NO: 3.1.Consistency Test.



GRAPH NO : 2 Consistency of Different Samples

The consistency test means how much amount of water is added to the cement. For that test we find the water percentage added to cement. The penetration ranges will come based on the water added to the cement. The consistency test mainly based on how much amount of water we added to cement. For particular amount of adding water what is the strength, workability, penetration etc. properties we find. So , "consistency" means how much amount of water added to the cement. The test that we have carried out, is by replacing some parts of cement with GGBS, Silica fumes and fly ash. From the results, it can be seen that the consistency values have increased gradually. We also come to understand that as the quantity of cement decreases in a mix, the consistency.

increases. This gives us a fair idea about how the replacement of cement by other cementitious materials effects the consistency of the mix. The highest value of consistency was achieved in the 18th iteration. In this iteration Cement was replaced with 3% Silica fumes, 15% of fly ash and 30% GGBS leaving only 52% cement in the mix. Hence, we understand that the combined role of Silica fumes, fly ash and GGBS in their maximum content raise consistency value in a brief manner.

IV. CONCLUSION

This experimental research has investigated the consistency and compressive strengths of the new mortar mixes. These mortar mixes were partially replaced by GGBS (10,20,30)% , Silica Fumes (2,3)% and Fly Ash (5,10,15)%.

1. The results of the consistency test showed an increase in the consistency values of the new partially replaced mortar mixes. The minimum consistency value i.e. 31.5, was achieved in mix number 1, in which the proportions of the cementitious materials were GGBS- 10%, Silica fumes- 2% and Fly Ash- 5%. The maximum consistency value obtained was 34.5 in mix number 18, in which the proportions of the cementitious materials were GGBS-30%, Silica Fumes- 3% and Fly Ash- 15%.
2. The results of compressive tests showed that five mixes gave compressive strength values greater than the regular 53 N/mm2 which is the standard Compressive value for OPC 53 grade cement. The increased values were found in mix numbers 7,10,13,14 and 17. The highest compressive strength value was found to be 60.19 N/mm2 in mix number 13.

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