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EXPERIMENTAL STUDY ON FRC BY PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME AND FLY ASH USING PEG-400

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Abstract— In the construction industry, mainly the production of Portland cement will cause the emission of pollutants resulting in environmental pollution which is reduced by increasing the usage of industrial by products in cement. Industrial by product such as Fly Ash & Silica Fume are cementitious material used as partial replacement for cement in concrete to produce high strength in concrete. Curing in concrete plays a main role in developing strength of concrete and it helps in maintaining moisture content in concrete during its early ages in order to increase the required properties.A concrete curing agent forms a membrane over the top of the concrete while. This stops the water on the surface of the concrete evaporating too quickly and hence helps to reduce cracking and dusting. Since concrete curing agent manages the behaviour of water in the concrete. The present experiment is carried out to investigate the effect of different curing agents on FRC with replacement of cement by silica fume at 10% and fly ash as (20% & 30%). Tests to be conducted by adding 1% of steel fibers. And different dosages of curing agent polyethylene glycol-400 as (0.5%, 1% & 1.5%) weight of water.

Keywords— silica fume, Fly ash, M-Sand, steel fibers, curing agents (polyethylene glycol-400) and water reducing admixture (conplast sp-430 BIS).

I. INTRODUCTION

Concrete is a very essential building material used extensively in the construction industry worldwide, thanks to its strength properties. Hardening of concrete plays an essential role in the durability plus other performance of concrete. Due to incorrect curing in concrete. The main characteristics of concrete effects. Due to modernization in the construction industry and due to lack of water. External curing becomes difficult now, so it will be necessary to find alternative curing methods for concrete. So self-curing of concrete is a standout amongst other techniques now days to accomplish the quality and additionally the toughness properties of concrete by utilizing numerous building chemicals accessible available we can accomplish self-solidifying. Curing is the way controlling the level of dampness misfortune from concrete amid hydration of concrete by reasonable curing strategies we can accomplish attractive quality properties. Down to earth cure isn't generally conceivable; however poor curing procedure will influence quality properties and solidness properties with the goal that self-curing techniques are produced. By including self-cured substances, the inside water stores have been made in crisp concrete advances the one that has been discharged continuously at the season of hydration.

II. LITERATURE REVIEW

[1] C.Agalya.et.al.
In this experiment materials used are cement, FA, CA, water, PEG-400 & super plasticizer.
The PEG-400 varies from 1%, 1.5% and 2% and the steel fibers 2% added in concrete compared with the conventional mix. In the strength parameters namely Compressive Strength, Split Tensile Strength, and Flexural Strength were determined at 7days, 14 days, and 28 days for different dosage of fiber/self-curing agent and compared with conventional concrete.
The workability of concrete is maintained by adding 0.5% of super plasticizer. The compressive strength was high at 1.5% adding of Polyethylene Glycol-400 and 2% of Steel fiber with increased strength in 25.94N/mm2 compared with conventional concrete. The percentage increasing was 4.13% when compared with conventional mix. The Split Tensile Strength was high at 1.5% adding of Polyethylene Glycol-400 and 2% of Steel fiber with increased strength in 24.8N/mm2 compared with conventional concrete. The percentage increasing was 4.49% when compared with conventional mix.

[2] **M V Jagannadha Kumal.et.al.**
In this project materials used are cement, microsilica, FA water, superplastcizer & PEG-400.
The optimum dosage of polyethylene glycol (PEG) (expressed in percentage by weight of cement) for M20, M40 and M60 grades self-curing concrete are 1%, 0.5% and 0.5% respectively.

It is observed that as grade increases workability decreases in self-curing concrete mixes. Similarly as dosage of polyethylene glycol (PEG) increases, workability increased. The optimum dosage of polyethylene glycol (PEG) (expressed in percentage by weight of cement) for M20, M40 and M60 grades self-curing concrete are 0.5%, 1% and 1.5%respectively.There is a significant increase in the compressive, split-tensile and flexural strength properties.
Self-curing concrete mixes at all ages of curing when compared to normal externally cured concrete mixes.

[3] Dr.S.Sundararaman.et.al.
In this project the materials used are cement, fly ash, silica fume, FA, CA & water.
Fly ash and silica fume can be used as filler and helps to reduce the total voids contentin concrete.M30 grade concrete mixes of different Fly ash levels (0% to 60% replacement of cement) and silica fume of 10% with w/c ratio of 0.45 were prepared.
The mixes were designated in accordance with IS: 10262-2009.A total of 27 concrete cubes and 27 cylinders were casted for the different percentages of replacement of cement. The specimens were demoded after 24 hours and curing was done for different age of testing. They were tested for their strength properties on 3rd, 7thand 28thday.
Compressive and split tensile strength showed an increased value with the fly ash is replaced up to 50% at the end of 28 days. Compressive and split tensile strength reduces when cement replaced by fly ash percentage is increased beyond 50% at the end of 28 days. It can be concluded that replacement of cement with silica fume up to 10 % and 50% of fly ash replacement would render the concrete more strong and durable.

[4] Shikha Tyagi.et.al.
In this project materials used are cement, FA, CA, water & PEG-400.
In this study the percentage of PEG by weight of cement from 0% to 2% as the dosage of internal curing compound was fixed .The test results were studied both for M25 and M40 mixes.
Tests conducted on workability (slump & compaction factor) & compressive strength is studied.
The optimum dosage of PEG400 for maximum strength was found to be 1% for M25 and 0.5%for M40 grade. As percentage of PEG400 increased slump increased forM25 and M40 grades of concrete. From the workability test results, it was found that the self-curing agent improved workability.

III. OBJECTIVES

- To develop the mix proportions for M30 grade concrete with partially replacement of cement with fly ash & Silica fume as well as addition of fibers and PEG-400.
- To study the properties of concrete by cement with partially replaced by silica flume and fly ash using PEG-400 by weight of water.
- To study the effect of PEG-400 on the compressive strength and split tensile strength tests of harden concrete.
- To find the optimum dosage of PEG-400.
- To find the optimum replacement of cement with fly ash.

IV. MATERIALS USED

4.1 General: In this research work number of cubes and cylinders are cast and tested at 3, 7 and 28 days respectively, for finding out the compression strength and split tensile test.

4.2 Cement:-In this research work 53 grades OPC is used for all concreting purposes. The tests on cement were done as per standard codal provisions.

Table 1:- physical properties

Properties	Results of conducted Tests
specific gravity	3.13
Normal consistency	30%
IST	50min
FST	400min
Fineness	5%

4.3 Fly Ash:-Fly ash will be collected from RTPS (Raichur Thermal power station). The test on fly ash is done as per IS:3812-2003, varied at (20% & 30%) in this project.

Table 2:- Physical properties of Fly ash

Properties	Tests Results
Specific Gravity	2.05
Fineness	350 m^2/kg

Table 3:- Chemical composition of Fly ash

Constituents	Percentage
Silica	55-60
Alumina	20-35
Calcium oxide	5-15
Ferric oxide	4-18
Loss on ignition	1-5

4.4 Silica Fume(SiO2):silica fume is a by product obtained from the reduction of high-purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or silicon alloy, specific gravity is 2.29, used at 10% in this project.

Table 4:- Chemical properties of Silica Fume

Constituents	Percentage (%)
SiO_2	90-96
$Al2O_3$	0.5-0.8
Fe_2O_3	0.2-0.8
MgO	0.5-1.5
CaO	0.1-0.5
Na_2O	0.2-0.7
K_2O	0.4-1

4.5 Steel Fibers: In this experiment amount of Crimped fibers to be used is (1%), Addition of steel fibers improves the mechanical properties of concrete in the all mixes. Available dimension of crimped fiber is length= 50mm, Aspect Ratio= 50 & diameter= 1mm.

4.6 Coarse Aggregates (CA): The coarse aggregate to be used in this project having size more then 4.75mm, 20mm down size aggregate are utilized.

Table 5:- Physical property of Coarse Aggregate

Properties	Results of the test conducted
Specific Gravity	2.78
Bulk Density(kg/m^3)	2086
Water absorption (%)	0.9

4.7 Fine Aggregate (FA): All the researchers have used locally available river sand as fine aggregate. This sand confirming to grading Zone II of IS:383-1970.

Table 6:- Physical property of Fine Aggregate

Properties	Results of the test conducted
Specific Gravity	2.77
FM	3.36
Water absorption(%)	0.8

4.8 Manufactured-Sand: In this Natural Sand is partially replaced by manufactured sand (50%), specific gravity range of M-sand is similar to natural sand.

4.9 Super plasticizer: A commercially available sulphated naphthalene formaldehyde based super plasticizer (Complots SP-430) will be used as an chemical admixture to enhance the workability of concrete. Used at 1% of weight of cement.

4.10 Poly Ethylene Glycol-400(PEG-400): In this examination work PEG is utilized as water based curing operator.PEG is a condensation polymer of ethylene oxide and water with the general formula H(OCH2CH2)nOH, where

n is the average number of repeating polyethylene groups from 4 to about 180. PEG is a non-toxic, odourless, neutral, lubricating, non-volatile, non-irritating. Thus, it is a shrinkage reducing agent. Polyethylene glycol used in this project is (0.5%, 1% & 1.5%) at weight of water. Appearance is clear liquid.

Table 7:- Properties of PEG-400

Properties	Values
Molecular weight	400
Specific gravity	1.13

4.11 Water: In this work portable water is used for the purpose of mixing.

V. MIX DESIGN FOR M_{30} GRADE CONCRETE

The experimental program was designed to compare the mechanical properties i.e. compressive strength and split tensile strength of high strength concrete with an M_{30} grade of concrete and with different replacement level of OPC-53 grade with silica fume 10% and fly ash (20% & 30%). With the addition of fibers by 1% and curing agent PEG-400 is added at (0.5%, 1%, 1.5%).

Table 8: -Mix Proportion *(*kg/m^3) and Mix Ratio of M30 Grade Concrete.

Cement	Fine Aggregate	Coarse Aggregate	Water
372.41	699.945	1250.1	167.586
1	1.87	3.35	0.45

Table 9:-Trial mix proportions Polyethylene Glycol-400 as curing agent, Fly ash 20%

Proportions	Fly ash	Silica fume	Fibers	Curing agent(PEG-400)
Mix-1(M_1)	20%	10%	1%	0.5%
Mix-2(M_2)	20%	10%	1%	0.1%
Mix-3(M_3)	20%	10%	1%	1.5%

Table 10:-Trial mix proportions Polyethylene Glycol-400 as a curing agent, Fly ash 30%

Proportions	Fly ash	Silica fume	Fibers	Curing agent(PEG-400)
Mix-1(M_1)	30%	10%	1%	0.5%
Mix-2(M_2)	30%	10%	1%	0.1%
Mix-3(M_3)	30%	10%	1%	1.5%

VI. RESULTS AND DISCUSSION

6.1 Tests on Fresh Properties of Concrete

The fresh property of concrete test is usually performed to verify the workability characteristics of mixed fresh concrete of any quality on site prior to concreting. In this project, the slump cone test and compaction factor are performed to find workability for added M50 grade concrete by partially replacing the fly ash, Meta kaolin as a cement and adding a curing agent and fibers

6.1.1 Compaction Factor Test

Workability gives an idea of the capability of being worked. That workability of concrete can be found out by compaction factor test. This test consist of essentially applying a standard measure of work to standard nature of concrete and estimating the resultant compaction

6.1.2 Slump cone test

Vertical settlement of unsupported concrete is known as slump. Slump will measure the consistency or workability of concrete mix. Normally concrete is designed for certain workability in terms of slump depending upon site requirement.

Table 11:- Results of compaction factor and slump cone for curing agent PEG-400, Fly Ash 20%

Mix Designation	Compaction factor	Slump(mm)
M0	0.85	75
M1	0.90	88
M2	0.92	95
M3	0.95	103

Table 12:- Results of compaction factor and slump cone for curing agent PEG-400, Fly Ash 30%

Mix Designation	Compaction factor	Slump(mm)
M0	0.85	75
M1	0.83	83
M2	0.89	90
M3	0.92	97

6.2 Tests on Hardened Concrete

The test on hardened concrete is agreed out to verify the strength characteristics of concrete and so. In this project, two tests are performed for different mixtures namely Compressive and split tensile strength tests.

6.2.1 Compressive strength

This is one of the essential properties of the concrete. Alternate properties of concrete have unmistakable association with compressive strength. On the off chance that the compressive strength of concrete is enhanced at that point there is change in different properties of concrete, in this manner compressive strength of the concrete is basic test.

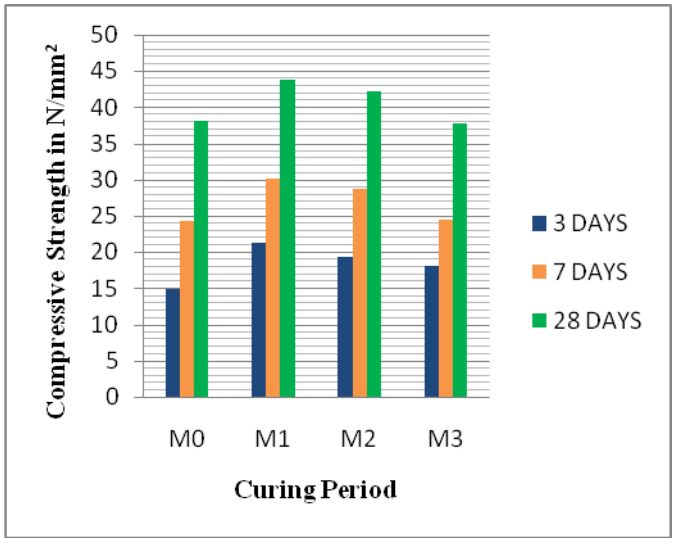
Cube of size 150*150*150mm are casted according to different mix proportions of this research work. After curing for number of days these cubes are tested in a compressive machine, to get a desired compressive strength for different days of curing.

Table 13:- Compressive Strength for curing agent PEG-400, Fly ash 20%

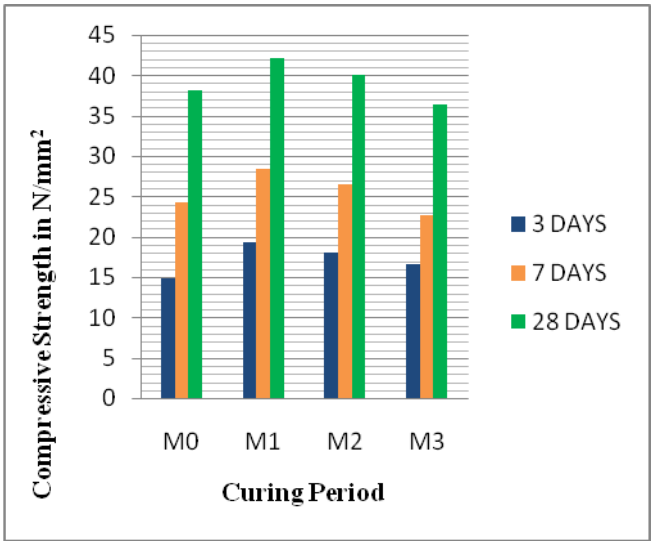
Type of mixes	3 Days N/mm^2	7 Days N/mm^2	28 Days N/mm^2
M_0	14.90	24.28	38.09
M_1	21.23	30.07	43.84
M_2	19.33	28.67	42.13
M_3	18.07	24.48	37.85

Table 14:- Compressive Strength for curing agent PEG-400, Fly ash 30%

Type of mixes	3 Days N/mm^2	7 Days N/mm^2	28 Days N/mm^2
M_0	14.90	24.28	38.09
M_1	19.25	28.47	42.20
M_2	17.99	26.48	40.13
M_3	16.64	22.69	36.41



Graph 1:- Compressive Strength for Curing Agent PEG-400, Fly ash 20%



Graph 2:- Compressive Strength for Curing Agent PEG-400, Fly ash 30%

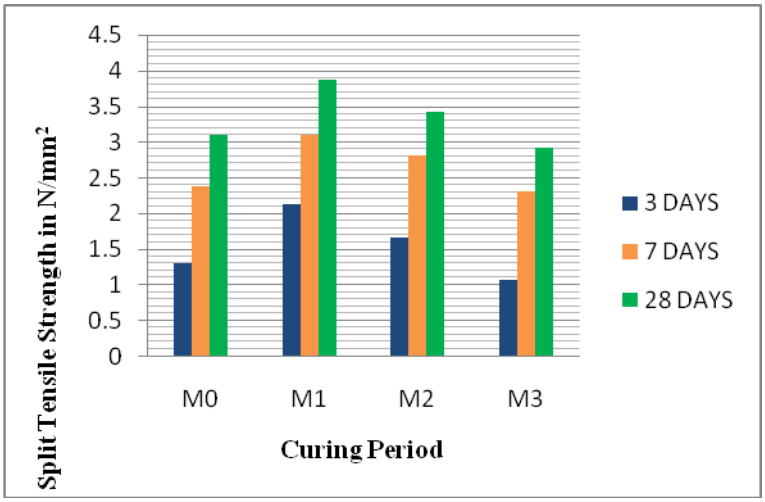
6.2.2 Split Tensile Strength

The tensile strength is one of the fundamental & significant property of concrete. The concrete is not frequently accepted to oppose the direct tension since of its low tensile strength and delicate nature. Therefore, in design of structure concrete is exploited so as not to rely on its tensile strength which is low. since, most structural concrete contains steel reinforcement which takes care of tensile strength.

To perform this test cylindrical mould of size 150mm diameter, 300mm height is taken and concrete is casted, then the specimen is tested in compressive testing machine at 3.7 and 28 days. Respectively

Table 14:- Split tensile Strength for curing agent PEG-400, Fly ash 20%

Type of mixes	3 Days N/mm^2	7 Days N/mm^2	28 Days N/mm^2
M_0	1.3	2.39	3.10
M_1	2.13	3.10	3.87
M_2	1.66	2.82	3.42
M_3	1.08	2.31	2.39



Graph 3:- Split Tensile Strength for Curing Agent PEG-400, Fly ash 20%

VII. CONCLUSION

1. In this research, the fresh property of M_{30} grade concrete that is workability is goes on increasing by the increase in the curing agent PEG-400.
2. The compressive strength of concrete after 28 days of curing agent PEG-400, with fly ash 20% is more effective than compare to PEG-400, with fly ash 30%.
3. The compressive strength of concrete with curing agent PEG-400, with fly ash 20% was found to increase by 10.1% than conventional concrete mix after 28 days, i.e.Mix-1.
4. The optimum dosage of curing agent PEG-400 was found to be 0.5% by weight of water.
5. The compressive strength is higher when fly ash is 20% replaced with cement.
6. The compressive strength of concrete with curing agent PEG-400, with fly ash 30% was found to increase by 6.7% than conventional concrete mix after 28 days, i.e.Mix-1.
7. Split tensile strength for concrete using curing agent PEG-400, with fly ash 20% was found to increase by 12.8% than conventional concrete mix after 28 days, i.e.Mix-1.
8. The split tensile strength and compressive strength is higher when fly ash is 20% replaced with cement.
9. By using of crimped steel fiber 1% we observed that split tensile strength is increased than conventional concrete.
10. By this project work we observed that natural sand is 50% replaced with M-sand gives higher strength than the conventional concrete mix.

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