International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 10 | Oct 2021 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Self Curing Concrete with Partial Replacement of Binding Material with Silica Fume & Metakaolin and Sand with GGBS

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Abstract - *Water is becoming increasingly scarce, there is a pressing need to conduct research into water conservation in concrete and building. Curing concrete entails maintaining an acceptable moisture content in the early stages of curing in order for the necessary qualities to emerge. The ingredients of concrete are binding material (cement), aggregate (coarse & fine) and water. Present era; the cement and sand are now becoming a non-renewable material because of lack of limestone deposits and sand in rivers or streams. Even thought, while production of cement (OPC) a lot of CO_2 emission causes to global warming and air pollution. Although, the necessity of concrete increasing day by day. Despite the worrying water constraint, concrete manufacture requires a significant amount of water, as water is required for the 28-day curing of concrete parts. Loss of strength and deterioration of concrete structures are caused by reductions in water content, such as water needed areas, neglect in watering, presence of salts, and so on.*

Key Words: Self-Curing concrete, Silica fume, Metakaolin, GGBS and PEG-400.

1.INTRODUCTION

In modern time, construction is the main part of structural development of the nation. Concrete is the important part of construction whose manufacturing composed of components such as cement, aggregates, water, admixtures. Self-curing plays an important role in strength development and durability of concrete. Self-curing occurs immediately after concrete placement and finishing, and it entails maintaining desired moisture and temperature conditions for extended periods of time, both at depth and near the surface. A sufficient amount of moisture is present in properly cured concrete for ongoing hydration and the development of strength, volume stability, freezing and thawing resistance, abrasion and scaling resistance. Self-curing is another term for internal curing. Adding self-curing chemicals to concrete makes it self-curing. Self-curing chemicals are used to prevent water from

evaporating from concrete and so increase its water retention capacity.

2. LITERATURE REVIEW

M.Vidhya et. al (2017) [1]: In this paper investigated the fresh and hardened properties of concrete by adding 15% silica fume instead of cement, extract from Calotropis Gigantea and Cypress tree bark. Calotropis Gigantea started from 0.2% to 0.4% with gradual increase of 0.1%. 15% extract water of cypress bark used instead of mixing water. Good result from 0.4% Calotropis Gigantea, 15% and Cypress tree bark and 15% silica fume at the age of 7 day and 28day is greater than the conventional concrete.

Jakkam Snehavi (2018) [2]: Studied on self-curing concrete with replacement of cement with Fly ash & Silica Fume and sand with Quarry dust. It evaluates the use Fosroc Concure Wb White of as self-curing agents. Self-curing concrete of M30 grade were cast by replacing fine aggregate with 50% quarry dust and by varying quantity of fly ash and silica fume by 5%, 10%, 15%,20% and 25%. The result carried out for M30 grade of concrete the max compressive strength achieved when 5% of flyash and silica fume is replacements of fly ash and silica fume is replaced by the weight of cement. Split tensile strength of concrete test on cylinder at different replacement of flyash and silica fume for 28days has highest strength at 10% and 5%.

Shaik Hydrail (2019) [3]: Examined the effect on concrete by partial replacement of cement with fly ash and rice husk ash and sand with copper slag for M25 grade concrete and instead of traditional curing method, a new method of curing is adopted i.e., self-curing by using Polyethylene Glycol 400 (PEG-400). The adopted methodology is the cement is replaced by FA & RHA in equal proportion i.e., 5, 7.5, 10, 12.5 & 15% by weight of cement and sand is replaced by CS as 20, 40, 60, 80 & 100%. The PEG-400 is added to the concrete by 1.0% by weight of binding material. The result carried out the 20% binding material & 60% FA showed the optimum values for strength.

T Udayabanu et. al (2020) [4]: Studied on the self-curing concrete using water-soluble polymer for developing countries. This study deals with the investigation on self-curing concrete with added % of PEG400 by weight of cement from 0% to 15% as the quantity for self-curing component. Test results were investigated and compared with conventional and self-cured concrete compressive, flexural and split tensile strength for M20 grade mix. The result found thePEG400 provides good results of self-curing concrete.

S. Sebastin et. al (2021) [5]: Studied on mechanical properties of self- curing concrete with partial replacement of granite powder as fine aggregate. The 0.5% of SAP is kept as a consistent amount all through the test. The granite powder is included in steps of 5% from rate of 25%. The concrete mix made utilizing granite powder as partial substitution of sand appeared great workability and smoothness comparable to ordinary concrete mixes.

3. EXPERIMENTAL WORK

3.1 MIX DESIGN

Mix details of Self-Curing Concrete

MIX DESGIN FOR M25 GRADE CONCRETE

Table A: Mix Details of M25 Grade concrete

Water	Cement	Fine aggregate	Coarse aggregate
186kg/m^3	392kg/m^3	555kg/m^3	1167kg/m^3
0.475	1	1.42	2.98

3.2 MATERIAL USED

3.2.1 Cement: The cement used in the present investigation is Ordinary Portland Cement (OPC 43). Ordinary Portland cement is a binding substance with cohesive and adhesive qualities that allows it to bind together various construction materials and compacted assemblies. The initial setting time of binding material is not less than 30 minutes & final setting time not greater than 10 hours.

3.2.2 Fine Aggregate: Aggregates are those materials, which when bounded together by cement, from mortar or concrete. Fine sediments that passed through a 4.75 mm screen were sourced from a nearby river. Aggregate provides better durability & greater volume stability to concrete. Fine aggregate fills up the voids in coarse aggregates & thus strong concrete with less quantity of cement is obtained by using fine aggregate.

3.2.3 Coarse Aggregate: Locally available coarse aggregate was used. Tests such as the specific gravity, fineness modulus sieve analysis were conducted to find the physical properties of coarse aggregate according to IS: 383-1970.

3.2.4 Silica Fume: Condensed silica fume is also known as micro silica, is an amorphous powder which, when added with standard cements will increase the durability and strength of the concrete as well as enhancing abrasion-erosion resistance and lowering permeability. Silica fume may also be used in many applications where high strength is required. The reduction of high-quality quartz with coal or coke and wood chips in an electric arc furnace during the manufacturing of silicon metal or silicon alloys produces silica fume as a byproduct

3.2.5 Metakaolin: Metakaolin is another pozzolanic materials which is manufacture from selected kaolin's, after refinement and calcination under specific conditions. It is a very effective pozzolana that, via a pozzolanic reaction, rapidly combines with excess calcium hydroxide produced by OPC hydration to create calcium silicate hydrates and calcium aluminosilicate hydrate.

3.2.6 GGBS: Ground granulated blast-furnace slag, is a byproduct of iron in blast-furnace. It largely consists of melted calcium silicate and aluminosilicate that had to be taken from the blast furnace on a regular basis. Ground granulated blast-furnace slag has pozzolanic qualities and is used in the building sector as an activator in conjunction with cement or lime.

3.2.7 Polyethylene glycol (PEG)-400: Polyethylene glycol could be a condensation chemical compound of ethene chemical compound and water the overall formula H-(OCH2CH2) n-OH, where n is the average number of repeated oxy-ethylene groups, which ranges between 4 and 180. The fact that PEG is water soluble is one of its most notable characteristics.

3.2.8 Water: Portable water was used in this investigation according to Indian standard code, IS 456-2000. Because it actively participates in the chemical reaction with cement, water is a significant component of concrete. It is the last expensive ingredient of concrete mix. Water should be free of alkalis, acids, oils, salts, sugar, organic materials, plant growth, and other things that could harm bricks, stone, concrete, or steel.

3.3 METHODOLOGY

The adopted methodology was to compare the results between conventional M25 grade self-curing concrete and the replacements of Self-Curing concrete by trails. The entire execution of concrete was divided as following trails.

Trial M– Conventional concrete without self-curing agent PEG-400

Trial M_0– Conventional concrete with self-curing agent PEG-400

Trial M_1 – Replacement of cement 5% of SF, 10% of metakaolin and FA 40% of GGBS

Trial M_2– Replacement of cement 5% of SF, 15% of metakaolin and FA 40% of GGBS

Trial M_3- Replacement of cement 5% of SF, 20% of metakaolin and FA 40% of GGBS

Trial M_4- Replacement of cement 6.5% of SF, 10% of metakaolin and FA 40% of GGBS

Trial M_5- Replacement of cement 6.5% of SF, 15% of metakaolin and FA 40% of GGBS

Trial M_6- Replacement of cement 6.5% of SF, 20% of metakaolin and FA 40% of GGBS

Trial M_7- Replacement of cement 8% of SF, 10% of metakaolin and FA 40% of GGBS

Trial M_8- Replacement of cement 8% of SF, 15% of metakaolin and FA 40% of GGBS

Trial M_9- Replacement of cement 8% of SF, 20% of metakaolin and FA 40% of GGBS

In Trail M_0 to Trail M_9 additionally added 1.5% of PEG-400 by weight of binding material.

4. RESULTS AND DISCUSSION

4.1 COMPRESSIVE STRENGTH OF CONCRETE

Compressive strength of concrete mix without and with replacing material admixtures were tested at the ages of 7 days and 28 days by using CTM (compression testing machine). The 7 days and 28 days compressive strength value of samples were studied in tabular form.

MIX	Average Compressive Strength of Concrete in N/mm²	
	7DAYS	28DAYS
M	17.50	26.72
M_0	21.92	34.56
M_1	23.43	36.42
M_2	26.67	47.72
M_3	24.72	35.33
M_4	25.30	50.46
M_5	32.23	52.75
M_6	27.18	48.75
M_7	25.83	45.36
M_8	27.16	48.65
M_9	24.86	47.82

Table 1: Shows Average Compressive Strength of Concrete After Various Ages In N/mm²

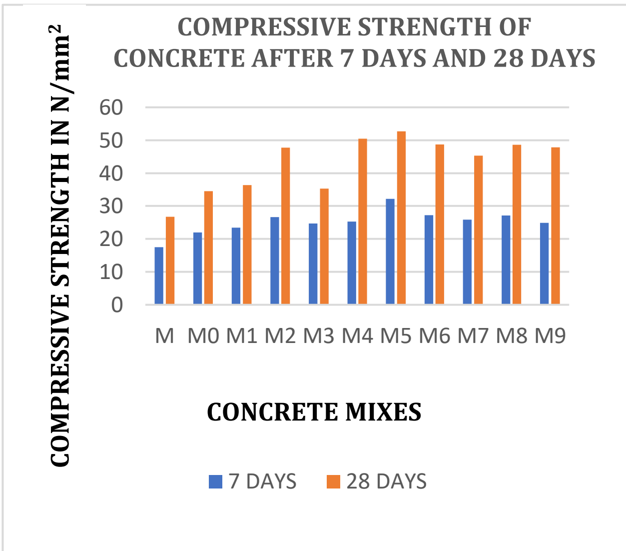

CHART 1: BAR CHART OF COMPRESSIVE STRENGTH OF CONCRETE

4.2 SPLIT TENSILE STRENGTH OF CONCRETE

The split strength of the concrete mix was tested at the ages of 7 days and 28 days, by using compression testing machine. The size of the cylinders was 150 x 300mm. The split tensile strength of concrete without and with replacing material, admixtures was increased 7 days and 28 days. With addition of PEG-400 split tensile strength was also increased. The results of Self-curing concrete at the age of 7days and 28days, were studied in tabular form

Table 2: Shows Average Split Tensile Strength of Concrete after various ages in N/mm²

MIX	Average Compressive strength of concrete in N/mm²	
	7DAYS	28DAYS
M	2.15	3.11
M_0	2.70	3.26
M_1	2.25	3.28
M_2	2.62	3.43
M_3	2.54	3.61
M_4	2.57	3.72
M_5	2.81	3.90
M_6	2.50	3.73
M_7	2.52	3.51
M_8	2.82	3.70
M_9	2.45	3.22

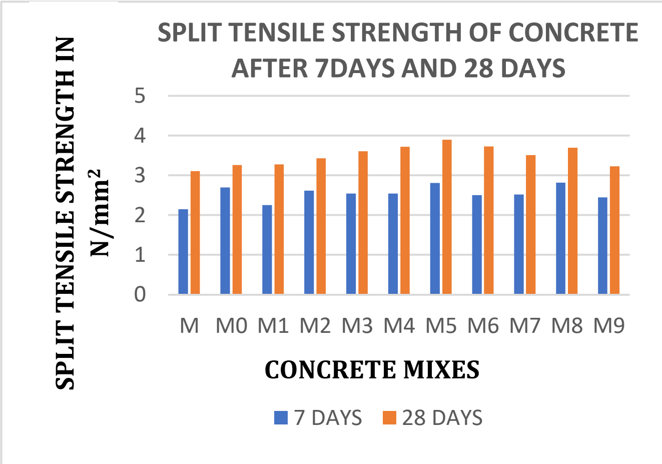

CHART 2: BAR CHART OF SPLIT TENSILE STRENGTH OF CONCRETE

4.3 FLEXURAL STRENGTH OF CONCRETE

Flexural strength is also measured a tensile strength of concrete. In practical, concrete may be subjected to flexural in many cases especially in beams. The flexural strength of the concrete mix was measured at ages of 7 days and 28 days by using universal testing machine. The size of the beam was (150mm x150mm x750mm).

Table 3: Shows Average Flexural Strength of Concrete after various ages in N/mm²

MIX	Average Flexural strength of concrete in N/mm²	
	7DAYS	28DAYS
M	4.29	6.26
M_0	4.62	6.86
M_1	6.96	8.91
M_2	7.89	9.75
M_3	7.43	9.33
M_4	8.12	9.89
M_5	8.82	10.45
M_6	7.90	9.93
M_7	7.74	9.55
M_8	8.22	10.05
M_9	7.98	9.72

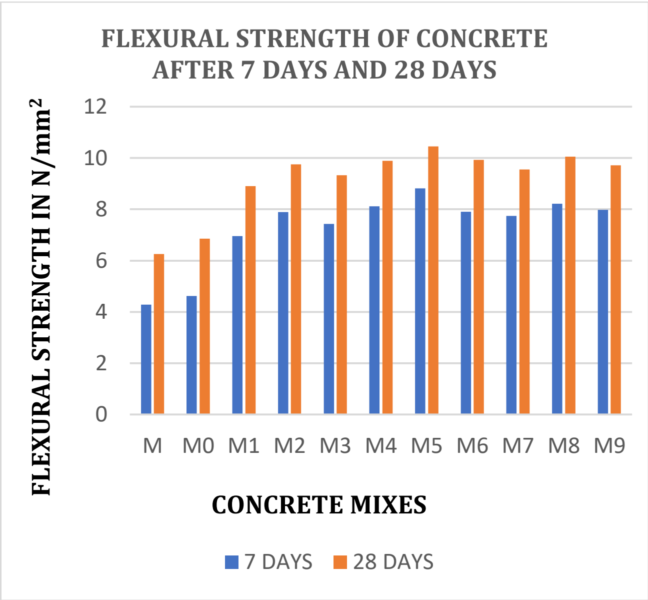

CHART 4: BAR CHART OF FLEXURAL STRENGTH OF CONCRETE

5. CONCLUSIONS

i. Silica fume and metakaolin are used as an accumulative in various percentages by weight of cement.

ii. Strength and durability test were conducted on self-curing concrete and the results shown that there is a 52.75 increase in compressive strength on addition of 6.5% silica fume and 15% metakaolin (M25) by weight of cement.

iii. Strength and durability test were conducted on self-curing concrete and the results shown that there is a 3.90 increase in split tensile strength on addition of 6.5% silica fume and 15% metakaolin (M25) by weight of cement.

iv. Strength and durability test were conducted on self-curing concrete and the results show that there is a 10.45 increase in flexural strength on addition of 6.5% silica fume and 15% metakaolin (M25) by weight of cement.

v. Addition of 6.5% silica fume, 15% metakaolin by weight of cement and 60% GGBS by weight of fine aggregate shows better results in strength as compared to other percentage.

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