Study on Sodium Silicate Based Cementing material- A self-curing Process

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Abstract **- As we all know Curing is considered as the most important part in the construction of a building and the main drawback of curing is the surplus wastage of water in the form of run-down. In this article self-curing concrete is casted by using Polyethylene-Glycol 400 and sodium silicate as replacement of the cement. 1.5% PEG400 is added in the cement (by wt.) and sodium silicate is used as cement replacement upto 5%, 10% (by wt.). Different tests such as compressive strength test, split tensile strength test, flexural strength test are carried out at 3,7 & 28 days on samples which has 1.5% PEG400 with cement, 5% sodium silicate as cement replacement, 1.5% PEG400 and 5% sodium silicate, 1.5% PEG400 and 10% sodium silicate as cement replacement and the results are compared with the conventional concrete. The concrete mixture of cement along with PEG400 gives the promising results when compared with the test results of normal concrete.**

Index Terms **- Curing, self-healing, PEG400, sodium silicate, rice husk ash, fly-ash**

1.INTRODUCTION

Materials such as cement, sand, clay, aggregates, bricks, timber generally represents the construction sector and are considered as conventional materials. Although in modern era we generally use cement, aggregate and sand in large quantity for the construction sector. This also have a negative effect on the environment as cement emits huge amount of carbon di oxide which leads to the depletion of ozone layer. To improve the environmental conditions that is degraded by the consumption of cement researchers are investigating many cementitious materials that can be used as the replacement for cement. In modern era different types of concrete such as high-performance concrete, self-healing concrete, self-curing, self-compacting concrete are made by using different cementitious materials as the replacement for cement. Different scholars gave different theories to modified the construction materials such as cement is being replaced by many binding materials like Fly-Ash, GGBS (grains granulated blast furnace slag), clay, foundry sand, rice husk ash (RHA), also the aggregates are replaced either with fine aggregate or with some other material like crumbled tires and also with mica. In this research, concrete with self-curing properties is investigated by using poly-ethylene glycol-400 (PEG-400) and sodium silicate slag as partial replacement of cement. Curing is considered as the most important part in the construction of a building and the main drawback of curing is the surplus wastage of water in the form of run-down. In most of the places where water is hard to find the process of curing becomes hard and non-economical also. PEG-400 generally helps in the formation of hydrogen bonds with water and reducing the evaporation of water from the concrete. As for sodium silicate, it reacts with calcium hydroxide and results in the formation of calcium silicate hydrate gel that helps in the self-healing of cracks that are developed in the concrete.

2.MATERIALS

1. Cement – According to IS 8112-1989, Ordinary Portland Cement is used.
2. Coarse aggregate - 20 mm nominal size with specific gravity 2.7 and water absorption 1.065% conforming to IS 383-1970 [9] specifications and tested as per IS 2386 standards
3. Fine aggregate conforms to the grading curve zone II with specific gravity 2.6 and fineness modulus 2.12 was thus obtained as per IS 383-1970 Specifications.
4. Water - cement requires about 3/10 of its weight of water for hydration. Hence the minimum water-cement ratio required is 0.35. But the

concrete containing water in this proportion will be very harsh and difficult to place. Additional water is required to lubricate the mix, which makes the concrete workable.

5. Sodium Silicate – Sodium Silicate is used in liquid form having lemon orange color and specific gravity of 2.1 kg/m^3 Sodium silicate shows some self-healing properties when added into the concrete mix.
6. Polyethylene glycol – PEG 400 with chemical formula H(OCH2CH2)nOH is used as a curing agent in concrete (table1). PEG forms hydrogen bonds with water and does not allow the water to evaporate from the concrete mix.

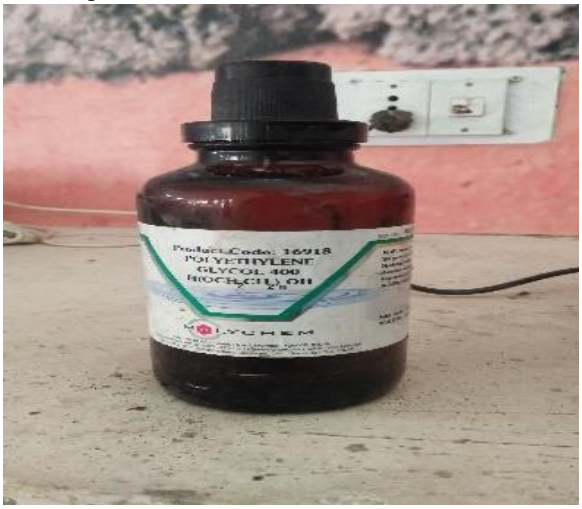

Fig 1. Poly ethylene Glycol 400

Table 1: Properties of Polyethylene Glycol 400

Sr. No.	Physical Prop	Value
1.	Mol. Weight	400
2.	Density (gr/cm2)	1.125
3.	Nature	Water soluble
4.	Specific Gravity	1.12
5.	pH	> 6
6.	Color	White
7.	Appearance	Clear Liquid

3.METHODS

7. Samples Preparation:

For Compressive strength test 6 cubes of 150 mm x 150 mm x 150 mm having w/c ratio of 0.45 are casted and tested after the age of 3days, 7days and 28 days.

For split tensile strength 6 cylinders of diameter 100 mm and height 200 mm are casted and tested at the age of 3, 7 & 28 days.

Fig 2. Samples for compression and split tensile strength test

For flexural strength 6 beams of 500mm x 100mm x 100mm are casted and tested at 3,7 & 28 days.

At first normal concrete is casted and then the samples in which amount of cement is replaced by chemicals are casted.

Fig 3. Samples for Flexural Strength test.

8. Working Methodology:

Sodium Silicate is used as replacement of cement at 5%, 10% and 1.5% polyethylene glycol PEG 400 is added in the concrete paste for curing purpose. Normal concrete samples are water cured whereas the samples having sodium silicate and PEG400 are air cured. Two samples for each age is tested and compared to the values of conventional concrete. XRD analysis is also performed on the sample having mixture of cement and PEG400.

XRD analysis is carried out on the mixture of cement and polyethylene glycol 400. The amount of cement is 100% and 1.5% PEG400 is added in the mixture.

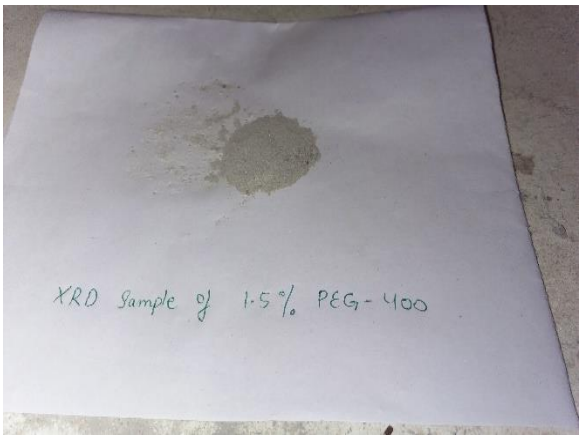

Fig 4. XRD Sample of 1.5% PEG400.

9. Mix Design

According to IS 10262–2009, M-25 mix has been adopted for this study. The quantities of materials replaced are tabulated in Table 2.

Table 2: Quantities of materials used.

Sr. No.	Cement (%)	Sodium Silicate (%)	PEG400 (%)
S01	100	0	0
S02	100	0	1.5
S03	95	5	0
S04	95	5	1.5
S05	90	10	1.5

4. RESULTS

10. Compressive strength

The main problem associated with concrete is to struggle the compressive stresses in most of the structural applications. On adding 1.5% PEG400 the compressive strength is increased by 3%, 8% & 11% at 3, 7 and 28 days respectively on comparing with the conventional concrete, whereas on adding sodium silicate it shows the decrease in the value of compressive strength by 23% at early age and upto 10% at later ages. For samples having 5% sodium silicate along with 1.5% PEG400 the value of compressive strength is decreased by 19% at earlier age and upto 7% at later ages when compared by the normal concrete. When the cement is replaced by 10% sodium silicate and 1.5% PEG400 the value of compressive strength is decreased by 29% at earlier age and 16% at later ages.

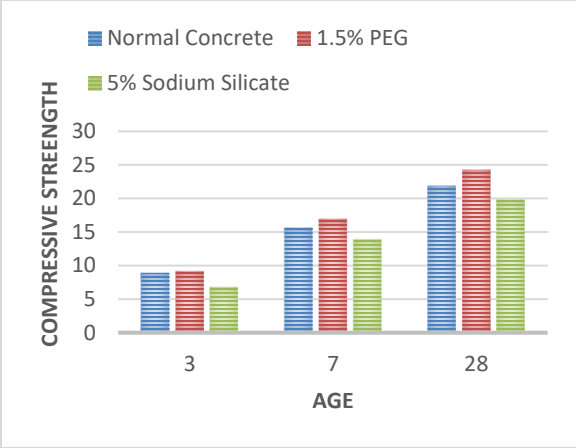

Fig 5. Strength of normal concrete along with 1.5%PEG400 and 5% sodium silicate

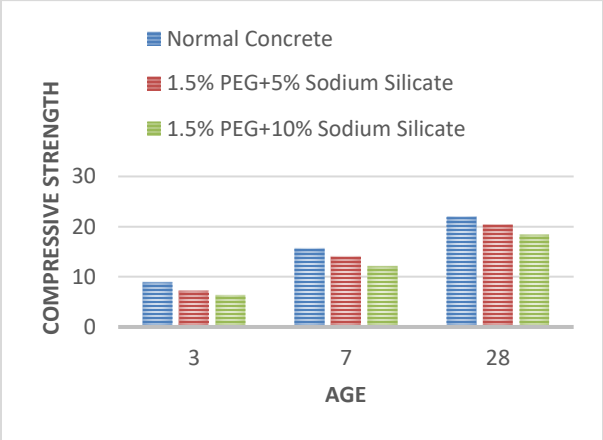

Fig 6. Strength of normal concrete along with other replaced samples.

11. Split Tensile Strength

On adding 1.5% PEG400 split tensile strength is increased by 4% at early age and upto 7% at later age on comparing with the conventional concrete, whereas on adding sodium silicate it shows the decrease in the strength by 15% at early age and upto 7% at later ages. For samples having 5% sodium silicate along with 1.5% PEG400 the value of strength is decreased by 11% at earlier age and upto 6% at later ages when compared by the normal concrete. When the cement is replaced by 10% sodium silicate and 1.5% PEG400 the value of compressive strength is decreased by 30% at earlier age and 16% at later ages on comparing with the normal concrete.

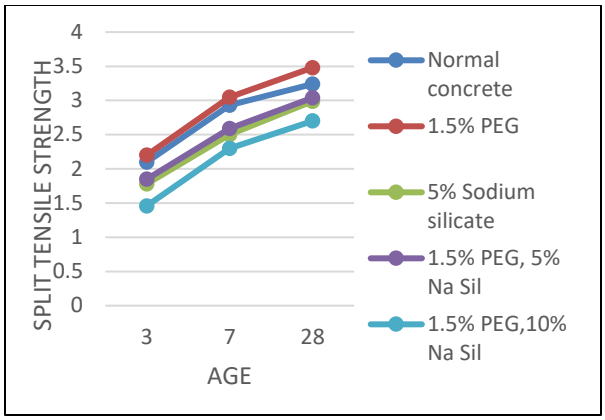

Fig 7. Split Tensile Strength of the samples casted.

12. Flexural Strength

On testing flexural strength it is seen that by using PEG400 the value obtained at 28 days is greater by 10% when comparing with the normal concrete at 28 days, whereas when the cement is replaced by sodium silicate the flexural strength of the concrete casted is lesser by 38% at earlier age as compared to that of normal concrete samples, while the value at 28 days is lesser by upto 8% when compared with the normal concrete.

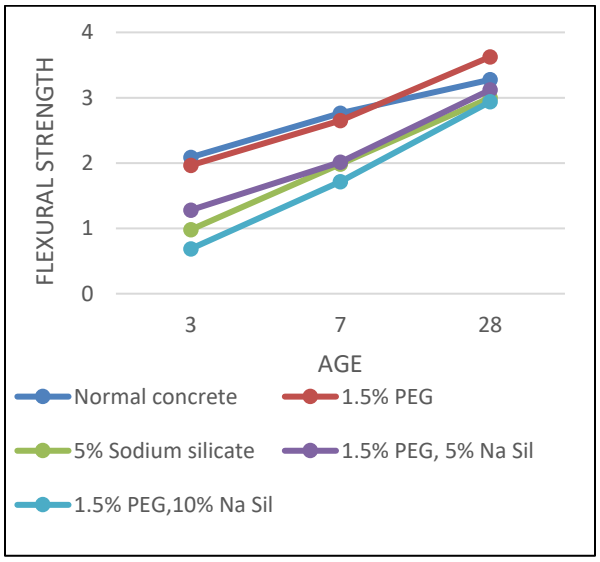

Fig 8. Flexural Strength of the samples casted.

13. XRD Analysis

XRD analysis is carried on the mixture of cement and PEG400 to investigate the fineness of bonding of polyethylene glycol 400 with the cement particles. Scanning range in 2-Theta is kept as 5-70 degrees while the scanning rate is adopted as 2 degree per min.

After testing a large peak was observed at $2\theta = 26.681$ degrees representing PEG400.

5.CONCLUSION

As we know curing is very important for the concrete structure to gain its strength also in many parts of the world there is scarcity of water, so internal curing of concrete should be adopted.

- Using PEG400 we can achieve desired strength of the concrete and in gaining strength no water is used for curing purpose.
- Using 1.5% PEG400 in the concrete mix helps to achieve good compressive strength, split tensile strength and flexural strength of concrete.
- On using sodium silicate desired strength of concrete is not achieved although it helps in self-healing of some cracks that are formed during curing period.
- Concrete mixture containing 5% sodium silicate as cement replacement with 1.5% PEG400 can be used as it undergoes self-curing along with self-healing upto some extent.
- Using 10% sodium silicate is not giving good results.

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