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EXPERIMENTAL INVESTIGATION OF BLENDED CEMENT WITH SIGNIFICANT USE OF FLY ASH AND ALCCOFINE

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Abstract – *This study presents the tentative analysis carried out to appraise the mechanical and durability properties of cement mortar, i.e. compressive strength at 3 and 28 days, water absorption at 28 days, sulphate resistance at 7 and 28 days by replacing 50% cement with fly ash and alccofine (GGBFS) and at an interval of 3.5%. The quantity of alccofine was increased from 0% to 21% and amount of fly ash decreased from 50% to 29%. The results have shown that on increasing alccofine in mortar and decreasing fly ash in the mortar, the increase in strength was positive at various ages of 7 and 28 days till certain percentage i.e. 32.5% for fly ash and 17.5% of alccofine. The present study focuses the particular consideration to use of blended cement (ternary cement) in recent times, on various properties of cement and mortar.*

KEYWORDS: ***Blended*** **Cement, Fly ash, Alccofine, Magnesium Sulphate ($MgSO_4$). Compressive Strength, Sulphate Resistance.**

1.INTRODUCTION

One solution to this crisis lies in recycling waste into useful products to replace natural/commercial products wherever possible which will reduce the economic and environmental problem of waste disposal and also reduce the depletion of natural resources. Space limitations on existing landfill sites and the problem of waste stabilization have prompted investigations into alternative reuse techniques and disposal routes for waste materials. One of the practical ways to be adopted for reducing waste is recycling these wastes into useful products such as use in civil engineering constructions as bulk quantities of materials are used in a short time in civil engineering constructions like fly ash, GGBFS, silica fume and limestone etc.

1.1 BLENDED CEMENT

Hydraulic cement is made by replacing some of the cement in a concrete mix with activated aluminium silicates, pozzolanic such as fly ash, to activate cement setting in wet condition or underwater and further protects hardened concrete from chemical attack. Supplementary cementitious material such as fly ash and Alccofine can be used as supplementary materials to replace cement to make it blended cement. Blended cement is produced either by inter-grinding Portland cement clinker with the other materials or by a combination of cement and supplementary material. The blended cement is manufactured by adding pozzolanic or cementitious materials like fly ash, ground blast furnace slag (GGBFS) known as Accofine which is a type of GGBFS to Portland cement. The beneficial effect of the various cementitious materials are so significant that it can be used in reinforced concrete liable to corrosion in hot climates (which is the condition prevailing in entire India during most part of the year) thereby making it virtually necessary.

1.2 FLY ASH

Fly ash also known as flu-ash is one of the residues generated in combustion, and comprises of the fine particle that raises the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash product during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with the bottom sag removed from the bottom of the furnace in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2), (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

1.3 ALCCOFINE

Alccofine1203 is a new generation, Ultrafine, low calcium silicate product, manufactured in India. It has distinct

characteristics to enhance 'performance of concrete' in fresh and hardened stages. It can be considered as used as the practical substitute for silica fume as per the results obtained. If the advantages of accofine1203 are observed in the concrete mix design, the initial rate of strength development was found to increase or similar as that of silica fume.

1.4 OBJECTIVE

The objective of this work is to study the effect of fly ash and alccofine used as partial replacement of cement in mortar. In order to achieve the object, various mixes were designed varying the percentage of alccofine and fly ash of various grades as a replacement at 3.5%, 7.0%, 10.5%, 14.0%, 17.5% and 21.0% for alccofine and vice versa. Whereas for the fly ash from 50% to 29% respectively, at the interval of 3.5% except for 1st mix. Also, tests were carried out for hardened properties such as compressive strength and durability properties such as sulphate resistance, water absorption etc. The use of fly ash and alccofine materials in mortar and concrete can add many benefits that are directly related to the durability of these materials, besides the fact that is possible to reduce the quantities of cement in the composite.

1) The scope of the present study is confined to use fly ash and alccofine in a mortar by replacing some percentage of cement.

2) Effect of fly ash and alccofine on fresh properties and hardened properties in cement mortar.

3) The properties of cement mortars incorporating fly ash and alccofine were experimentally studied.

4) Finally, the experimental and theoretical results were used to relate knowledge on raw properties, the mix design tool and experiments.

2. LITERATURE REVIEW:

Yatin H Patel et al. (2013): He evaluated the performance of concrete (HPC) containing supplementary cementitious materials such as Fly ash & Alccofine. In this study, the effect of local Alccofine as supplementary cementing materials and filling materials on the strength and durability of concretes was investigated. From the results obtained in this study, the following conclusion can be drawn; we concluded that compressive strength achieved by using Alccofine (8%) + Fly Ash (20%) is 54.89Mpa and 72.97 Mpa at 28 and 56 days respectively. The minimum loss of weight and loss of compressive strength of concrete in Chloride Resistance test and Sea water test due to addition of Alccofine.

Alok Kumar et al. (2016): He established the influence of Alccofine 1206 a mineral admixture in concrete when it is mixed in cement concrete for the green state and hardened state i.e. for workability and strength of concrete using OPC (43 grade). Alccofine 1206 has been added to OPC which varies from 5% to 15% at interval of 5% by total weight of OPC and partial replacement of OPC (43 grade) by Alccofine 1206 which varies from 5% to 15% at interval of 5% by total weight of OPC. A total eighteen mixes (trial mix, control mix and variation mix) were prepared for grade M25 of concrete. This study investigates the performance of concrete mixture in terms of Compressive strength for 7days and 28 days, Flexural strength of beam 28 days and Splitting tensile strength of Cylinder for 28 days respectively of M-25 grade concrete. The addition levels of OPC by Alccofine 1206 were 5%, 10% and 15% where addition levels of 1% super-plasticizer was used in all the test specimens for better workability at lower water-binder ratio and to identify the sharp effects of Alccofine1206 on the properties of concrete. Water-binder ratio was kept 0.43 for all cases.

Siddharth p upadhyay et al. (2014): He described in this study that the effect of Alccofine as a complementary cementing material and filling material on the strength of concrete was investigated. The maximum compressive strength of concrete is achieved by using Alccofine 10% at Fly Ash 30%. In all mix proportions, strength gain up to 3 days is good. Between 3 to 7 days the strength gain is excellent. Between 7 to 28 days strength gain comparatively slow or less. Average compressive strength at 28 days for 0.5 w/c ratio gives 73.8 Mpa & 0.45 w/c gives 71.0 Mpa, Hence at aeging compressive strength increment is not that much marginal.

Vikas et al. (2015): In this study, he reported that the Fly ash and Alccofine have the potential to be the key to a brand new world in the field of construction and building materials. The role and application of the Alccofine with cementitious materials (fly ash) have been studied and discussed in details. The amount of alccofine was increased from 0% to 25% and amount of fly ash decreased from 50% to 25%, the increase in strength was positive at various ages of 3, 7, 28, 56, and 90 days till certain percentage of alccofine and fly ash. With the increase in the alccofine content strength increases but after a certain percentage, it starts decreasing with optimum strength achieved at 15% alccofine content.

Abhish M.S et al. (2015): He presented the laboratory investigations carried out on Portland pozzolana cement

(PPC) & Portland slag cement (PSC) both are blended cement (factory blended), 53 grade OPC concrete to study and compare the different parameters of concrete prepared from the above three types of cement and a comparison is made to ascertain the quality and performance of the concrete. The physical properties of ingredient materials were determined in accordance with IS specifications. The investigation is carried out for M30 grade of concrete mix with W/C ratio of 0.43, 0.41, 0.41 respectively. The design of concrete mix is carried out according to IS method. Tests are carried out for fresh concrete and hardened concrete according to IS code. It has been observed from experimental data that, the blended cement concrete is performing well when compared to conventional concrete.

Priyanka et al. (2013): She reported that the effect of water cement ratio on hardened properties of cement mortar with partial replacement of natural sand by manufactured sand is investigated. Designed mortar mix having proportion as 1:2, 1:3 and 1:6 with water-cement ratio of 0.5 and 0.55 respectively is used in the experimental study. Mortar cube specimens are tested for evaluation of compressive strength. The mortar exhibits excellent strength with 50% replacement of natural sand by manufactured sand. Results are compared with reference mix of 0% replacement of natural sand by manufactured sand. The compressive strength of cement mortar with 50% replacement of natural sand by manufactured sand reveals higher strength as compared to reference mix. The overall strength of mortar linearly increases for 0%, 50% replacement of natural sand by manufactured sand as compared with reference mix.

Seyed Mahmoodreza (2010): He evaluated the three sulfuric acid solutions with concentrations of 3%, 5% and 7% were used for examining the resistance of concrete specimens for a total exposure period of eight weeks. The performance of the degraded specimens was evaluated by measuring the weight loss, change in strength and visual assessment. The results of the weight loss and visual assessment reveal that the increase in the amount of MK would enhance the performance of concrete, while the inclusion of LF into MK concretes has shown positive results in terms of resistance against sulfuric acid attack. The mixtures with ternary binders of OPC, MK and LF experienced the lowest strength loss after exposure to high concentrations of sulfuric acid. Measuring the change of weight was found to be a better way to evaluate the resistance of concrete specimens immersed in sulfuric acid solutions as the results of the load bearing capacity can be affected by several parameters such as the variable geometry of degraded specimens. The rate of the water absorption of concrete with MK and LF was lower than the reference mixture with only Portland cement. The RCPT results also showed that the reference mixture had considerably higher permeability than other concrete mixtures. The results of the water porosity on degraded samples indicate that the inner parts of the concrete (not in contact with sulfuric acid) have remained sound and maintained their original pore structure after different exposure periods.

Dr M. Vijaya Sekhar et al. (2016): In this research, he presented the results of an experimental investigation carried out to evaluate the compressive strength of standard concrete. Standard concrete is made by ternary blending with partial replacement of cement by bottom ash and blast furnace slag in fine aggregate. In this study the bottom ash used in various proportions 10%, 20%, 30% in partial replacement of cement and that of alccofine 10% constant to the total weight of cement and blast furnace slag used in various proportions 20%, 30% and 40% in partial replacement of fine aggregate. The mix proportions of concrete had a constant water-binder ratio of 0.4 and super plasticizer was added based on the required degree of workability. The concrete specimens were cured on normal moist curing under normal atmospheric temperature. The compressive strength was determined at 7 days and 28 days. The results indicate the concrete made with these proportions generally show excellent fresh and hardened properties.

Mr.Shantanu Sureshrao Gholap (2014): He studied that the traditional, strength of concrete in construction work is evaluated in terms of its 28 days strength of cubes. This procedure requires 28 days of moist curing before testing as per IS: 516-1959[9]. This time duration may be considered as a long period. Hence, needs for an accelerated curing technique has arisen, where 28 days strength of concrete can be easily predicted. The main objective of this paper is to develop a mathematical model, which gives relation between accelerated curing strength and normal curing strength for 7 and 28 days compressive strength. Boiling water curing at 100˚ 3˚ C is applied to accelerate the strength gain of concrete for the early prediction of 7 days and 28 days compressive strength. Various concrete mixes in terms of cement (OPC), cement replacing materials like activated fly ash, Metakaolin was considered to prepared cube**s.**

3. PROPORTIONING OF MIXES:

The proportions of the mortar mix are in the ratio 1:3, where 1 part is cement and 3 parts are fine aggregates. The amount of replacement of cement is 50%. The various mixes are elected as given in Table below, the control mix with 100% cement was designated as CM and varying the

percentages of alccofine from 0% to 21% and fly ash 50% to 29%, simultaneously at the interval of 3.5%, other mixes were designated from M0 to M6. The sand was kept constant throughout and water was taken as per consistency of cement obtained.

TABLE-1 DETAILS OF VARIOUS MIXES

Sr. No	Mix	Cement (%)	Fly ash (%)	Alccofine (%)
1	CM	100%	0%	0%
2	M0	50%	50%	0%
3	M1	50%	46.5%	3.5%
4	M2	50%	43.5%	7.0%
5	M3	50%	39.5%	10.5%
6	M4	50%	36.0%	14.0%
7	M5	50%	32.5%	17.5%
8	M6	50%	29.0%	21.0%

2.1 PROCEDURE FOR STRENGTH

It is the most important material parameter used to characterize cement based products. Usually, the term strength implies a crushing strength of cubes cast in a steel moulds. Cube specimens of size 70.6mm × 70.6mm × 70.6mm were cast for compressive strength as per IS Code:4031 (part 6)-1998. After casting, all tests specimens were finished with steel trowel. Specimens were remoulded after 24 hours and then cured in water at approximately room temperature till testing. Compressive strength test for cubes was carried out at 7 and 28 days. All the specimens were tested in UTM. The compressive strength was calculated using the formula:

$$F_C=P/A$$

Where

F_c= compressive strength (N/mm^2)

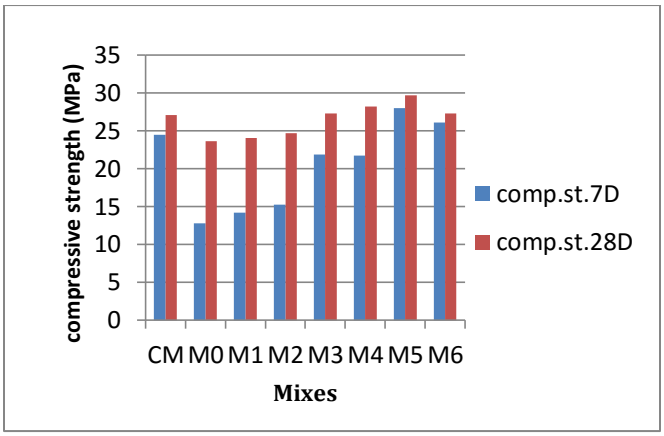
P= maximum load (KN)

A= cross section of the sample (mm^2)

TABLE-2 COMPRESSIVE STRENGTH OF VARIOUS MIXES AT DIFFERENT AGES (MPa)

		Compressive strength of mixes (Mpa)			
S.NO.	MIX	7 days	Variation decrease	28 days	Variation Decrease
1	CM	24.50	Reference	27.52	Reference
2	M0	12.81	47.71	23.61	14.20
3	M1	14.22	41.96	24.04	12.64
4	M2	15.27	37.67	24.70	10.24
5	M3	21.89	10.65	27.30	0.79
6	M4	21.77	11.14	28.19	2.43
7	M5	28.00	14.28	29.72	7.99
8	M6	26.10	6.53	27.31	0.76

CHART-1 COMPRESSIVE STRENGTH OF VARIOUS MIXES AT DIFFERENT AGES (MPa)



2.2 PROCEDURE FOR SULPHATE RESISTANCE

It is the most important material parameter used to characterize cement based products usually the term strength implies a crushing strength of cubes cast in steel moulds. Cube specimens of size 70.6 × 70.6 × 70.6mm were cast for compressive strength as per IS Code: 4031 (part 6)-1998. After casting all tests specimens were finished with a steel trowel. Specimens were remoulded after 24 hours and then cured in a solution of magnesium Sulphate ($MgSO_4$) at approximately room temperature till testing. Compressive strength test for cubes was carried out at 7 and 28 days. All the specimens were tested in UTM.

TABLE-3 SULPHATE RESISTANCE VALUES FOR VARIOUS MIXES

Sr. No.	Mix	7 D	7 D with $MgSO_4$	V.D	28 D	28 D with $MgSO_4$	V.D
1	CM	24.50	25.56	4.32	27.52	25.40	7.70
2	M0	12.81	9.74	23.96	23.61	16.02	32.14
3	M1	14.22	11.04	22.36	24.04	16.84	29.95
4	M2	15.27	12.23	19.90	24.70	17.31	29.91
5	M3	21.89	17.42	20.42	27.30	19.84	27.43
6	M4	21.77	17.90	17.77	28.19	21.20	24.79
7	M5	28.00	23.42	16.32	29.72	23.03	22.51
8	M6	26.10	22.42	14.09	27.31	22.44	17.83

Whereas,

7D- stands for 7 days

28D- stands for 28 days

V.D- variation decrease

Chart-2 SULPHATE RESISTANCE FOR 7 DAYS

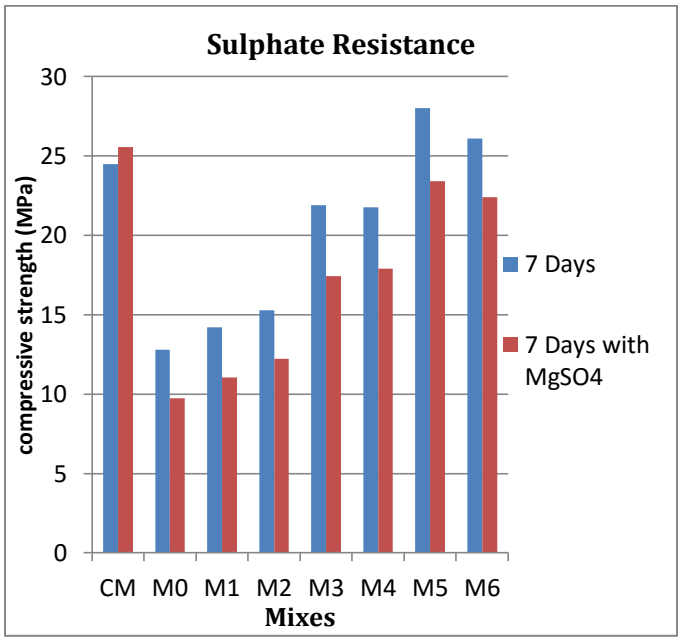
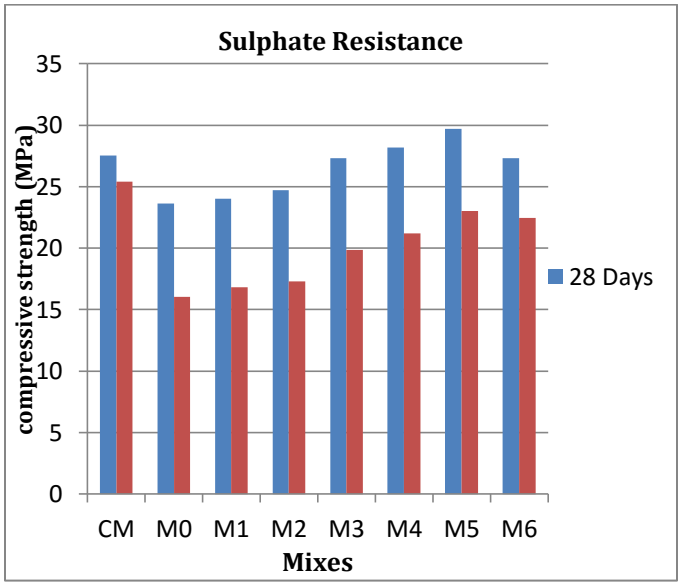


CHART-3 SULPHATE RESISTANCE FOR 28 DAYS



2.3 WATER ABSORPTION TEST PROCEDURE

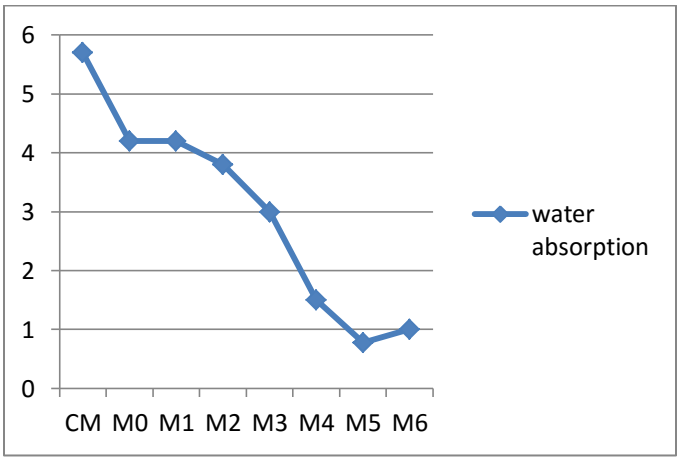
The cubes specimen, were placed for curing in water for 28 days. After 28 days were completed, the cubes specimens were taken outweighed. The weight of specimen after curing minus the weight of specimen before curing is considered as the water absorbed by specimens.

Water absorbed = weight after curing – weight before curing

Table-4 water absorption at 28 days

S. No.	MIX	Water absorption 28 days (%)
1	CM	5.7
2	M0	4.2
3	M1	4.2
4	M2	3.8
5	M3	3.0
6	M4	1.5
7	M5	0.78
8	M6	1.0

CHART-4 PERCENTAGE WATER ABSORPTION OF VARIOUS MIXES



3. CONCLUSIONS

It is apparent that ternary cementitious blends of ordinary Portland cement (OPC), Alccofine, and fly ash offer significant advantages over blends and even greater enhancements over plain Portland cement. The combination of alccofine and fly ash is complementary, the alccofine improves the early age performance of mortar with fly ash continuously refining the properties of the mortar as it measures.In terms of durability, such blends are vastly superior to ordinary Portland cement mortar. Based on the scope, materials, techniques, procedures and other parameters associated with this work, the following conclusions and recommendations can be drawn.

1) The blended cement mixes show more deterioration in magnesium sulphate exposure in compared to plain cement mixes.

2) The deterioration of mixes increases in the concentration of sulphate.

3) Fly ash and alccofine modified the characteristics of fresh mortar.

4) With the increase in the alccofine content strength increases but after some percentage, it starts decreasing with optimum strength achieved at 17.5% alccofine content.

5) Incorporating alccofine to cement mortar mixtures generally enhance their mechanical properties.

6) Enhancement in early age strength of mortar (at optimum level) by incorporation of alccofine was observed.

7) The increase in the percentage/amount of alccofine decreases the water absorption of motor specimens. It can be the result of the enhancement in permeability mechanism of mortar specimens. It can be a result of the enhancement in permeability mechanism of mortar due to super-pozzolanic of alccofine particles.

8) The optimum max was M4 in which the percentage of fly ash was 32.5% and alccofine was 17.5% with 50% of cement content replacement which gives a strength closest to the control mix by using this mix the energy consumption can be reduced for the manufacturing of cement on replacement by 50% of fly ash and alccofine with waste materials, which will require less energy for the manufacturing and thus it would be sustainable to use.

4. ACKNOWLEDGEMENT

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