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Experimental Investigation on Self-Curing Concrete Incorporated with Rice Husk Ash and PEG-400

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Abstract

The necessity of concrete increasing year by year. In present, cement is now becoming a non-renewable material because of lack of limestone deposits. Also, while the production of cement (OPC) a lot of CO2 emission causes to global warming and air pollution. Even though Water curing is the most effective curing method to promote continuous hydration of cement and cement supplementary material in concrete. In practice, this ideal curing condition is provided for a limited period in concrete construction. Hence, Self-curing concrete is relatively a new chemical admixture to improve the water retention in concrete.

The project work discusses the expected result of an experimental investigation into the evaluation of a concrete mix with replacement of cement by Rice Husk Ash with 5%, 15%, 20% and PEG-400 is to be taken 1.0% on M30 Mix. It is expected that a self-curing admixture will be a useful ingredient in concrete mixes and will increase the workability of concrete mix. Also, it is expected that use of this combination i.e., Rice Husk Ash and PEG-400 will eliminate the errors in conventional curing and overall economy will be achieved.

***Keywords**—Poly ethylene Glycol 400, Rice Husk Ash, Self-curing Concrete.*

I. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with a fluid cement that cures over time. When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. Cement is now becoming a non-renewable material because of lack of limestone deposits. While the production of cement (OPC) a lot of CO_2 emission causes to global warming and air pollution. The present competitive world encouraging towards rapid development, results in large construction activities cause to heavy amount of concrete consumption. The raw materials of concrete are purely related to natural resources which are non-renewable. And during the manufacturing or processing, it also leads to environmental instability. So, to minimize the use of natural resources and to control the stability of environment, the alternative materials are introduced to the concrete, and this type of replacement experiments on concrete are enormously conducted by different research scholars all over the world. Among the different research replacements, one of the replacements in self-curing concrete is nothing but introducing replacing materials to the traditional ingredients of concrete. The binding material generally used is Ordinary Portland Cement can be replaced by a material having hydraulic or pozzolanic activity or both like Lime stone, Fly ash, Ground Granulated Blast Furnace Slag (GGBS), Silicon fume, Metakaolin, Rice husk ash, etc.

Rice husk ash is used in concrete construction as an alternative of cement. Rice husk is an agricultural residue from the milling process. It has been found beneficial to burn this rice husk in kilns to make various things. The rice husk ash is then used as a substitute or admixture in cement. The rice paddy milling industries give the by-product rice husk. Due to the increasing rate of environmental pollution and the consideration of sustainability factor have made the idea of utilizing rice husk. About 100 million tons of rice paddy manufacture by-products are obtained around the world. They have a very low bulk density of 90 to 150kg/m3. This results in a greater value of dry volume. The rice husk itself has a very rough surface which is abrasive in nature. These are hence resistant to natural degradation. This would result in improper disposal problems. So, a way to use these by-products to make a new product is the best sustainable idea. Among all industries to reuse this product, cement, and concrete manufacturing industries are the ones who can use rice husk in a better way.

Curing plays an important role in strength development and durability of concrete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface, for extended periods of time. Properly cured concrete has an adequate amount of moisture for continued hydration and development of strength, volume stability, resistance to freezing and thawing, abrasion and scaling resistance. The curing is adopted by applying water to the concrete surface for a desired period (generally 28 days). This process is termed as External Curing Method. As per the ACI-308 code- “Internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water”. Internal curing is often also referred as Self–curing. Self-Curing Concrete can be achieved by adding self-curing agents. The concept of self-curing agents is to reduce the water evaporation from concrete and hence increase the water retention capacity of the concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. The different types of curing agents are comprising with Poly Vinyl Alcohol (PVA), Poly Ethylene Glycol (PEG) and Super Absorbent Polymer (SAP).

PEG 400 (polyethylene glycol 400) is a low-molecular-weight grade of polyethylene glycol. It is a clear, colorless, viscous liquid. Polyethylene glycol 400 was discovered that which diminishes the water evaporation minimizes and surface tension of water from concrete, consequently assembles the water maintenance limit of the concrete for the nonstop hydration reason. Based on the

advantages an application of the current methods, a study has been taken up to assess the applicability of self-curing concrete for using the optimum percentage of polyethylene glycol (PEG-400) and to compare the strength parameters between conventional concrete and self-curing concrete.

II. PROBLEM STATEMENT

Problems occur while curing due to human negligence, scarcity of water in arid areas, inaccessibility of structures in difficult terrains. While the production of cement (OPC) a lot of CO_2 emission causes to global warming and air pollution. To overcome these, replacement to Cement with Rice Husk Ash and Self Curing Compound i.e., PEG-400 has to be done.

III. OBJECTIVES

The main objectives are to study the mechanical properties of concrete by varying the percentage of Rice husk ash from 5%, 15% and 25% by weight of cement for M30 grades of concrete. Also, to study the effect of curing compound (PEG-400) on the strength properties of concrete.

IV. LITERATURE REVIEW

M.V. Jagannadha Kumar, M. Srikanth have used shrinkage reducing admixture i.e., Polethylene Glycol-400 which helps in self-curing and helps in better hydration and hence strength.

Mohanraj A, Rajendran M, et. al. has experimentally investigated compressive strength and split tensile strength of concrete containing self-curing agent and compared it with those of conventionally cured concrete.

Shikha Tyagi has experimentally investigated the use of shrinkage reducing admixtures like Polyethylene Glycol (PEG 400) as internal curing compound.

G. Thrinath, P. Sundara Kuma have discovered the effect of admixture polyethylene glycol (PEG-400) on compression strength, split tensile strength and flexural strength, adding the diverse rate of PEG-400 to the weight of cement from zero to two percentages.

K V S Gopala Krishna Sastry, Putturu Manoj Kumar have studied impact of selfcuring agents such as Poly Ethylene Glycol (PEG), Poly Vinyl Alcohol (PVA) and Super Absorbent Polymer (SAP) on the concrete mix of M25 grade (reference mix).

Ananthi, R. Ranjith et. al. has experimentally studied effect of curing agent Polyethylene glycol in the performance of concrete. They've used PEG with different percentage; 1%, 2%, 3% to the weight of cement and Super Plasticizer named glenium to improve workability of concrete.

Er. Parasram Meena, Er. Nandeshwar Lata, et. al. [7] (2018) have carried out the research to study the mechanical properties of concrete by partial replacement of cement with rice husk ash. The M40 grade concrete with partial replacement of cement by rice husk ash by 0, 5, 10, 15, and 20%. They have studied the compressive strength, split tensile strength, flexural strength at age of 7 and 28 day.

V. MATERIALS

1. OPC 53 Grade Cement

Cement is mostly used as mortar and concrete, in which cement is mixed with aggregates to form a specific grade of concrete. Mortar is basically a mixture of cement and sand (crushed stone) having a size of less than 5mm i.e., 0.2 inches. Cement is available in different types, each with unique properties that make them suitable for specific applications. These types include Portland cement, which is the most common type of cement, as well as white cement, rapid hardening cement, and low-heat cement. The use of cement has revolutionized the construction industry, providing builders and engineers with a versatile and durable material that can withstand the test of time.

TABLE – Properties of Cement

2. Fine Aggregate (Sand)

Sr. No.	Description of Test	I.S. 12269-1989	Results
1	Fineness of cement (residue on IS sieve size 90 micron)	10%	8 %
3	Specific Gravity	3.15	3.15
4	Standard Consistency of Cement	25-35%	30%
5	Setting time of cement: (IS 12269-1987)		
	a) Initial Setting Time	30 min.	45 min.
	b) Final Setting Time	600 min.	370 min.

Sand is one of the oldest building materials used throughout the centuries in various construction projects. However, not all sand is created equal – numerous types of sand have different properties and uses. Sand is a mixture of small grains of rock and granular materials which is mainly defined by size, being finer than gravel and coarser than silt. And ranging in size from 0.06 mm to 2 mm. Particles which are larger than 0.0078125 mm but smaller than 0.0625 mm are termed silt. Sand is made by erosion or broken pebbles and weathering of rocks, which is carried by seas or rivers. Fine aggregates are the aggregates whose particles passed through 4.75 mm IS Sieve.

TABLE – Properties of Sand

Sr. No.	Property	IS 383:1970	Results
1.	Particle Shape, Size	Passed through 4.75 mm IS Sieve	Angular, passed through 4.75 mm
2.	Fineness Modulus	2-3.5	2.83
3.	Silt Content	8%	5.1%
4.	Water Absorption	2.86%	0.99%
5.	Grading Zone	-	III

3. Coarse Aggregate

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed and graded. Much of the stone used is granite, limestone, and trap rock. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although lager sizes may be used for massive concrete aggregate. Machine chorused granite broken stone angular in shape is use as coarse aggregate.

TABLE- Properties of Coarse Aggregates

Sr. No.	Property	IS 383:1970	Results
1.	Particle shape and max size	Retained on 4.75 mm IS Sieve	Angular, 10 mm, 20 mm
2.	Fineness Modulus of coarse aggregates	6.5-6.9	6.78
3.	Specific Gravity	2.5-3	2.85
4.	Water Absorption	0.1-2%	0.2%

4. Water

Water should be free from acids, oils, alkalis, vegetables or other organic impurities. Soft water also produces weaker concrete. Water has mainly two functions in concrete mix. Firstly, it causes a chemical reaction with the cement to form cement paste in which the inert aggregate is held in suspension until the cement paste has hardened. And secondly it acts as a lubricant in the mixture of fine aggregate and cement.

5. Rice Husk Ash

Rice husk is an important byproduct from the milling process of paddy rice, with a huge amount being produced worldwide each year. Silica exits abundantly in rice husk in an amorphous form. Hence, rice husk is a natural and renewable biomass source for extraction of silica and subsequently for manufacturing value-added, silicon-based materials. They have a very low bulk density of 90 to 150kg/m3. This results in a greater value of dry volume. The rice husk itself has a very rough surface which is abrasive in nature.

TABLE- Properties of Rice Husk Ash

Sr. No.	Particular Properties	
1.	Colour	Gray
2.	Shape Texture	Irregular
3.	Minerology	Non-Crystalline
4.	Particle Size	< 45 Microns
5.	Specific Gravity	2.37
6.	Fineness	8%

Fig. 1 - Rice Husk Ash

6. Polyethynel Glycol (PEG-400)

PEG 400 (polyethylene glycol 400) is a low-molecular-weight grade of polyethylene glycol. It is a clear, colourless, viscous liquid. Polyethylene glycol 400 was discovered that which diminishes the water evaporation minimizes and surface tension of water from concrete, consequently assembles the water maintenance limit of the concrete for the nonstop hydration reason. Based on the advantages an application of the current methods, a study has been taken up to assess the applicability of self-curing concrete for using the optimum percentage of polyethylene glycol (PEG-400).

TABLE – Properties of PEG-400

Appearance	Clear liquid or white solid
Odour	Mild Odour
Solubility	Soluble in water
Density range	1.1 to 1.2 (increase as molecular weight increases)
Specific Gravity	1.12
Molecular Weight	400

Fig. 2 - PEG-400

VI. CASTING AND TESTING

1. Mix proportion and casting of concrete specimen

The mix Design is done as per IS 10262:2019 for M30 Grade of Concrete. Concrete cubes of size 150 mm x 150 mm x 150 mm, Concrete Beams of size 500 mm x 100 mm x 100 mm will be casted and tested accordingly.

TABLE -Quantity of Materials per Cubic Meter of Concrete Grade M30.

Material	Proportion by Weight	Weight in Kg/m^3
Cement	1	372
Fine Aggregate	3	1123.33
Coarse Aggregate	3.22	1197.16
W/C	0.5	186

The aspect ratio for M30 Grade Concrete is found to be 1:3:3.22

TABLE - Proportion of Polyethylene Glycol and Rice Husk Ash

Specimen Designation	% Cement	% Rice Husk Ash	% PEG 400
SM	100	0	0
RHA5	95	5	1.0
RHA15	85	15	1.0
RHA25	75	25	1.0

2. Compressive strength of concrete cube

Compressive strength of regular mix concrete cubes and concrete having RHA and PEG 400 are tested.

3. **Flexure strength of concrete beam**

Flexural strength of regular mix concrete beam specimen and concrete having RHA and PEG 400 are tested.

VII. RESULTS AND DISCUSSION

1. Compression Test

TABLE – Compressive Strength of Cubes

Replacement (%)	7 Days (N/mm^2)	21 Days (N/mm^2)	28 Days (N/mm^2)
0%	18.9	26.31	29.82
RHA+PEG400 (5% + 1%)	19.02	27.41	29.45
RHA+PEG400 (15% + 1%)	19.68	27.88	29.69
RHA+PEG400 (25% + 1%)	13.22	22.11	23.48

2. Flexure Strength of Concrete Beams

TABLE – Flexure Strength of Beams

Replacement (%)	28 Days (N/mm^2)
0%	3.73
RHA+PEG400 (5% + 1%)	4.03
RHA+PEG400 (15% + 1%)	4.10
RHA+PEG400 (25% + 1%)	2.37

For all the tests, it is seen that when RHA+PEG-400 is replaced, the strengths increase as the replacement of RHA and PEG-400 increases for up to 15% and 1% replacement respectively and there is a fall in the strength after that i.e., for the combination of 25% RHA and 1% of PEG-400. Therefore, the strength is found to be optimum when replaced with 15% RHA and 1% PEG-400. Therefore, we can conclude that RHA and PEG-400 best when 15% and 1% is replaced respectively.

VIII. CONCLUSION

- It is seen that Rice Husk Ash could be a good replacement option for cement in concrete material.
- Use of Polyethylene Glycol increases the water retention capacity of concrete.
- The optimum % of Rice Husk Ash for the replacement of cement in concrete material is 15%.
- Using the combination of Rice Husk Ash and PEG increases the strength and of concrete.
- Using Self-Curing agent reduces the error in conventional curing. Overall economy could be achieved.

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