STUDY OF STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH RICE HUSK ASH AND CHEMICALLY CURING WITH POLYETHYLENE GLYCOL-400

A

DISSERTATION REPORT

submitted by

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MASTER OF TECHNOLOGY

in

STRUCTURAL ENGINEERING

(CIVIL ENGINEERING)

Under the supervision of

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DECLARATION

I, ImlimenWatiLongkumer (11205736), a student of Master of Technology inStructural Engineering under department of Civil Engineering of Lovely Professional University, Punjab, hereby affirm that this dissertation report titled “**Study of strength of concrete by partial replacemnet of cement with rice husk ash and chemically curing with polyethylene glycol-400**” contains information thoroughly researched and printed by my own, and is genuine and true.

This research study does not, to the best of my knowledge, contain any information which has been already studied and published for the award of the same degree either in this university or any other university.

ImlimenWatiLongkumer
(11205736)

CERTIFICATE

This is to certify that ImlimenWati Longkumer (11205736), have successfully finished this dissertation project report titled **“Study of strength of concrete by partial replacement of cement with rice husk ash and chemically curing with polyethylene glycol-400”** supervised and guided by me. I can state with affirmation that this study is the product of her exclusive and genuine investigation and study. No part of this written report has ever been published for the same degree at any University.

The project report is fit for submission and is qualified for the partial fulfillment of the conditions for the award of Master of Technology in Civil Engineering in Lovely Professional University, Phagwara.

Ms. Sristi Gupta

Assistant Professor

Supervisor

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The contentment and euphoria that come with the successful accomplishment of any work would not be complete without mentioning the people whose continuous assistance and support made it possible. I would like to present before you my dissertation work which is a result studied with a blend of both research and knowledge.

I would like to firstly convey my heartfelt appreciation to my supervisor Ms. Sristi Gupta for her valuable supervision. Her continuous encouragement and support has always been a motivation. I thank her for her valuable effort, time, and help.

I would also like to convey my gratitude towards Lovely Professional University for providing with best facilities and proper environment to work on my project, and providing me the opportunity to enhance my practical skills by implementing this project.

ABSTRACT

This paper covers a detailed study on the determination of the strength of concrete by partial replacement of cement with admixtures Rice Husk Ash (RHA) and Polyethylene Glycol-400 (PEG-400). RHA is a mineral type admixture while PEG-400 is a shrinkage reducing chemical admixture. Both the admixtures are added in the concrete in two ways and comparatively their impact on strength is studied – first only RHA is added by partial replacement of cement by weight in percentages of 11%, 18%, and 22%, and both RHA and PEG-400 are added together with the same quantity of RHA with PEG-400 in percentages of 0.5%, 1%, and 1.5%. The strength of concrete is evaluated thereby after curing days of 7, 14, and 28 days. The tests that are conducted are – compression test on cubes, split tensile test on cylinder, and flexure test on beams. It is observed that when only RHA is added, the strength of concrete is more than that of the control mix, and when RHA and PEG-400 are added, the strength is more than control mix and even more than the strength observed when only RHA is added. All the tests and results were conducted and compared under the Indian standard codes IS 10262-2009 and IS 456-2000.

Keywords: concrete, RHA, PEG-400, self-curing.

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CHAPTER 1

INTRODUCTION

1.1. General

Presently the construction industries and companies are booming with the advancement and so there is a high demand of buildings – residential buildings, and important buildings like hospitals, schools, communication buildings/towers, power plant structures. Civil engineering is a discipline of science that deals with designing of structures, constructing them, and maintaining them. Construction also means that any structure that a civil engineer builds is not only safe but is also cost effective; the conventional construction materials that we normally use are expensive .As a result there is a need to lessen the price of Ordinary Portland Cement and it has made many researchers to try to replace the cement with some locally available waste materials. We can reduce some amount of the total expense by using alternative construction materials; they can be any waste products and/or chemicals. In this study report, Rice Husk Ash is used as a mineral admixture and Polyethylene Glycol – 400 is used as a shrinkage reducing admixture and consequently the effect of these admixtures on the concrete is evaluated. We should also note that usage of these admixtures not only reduces the cost but also it increases the strength of concrete to some percentage most importantly. This study report gives a thorough explanation about how these admixtures will have an impact on the strength of the concrete.

1.2. Admixtures

An ordinary concrete mix constitutes only cement, aggregates (fine and coarse), and water. It does not contain any extra material(s) other than the aforementioned materials. As concrete is widely and extensively used for a number of purposes, it needs to be improved time and again so that it is suitable for different conditions. In such conditions, oftentimes, the concrete fails to exhibit the requisite quality performance. So in cases like that, an extra material(s) called admixtures are used which helps to modify the properties of an ordinary concrete mix and helps in improving the strength of the concrete. So, an admixture is a material that is used for one purpose – it is added as an ingredient in the concrete batch to improve some properties of concrete and is added during or after mixing.

Admixtures were used since the 1930's but they were not considered as an important material in concrete technology. But in the course of time, it is being used increasingly. Despite the fact that many technologists disapprove using admixtures, there are still many who recommend using it as it exhibits several desirable characteristics and also have an impact on the total financial expenditure of the concrete construction. However, we should keep in mind that admixtures shouldn't be used as an alternate material for good concreting. Other drawbacks includes - prediction of the effect of using admixture because many a times the brand of cement we use changes, the grading of aggregates also changes, the mix proportion alters the concrete property and sometimes it affects more than one property. Also when we use more than one admixture, it becomes tricky to predict the property of the concrete. And for that reason one must take precautions in choosing which admixture to use and in predicting the outcome of the same.

1.2.1. Classification of Admixtures

The America Concrete Institute Committee 212, in its report, has classified admixtures into fifteen groups in accordance with the type of materials constituting the admixtures or its characteristics. However when the committee submitted its report in 1954, the admixtures like plasticizers and super plasticizers were not included during that time.

- Types of admixtures:

1. Plasticizers
2. Super-plasticizers
3. Retarders and Retarding Plasticizers
4. Accelerators and Accelerating Plasticizers
5. Air-entraining Admixtures
6. Pozzolanic or Mineral Admixtures
7. Damp-proofing and Waterproofing Admixtures
8. Gas forming Admixtures
9. Air-detraining Admixtures
10. Alkali-aggregate Expansion Inhibiting Admixtures
11. Workability Admixtures
12. Grouting Admixtures
13. Corrosion Inhibiting Admixtures
14. Bonding Admixtures
15. Fungicidal, Germicidal, Insecticidal Admixtures
16. Colouring Admixtures

- Type of Construction Chemicals

1. Concrete Curing Compounds
2. Polymer Bonding Agents

3. Polymer Modified Mortar for Repair and Maintenance
4. Mould Releasing Agents
5. Protective and Decorative Coatings
6. Installation Aids
7. Floor Hardeners and Dust-proofers
8. Non-shrink High Strength Grout
9. Surface Retarders
10. Bond-aid for Plastering
11. Ready to use Plaster
12. Guniting Aid
13. Construction Chemicals for Water-proofing
    i. Integral Water-proofing Compounds
    ii. Membrane Forming Coatings
    iii. Polymer Modified Mineral Slurry Coatings
    iv. Protective and Decorative Coatings
    v. Chemical DPC
    vi. Silicon Based Water-repellent Material
    vii. Waterproofing Adhesive for Tiles, Marble and Granite
    viii. Injection Grout for Cracks
    ix. Joint Sealants

But a modified classification given by M.R. Rixom is shown in figure 1.1.

In this study report, the two admixtures are added in two ways –

1. RHA only.
2. RHA and PEG – 400.

And accordingly a comparative check of strength property of the concrete is evaluated by checking the compressive, tensile, and flexural strengths.

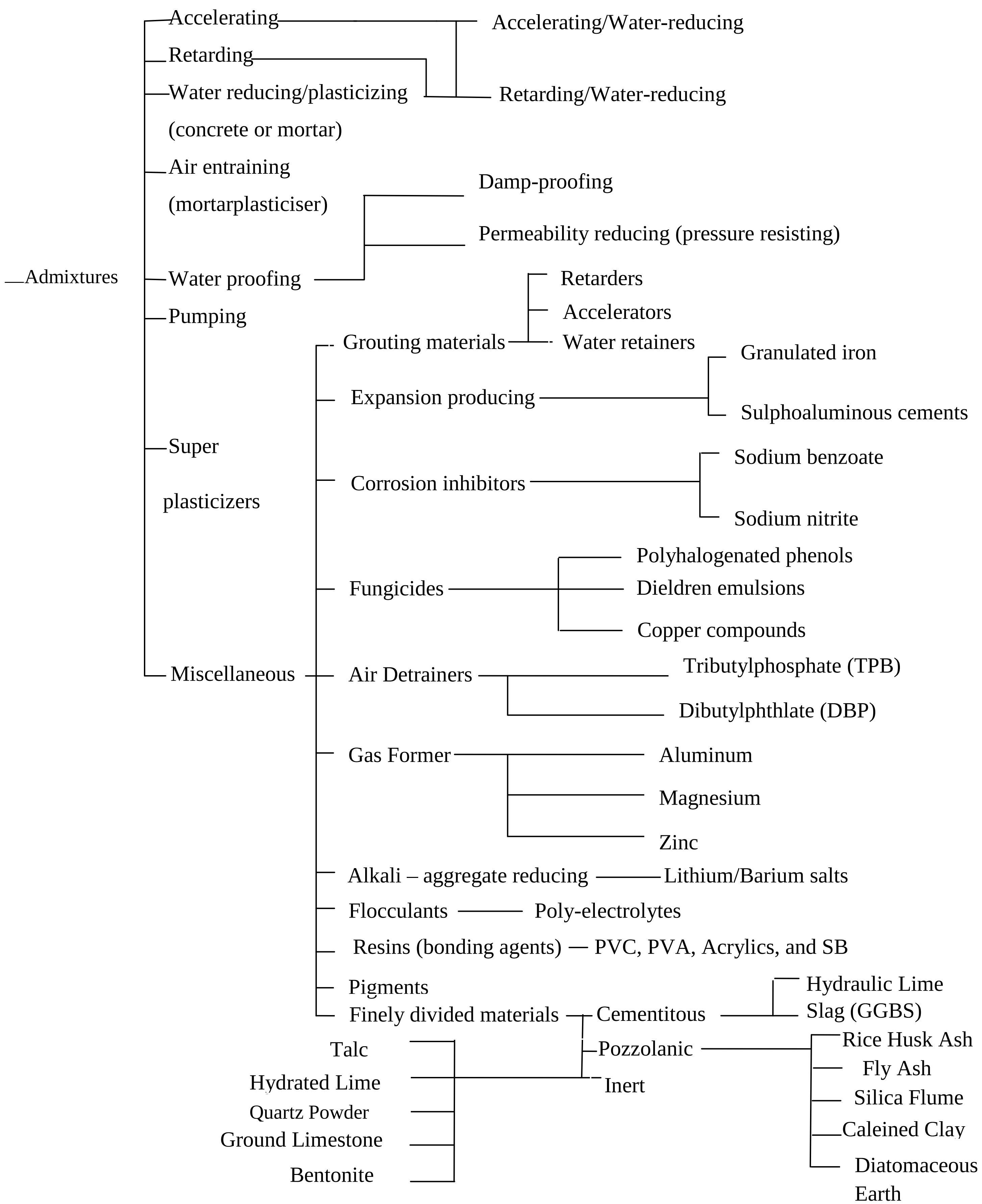


Figure1.1. Classification of Admixtures by Rixom

1.3.Pozzolanic admixtures/Mineral Admixtures

Pozzolans were discovered and used during the times of ancient Greeks and Romans which lead to the advancement and growth of using pozzolans. It is said that the ancient Greeks and Romans mixed siliceous materials in powdered form with lime to use as a binding material to make structures like bridges, arches, and aquaducts. One material that was widely and commonly used as an admixture during that time was consolidated volcanic ash/tuff which they termed it as "Pozzuolana." It was later coined into a new term as "pozzolan" to define any material that shows cementitous/binding property.

The practice of using pozzolans however declined after natural cement and Portland cement were developed in the 18^{th} and 19^{th} century respectively. However, in the 21^{st} century, more and more people are using pozzolans, and most popularly in USA, Japan, and Europe.

Pozzolans are materials that contain silicate or silicate and aluminous materials. However presence of these materials does not show any signs of cementitous property; but when it is in powdered form and mixed with water, it will react with calcium hydroxide to form compounds at a room temperature. And only then does it behave as a binding material.

When hydrated tri-calcium silicate and di-calcium silicate reacts, it forms a non-cementitous compound called calcium hydroxide which is soluble in water. After that the calcium hydroxide reacts with compounds of siliceous and aluminous materials to give products of highly stable compounds composing of water, calcium, and silica which act as a binding material.

The reaction involved is shown as follows –

1) Silicon reacts with oxygen to generate silica.

$$Si + O_2 \longrightarrow SiO_2$$

2) And calcium hydroxide is produced when cement is mixed with water.

$$C_3S\ (Cement) + H_2O \longrightarrow C\text{-}S\text{-}H + Ca\ (OH)_2$$

3) Then the silica reacts with calcium hydroxide which was released during the hydration of cement to generate calcium silicate hydrate which is responsible for the strength of concrete.

$$SiO2 + Ca\ (OH)2 \longrightarrow C\text{-}S\text{-}H + SiO2$$

The above reaction is called as a "Pozzolanic reaction." Initially, the reaction is slow; the heat of hydration and strength development is slow.

1.3.1. Classification of Pozzolanic material

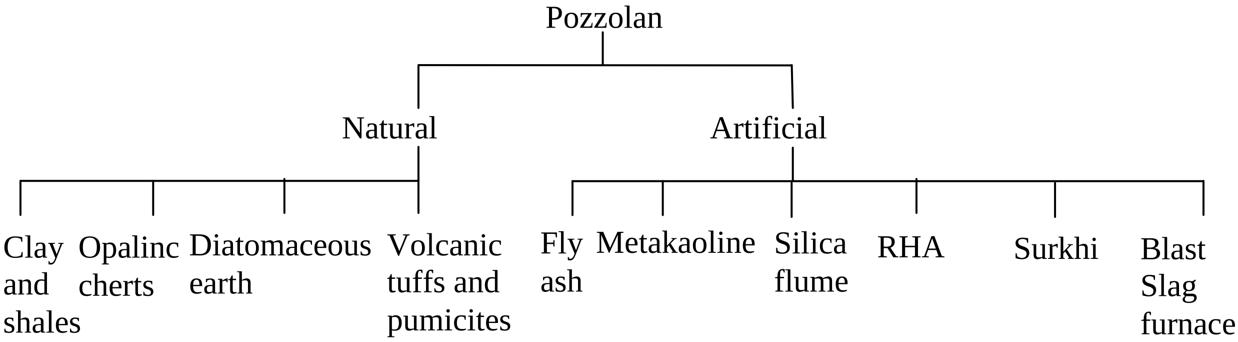


Figure1.2. Classification of Pozzolan

1.3.2. Rice Husk Ash

Rice Husk Ash is an agricultural by- product produced by burning the husks of rice which composes highly of silica. During the production of rice collected from paddy field, from the total weight, about 78% is rice and the remaining 22% is husk which is a waste product. From this 22% of husk, approximately 75% is organic volatile matter and the remaining 25% is burned to ash which is called as Rice Husk Ash or RHA. Instead of dumping this husk which only leads to the pollution of the environment, we can utilize it in the field of construction as an alternative material in a concrete mixture. It is also used as a low quality fuel but it is effectively used as a pozzolanic material commercially in many countries including India. RHA is a sustainable, environment friendly and durable option for concrete. The burnt rice husk has high reactivity and pozzolanic property which contributes to great strength of concrete, impermeability, and workability of concrete.

The pozzolans present in RHA depends on the composition and crystallization phase of silica, rice husk ash particles' surface area and size. The burning process and temperature variation affects the chemical composition of RHA.

- The chemical composition is shown in the given table –

Fe_2O_3	0.5
K_2O	0.1-2.5
SiO_2	62.3-97.5
CaO	0.1-1.3
MgO	0.01-1.9
Na_2O	0.01-1.6
P_2O_5	0.01-2.7
SiO_3	0.1-1.2
C	2.7-6.4

Table1.1. Chemical composition of RHA

- The physical property of RHA is shown as follows –

Particulars	Properties
Colour	Grey
Shape	Irregular
Mineralogy	Non-crystalline
Odour	Odourless
Specific gravity	2.21

Table1.2. Physical properties of RHA

(a) (b)

Figure1.3. (a) Rice Husk (b) Rice Husk Ash

1.3.3. Advantages of RHA–

1. Used as a substitute of cement in concrete.
2. Used as fillers for concrete.
3. Economically cheaper as compared to commercial materials.
4. Easily available.
5. Increases the strength characteristics.
6. Reduces the weight of the structure as RHA is light in weight.

1.3.4. Disadvantage of RHA –

1. It reduces the hydration of cement thereby requiring for us to use more water.
2. If replaced with more than 30%, it reduces the strength of the concrete. So, we cannot use RHA at a large amount.

1.4. Polyethylene Glycol-400

Polyethylene glycol is a condensation polymer of ethylene oxide and water. And it is an example of water soluble polymers. It is used as a plasticizer and acts as a water retention compound.

The general formula is given by -

$H(OCH_2CH_2)nOH$

where n = average number of repeating oxyethylene groups normally at a range of 4-180approximately.

The numeric suffix 400 represents the average molecular weights. It is a non-hazardous, non-volatile, colourless, odourless, lubricating, and does not cause irritation. It is widely used for various pharmaceutical purposes.

1.4.1. Physical properties of PEG – 400 -

In context with the molecular weight, the various physical properties are shown.

1. Property of Solubility - The increase in molecular weight results in reduction of water solubility.
2. PEG also mixes readily in acetone, alcohols which are polar organic solvents.
3. Property of Hygroscopic - PEG is hygroscopic which means that they draw and trap moisture. Hygroscopic property declines as the molecular weight rises.
4. Property of - It is considered as Newtonian fluids which mean that the kinematic viscosity decreases when there is increase in temperature.
5. Property of Stability – It shows low volatile property and is thermally stable for a period of time if the temperature is below 300°C and there is no presence of O_2.

1.4.2. Chemical properties of PEG – 400 -

1. Hydrophilic in nature.
2. PEG – 400 shows water solubility property.
3. Contains acetones, alcohols, benzene, glycerines, glycols, and aromatic hydrocarbons.
4. Slightly soluble in aliphatic hydrocarbons

1.5. Curing of concrete by PEG – 400

Because concrete is kept open in the atmosphere, after some course of time, the water in the concrete reduces. And so curing of concrete becomes necessary to avoid the structure from shrinking and failing. The curing of concrete can be defined as providing sufficient moisture, temperature and time to let the concrete attain the desired properties for its proposed use. It maintains sufficient moisture content and temperature in concrete which has been freshly casted for a specific period of time.

PEG – 400 can be used as a type of admixture for reducing shrinkage and providing internal self-curing in concrete. It is added with the concrete mix during dry mixing. The compound maintains the hydration in the concrete by trapping the moisture in the structure and does not allow evaporation of moisture.

The process serves two major purposes:

1. The moisture that was lost from the concrete is replenished due to PEG - 400.
2. The temperature is maintained due to PEG - 400that is required for hydration to take place.

Concrete is shrunk when the water is lost from the concrete. Due to this, tensile stress is increased which may result in cracking, deflection and failing of concrete. It also causes internal warping. Therefore proper curing is essential.

PEG – 400 is a self-curing agent which means that it entraps and helps in maintaining the moisture of the concrete and prevents evaporation of water as compared to the conventional method of curing. It decreases the self-desiccation of concrete. Since PEG – 400 is a hygroscopic substance, it acts a desiccant.

1.4.3.1. Advantages of self-curing -

1. To avoid shrinkage.
2. Improves moisture content which increases hydration of concrete.
3. Hydrates the concrete more than what mixing water fails to do.
4. The strength of concrete is increased if an optimal dose is added.
5. When correctly added a premium-grade coating is formed which does not allow water to escape. It entraps the water.
6. Shields the structure by reflecting the rays of sun and keeps the surface of concrete cooler and prevents unnecessary heat buildup which will only result to thermal cracking.
7. Produces firm and dense concrete.
8. Reduces the formation of hair cracking and thermal cracking.
9. Makes the compressive strength of concrete higher.
10. Abrasion is reduced and action due to corrosion is lessened.

1.6. Concrete strength

There are many properties that influence the strength of concrete. One very important property is the compressive strength of concrete. Other important properties include flexural strength, tensile strength, modulus of elasticity, permeability. To test these properties, traditionally, it is done by making various mix of concrete these mixes are made into concrete cubes or prisms in the laboratory, and then finally curing them for specific days to make them as a hardened concrete.

Hardened concrete should be tested in order to make sure that the quality of concrete work done is proper and achieves a great efficiency in terms of strength and durability; we test hardened concrete to scrutinize and study the durability and strength of concrete. Hence before starting a work at the site, testing of specimens – be it fresh concrete or hardened concrete – gives us an idea about the actual strength of the concrete that we are using at the site. The tests are simple, convenient, direct, and easy to apply.

- Properties of a hardened concrete –

1. Great strength with less water-cement ratio.
2. Durable and with low permeability, with minimum content of cement, mixed properly, compacted properly, and cured properly.
3. Creep and shrinkage of concrete is low.

In this study report, the strength of concrete is measured by three important tests namely – compression test of cube, split tensile test of cylinder, and flexure test of beam specimens. These tests help us to decide whether proper concreting has been done or not.

1.5.1. Compression test

The compressive strength is the ability of a material/structure to endure loads that is likely to shrink the size. In simple words, compressive strength is the capacity of a material/structure to resist being pressed together. Compression of an element is dependent on factors like water-cement ratio, strength and quality of concrete, and quality control during production of concrete.

In this report, the compressive strength is tested on a concrete cube with asize of $0.15m^2$. The test is conducted in the laboratory in a Compression Testing Machine (CTM) having a total load capacity of 1000KN. The total cube moulds casted was 63 in number. RHA was replaced with cement in percentages of 11%, 18%, and 22%. While PEG – 400 was replaced with cement in percentages of 0.5%, 1.0%, and 1.5% with curing days of 7, 14, and 28 days.

Figure1.4. Compression test of concrete cube

1.5.2. Split Tensile test

The tensile strength of a material/structure is the capacity to endure loads that is likely to lengthen its size. In simple words, tensile strength is the capacity of a material/structure to resist being pulled together. Due to the brittle nature of concrete, split tensile test is an important test as concrete is weak in tension while it is significantly stronger in compression.

In this report, the tensile strength is tested on a concrete cylinder with a dimension of (0.20 X 0.10) m. The test is conducted in the laboratory in a Compression Testing Machine (CTM) having a total load capacity of 1000KN. The total cylinders moulds casted were 63 in number. RHA was replaced with cement in percentages of 11%, 18%, and 22%. While PEG – 400 was replaced with cement in percentages of 0.5%, 1.0%, and 1.5% with curing days of 7, 14, and 28 days.

Figure1.5. Split tensile test of concrete cylinder

1.6.3. Flexure test

Flexure strength or modulus of rupture is the capacity to tolerate bending. It is tested on an unreinforced concrete beam. The flexure strength of a material/structure is the capacity to bear loads that is likely to bend the material/structure.

In this report, the flexural strength is tested on a concrete beam with a dimension of (0.50 X 0.10 X 0.10) m. The test is conducted in the laboratory in a Compression Testing Machine (CTM) having a total load capacity of 1000KN. The total cylinders moulds casted were 63 in number. RHA was replaced with cement in percentages of 11%, 18%, and 22%. While PEG – 400 was replaced with cement in percentages of 0.5%, 1.0%, and 1.5% with curing days of 7, 14, and 28 days.

Figure1.6. Flexure test of concrete beam

1.7. Objective

- Study the strength of concrete by partial replacement of cement by weight with a mineral admixture called Rice Husk Ash and a shrinkage reducing admixture called Polyethylene Glycol-400.
- Comparative study of strength of concrete by adding RHA and PEG-400.

1.8. Scope of Study

The scope of this study is to mainly reveal the effect of addition of admixtures like RHA and PEG-400 in concrete and consequently study the behavior of the strength of concrete. By performing various tests we can determine the strengths of concrete.

CHAPTER 2

LITERATURE REVIEW

2.1. Literature Review

El-Dieb et al. (2002)[1] studied "the retention of water in concrete by using water-soluble polymeric glycol as self-curing agent." Calculations of loss of weight of concrete and internal relative humidity of concrete with time were carried out to evaluate the water retention of self-curing concrete. Transport of water through concrete is evaluated by measuring absorption percentage, permeable voids percentage, and water sorptivity and water permeability. The water transport through self-curing concrete is investigated with time.

Cusson et al. (2005)[2] studied "the autogenous shrinkage in order to be able to model it and possibly lessen it. After the application of self-desiccation shrinkage in autogenous shrinkage is shown, the benefits of avoiding self-desiccation through internal curing become noticeable.

Abdelaziz et al. (2006)[3] investigated the effect of water based curing compound on strength, hardness, sorptivity, and porosity of blended concrete. His study revealed that the WBCC in the early stage in the first 2 hours of casting would give the best possible properties of concrete. The use of WBCC and pre-water curing had a greater outcome on the durability of the concrete i.e., sorptivity property and porosity property than on the mechanical properties i.e., strength and hardness. He also recommended that the compressive strength and Schmidt hammer tool are not appropriate for checking the efficiency of curing compound. Comparatively the report also reported that the effectiveness of the membrane curing compound is 90% compared to the usual standard method of curing of water. The strength of compression which was calculated by them using the curing compound showed no fall of ratio under 85% as compared to the conventional method of cuing. The results were calculated according to the ACI 318 requirements. The final result indicates 92.11% as minimum field-standard ratio.

K. Ganesan et al. (2008)[4] studied "the strength and permeability properties of cement with RHA." In this report the RHA used was boiler burnt. The tests were conducted on compressive strength, splitting tensile strength, water absorption, sorptivity, total charge-passed derived from rapid chloride permeability test (RCPT) and rate of chloride ion penetration in terms of diffusion coefficient. 30% of replacement showed the optimum replacement level. Also an interesting conclusion was emanated which showed the linear relationship between water sorptivity, chloride penetration and chloride diffusion. The following readings were drawn from their study.

Mix designation	RHA (%)	Compressive strength (MPa)			
		One day	Three days	Seven days	28 Days
M0 (control)	0	11.6	20.9	27.2	37.0
M1	5	12.0	22.1	27.4	38.9
M2	10	12.8	24.4	27.8	42.8
M3	15	13.8	28.9	29.3	46.7
M4	20	12.2	24.8	28.3	39.8
M5	25	11.7	23.6	27.6	38.3
M6	30	11.1[a]	20.7[a]	27.4[a]	37.0[a]
M7	35	10.4	18.4	26.4	36.0

Mix designation	RHA (%)	Saturated water absorption (%)		Coeff. of water absorption $\times 10^{-10}$ (m^2/s)		Sorptivity $\times 10^{-6}$ ($m/s^{1/2}$)	
		28 Days	90 Days	28 Days	90 Days	28 Days	90 Days
R0 (control)	0	4.71	3.76	1.62	0.85	11.05	9.76
R1	5	4.83	3.21	1.42	0.71	10.60	7.09
R2	10	5.02	3.20	1.03	0.61	9.16	4.86
R3	15	5.58	3.11	0.99	0.46	7.37	4.09
R4	20	5.81	2.20	0.92	0.31	6.00	3.61
R5	25	6.09	2.80	0.51	0.20	5.53	2.28
R6	30	6.35	3.05	1.06	0.43	6.08	3.38
R7	35	6.92	3.98	1.51	0.58	10.30	4.04

They concluded that up to 30% by weight of OPC can be replaced with RHA without any adverse effect on the properties of strength and permeability. Replacement with 30% leads to considerable improvement in the permeability properties of blended concrete as opposed to that of unblended concrete, namely (a) A35% reduction in water permeability (b) 28% reduction in chloride diffusion (c) 75% reduction in chloride permeation. These observations had a direct bearing on the durability of reinforced concrete constructions. For compressive strength and chloride permeation properties, curing for 28 days is found to be satisfactory. However, curing up to 90 days is found to be beneficial only for improving the water absorption resistance.

Alireza Naji Givi et al. (2010)[5] studied "Evaluation of the impact of particle size of RHA on strength, in water permeability, and workability of binary blended concrete." In this they use two types of RHA on the basis of its size particles – 5µ (ultra fine) and 95µ with 5%, 10%, 15%, and 20% replacement. The following readings were drawn from their study.

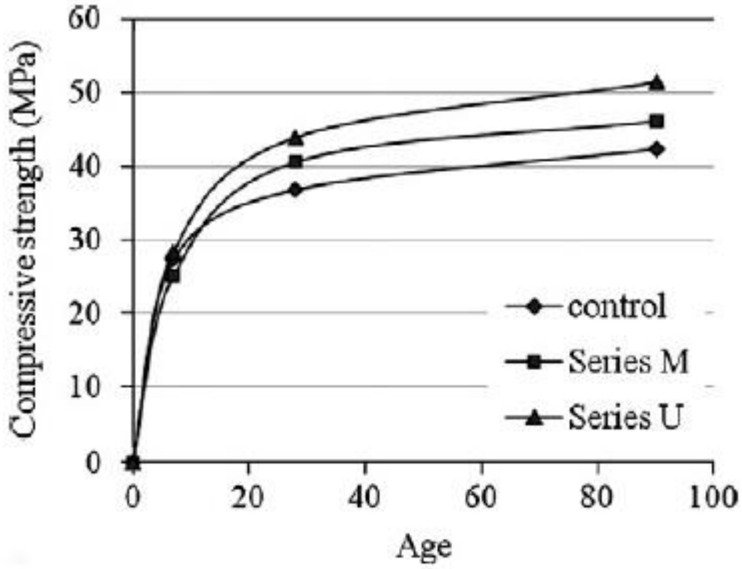
Compressive strength of RHA blended cement mortars.

Sample designation	RHA (%)	Compressive strength (MPa)		
		7 days	28 days	90 days
C0 (control)	0	27.3	36.8	42.3
M1[a]	5	25.7	38.7	43.5
M2	10	25.1	40.6	46.1
M3	15	23.7	37.9	42.7
M4	20	21.5	36.7	41.3

Compressive strength of concrete blended with ultra fine RHA.

Mix designation	RHA (%)	Compressive strength (MPa)		
		7 days	28 days	90 days
U1[a]	5	27.4	39.9	45.8
U2	10	28.3	43.8	51.2
U3	15	25.9	39.1	44.4
U4	20	24.6	38.3	42.8

They concluded that RHA blended with cement showed great compressive strength for the 90 days of curing. It was also concluded that cement can be replaced with RHA at a percentage of 15% and 20% for 5µ (ultra fine) and 95µ sizes respectively. However, it is observed that the optimum RHA content for both average particle sizes were achieved with 10%. Water absorption, velocity of water absorption, and coefficient of water absorption of ultra fine RHA at all ages showed a significant decrease in percentage. The water permeability for 95 micron size, however, is reduced after 90 days of curing. The workability of fresh concrete improved due to RHA for both the sizes but the 95 micron size gave rise to higher slump value. They also concluded that RHA can be replaced at least up to 20% which will reduce the consumption of cement. In the end, it was found that U2 could be considered as an optimum formulation due to its high compression value, less water permeability and good workability property.



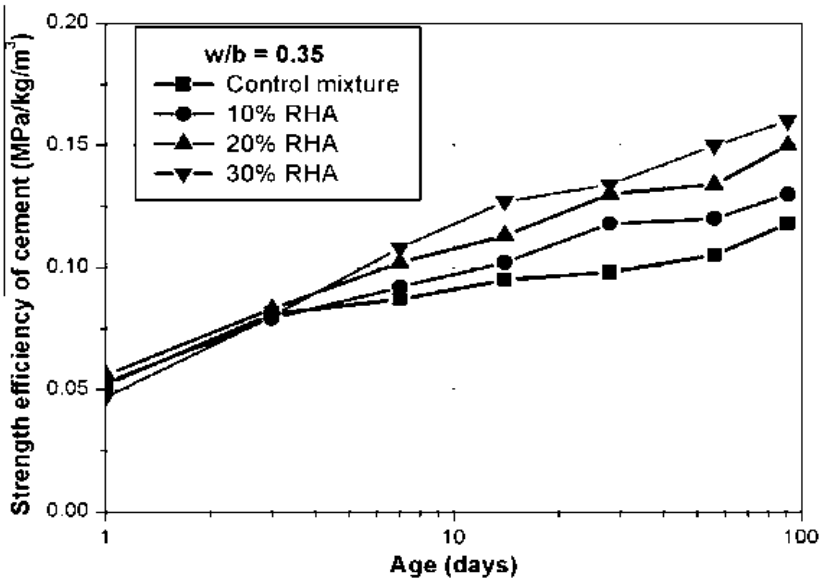
Hwang Chao-Lung et al. (2011)[6] studied "the strength and durability with the addition of RHA in concrete." In their research studied, they added RHA in two ways – in ground form and non-grounded form in the percentages of 0%, 10%, 20%, and 30%. The curing days were 1,3, 7, 14, 28, 46, and 91 days. The tests that were performed in their study course were – compression, electrical resistivity, and ultrasonic pulse velocity. The following readings were drawn from their study.

Mix	*w/b* ratio	RHA content (%)	Compressive strength (MPa)						
			1 day	3 days	7 days	14 days	28 days	56 days	91 days
A23-10	0.23	10	41	59	62	63	66	69	74
A35-00	0.35	0	30	46	50	54	56	60	67
A35-10	0.35	10	27	41	47	52	61	62	67
A35-20	0.35	20	26	38	47	52	60	61	69
A35-30	0.35	30	19	32	43	51	54	60	64
A47-10	0.47	10	16	26	37	40	47	51	56

Mix	*w/b* ratio	RHA content (%)	Electrical resistivity (kΩ-cm)						
			1 day	3 days	7 days	14 days	28 days	56 days	91 days
A23-10	0.23	10	4.6	8.3	12.1	15.2	21.3	36.3	37.5
A35-00	0.35	0	6.7	8.1	11.7	12.6	14.1	20.3	22.9
A35-10	0.35	10	5.9	7.6	11.4	14.3	19.6	37.9	40.9
A35-20	0.35	20	4.4	6.0	10.2	17.6	30.4	58.1	64.1
A35-30	0.35	30	3.7	5.2	11.3	24.4	38.1	65.9	69.1
A47-10	0.47	10	3.3	4.9	7.3	8.4	12.0	24.5	28.5

Mix	w/b ratio	RHA content (%)	Ultrasonic pulse velocity (m/s)						
			1 day	3 days	7 days	14 days	28 days	56 days	91 days
A23-10	0.23	10	4205	4323	4525	4579	4606	4662	4788
A35-00	0.35	0	4121	4264	4443	4463	4515	4599	4642
A35-10	0.35	10	4146	4265	4436	4456	4530	4599	4637
A35-20	0.35	20	4086	4165	4361	4381	4446	4493	4611
A35-30	0.35	30	4047	4147	4342	4372	4417	4457	4611
A47-10	0.47	10	3795	4059	4237	4332	4452	4541	4579

They concluded that the strength increased as the amount of ground concrete increased. The UPV value increased as amount of cement is used. The strength recorded for 91 days shows that the efficiency of strength of cement rises to 0.131, 0.152 and 0.161 MPa/kg/m3 corresponding to when RHA is replaced in 10, 20, and 30% respectively. The strength obtained on 91 day is roughly greater than control mix by 1.2-1.5 times. At the same compressive strength these results indicates that the consumption of cement is only a quarter to the normal usage. That way the consumption of cement, the energy used during production of cement and consequent the emission of carbon dioxide, can largely be reduced for advantageous environmental issues. The electrical resistivity of RHA increased after 91 days of curing. The recorded electrical resistivity became higher than 20 kilo-ohm per cm. Similarly, the UPV also increased to 3660m/s after 91 days of curing. All these positive conclusions made them to conclude that RHA can be best used in the grounded form, and it can be replaced with cement which will reduce the consumption of cement thereby decreasing the emission of carbon dioxide by cement.



Ravande Kishore et al. (2011)[7] studied "strength of high strength RHA concrete." In their paper, the aim was to investigate the mechanical properties of high strength concrete by replacing RHA. The standard cubes (150mmX150mmX150mm), Cylinders (height 150mm and diameter 300mm), and prisms (100mmX100mmX500mm) were casted. 144 samples with M40 and M50 mixes were casted and tested. RHA was replaced in 0%, 5%, 10%, and 15% with compressive strength of 7, 28, and 56 days. The optimum level was recorded to be 10%. The following readings were drawn from their study.

Rice Husk Ash %	Compressive strength (MPa)		
	7 days	28 days	90 days
0	37.20	50.80	51.74
5	35.34	48.26	49.15
10	34.12	44.72	47.08
15	30.36	43.18	45.04

Rice Husk Ash %	Compressive strength (MPa) of M50		
	7 days	28 days	90 days
0	48.31	59.37	62.50
5	42.00	56.40	58.36
10	38.40	53.43	56.40
15	37.37	50.46	52.50

Rice Husk Ash %	Splitting Tensile Strength (MPa)	
	M40	M50
0	4.19	4.19
5	4.05	4.60
10	4.05	4.26
15	3.98	4.19

Rice Husk Ash %	Flexural Strength (MPa)	
	M40	M50
0	4.87	5.36
5	4.40	4.87
10	4.34	4.76
15	4.17	4.72

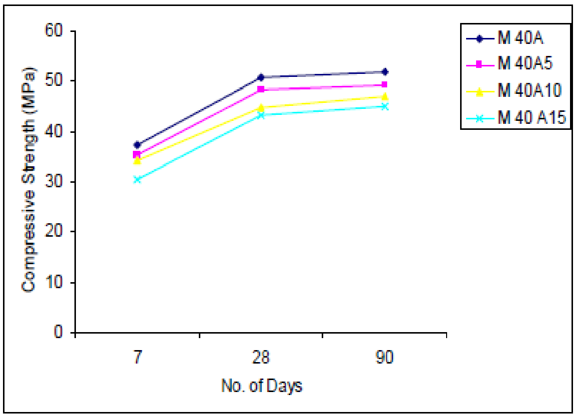


Figure 1: Variation of Compressive Strength of M40 Grade Concrete

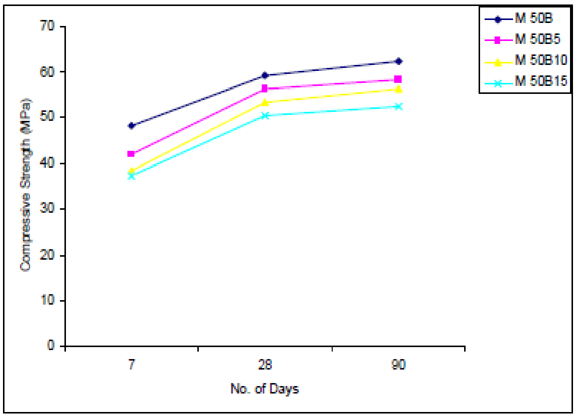


Figure 2: Variation of Compressive Strength of M50 Grade Concrete

The following conclusions were drawn from their study – increased replacement of cement by RHA in concrete decreased the workability of concrete by 27% slump and 9% compaction factor. Replacement decreased the compressive strength, enhanced the workability, and achieved the target strength for 10% replacement for both the grades.

S. D. Nagrale et al. (2012)[8] studied “the utilization of RHA.” In this, study about the advantages of using Rice husk Ash for various purposes without discarding it was studied. It concluded that instead of dumping the waste material we can utilize it in concreting purposes effectively for construction of large buildings. It was also concluded that RHA is a light weight concrete material and that it can be used for the construction of structures where the weight of structure is considered. 72-75% of weight density was reduced due to the utilization of RHA. So, RHA can be used effectively as lightweight concrete to build structures where the weight of the structure is of utmost importance. Utilization of RHA also helped in reducing the cost by 8-12% which makes it as an economical concrete practice. The compressive strength increased with the addition of RHA. The use of RHA significantly reduced the absorption of concrete water. Thus it was concluded that concrete containing RHA can be used effectively in places where the concrete can come in contact with water or moisture and that RHA has the potential to act as an admixture, which increases the strength, workability & pozzolanic properties of concrete.

Patel Manishkumar Dhyhbhai et al. (2013)[9] the optimal dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1% in M20. As a percentage of PEG-400 increased depression increased to M20 concrete quality. Strength of concrete self curing is flush with conventional concrete. Self hardening concrete is the answer to many problems faced due to lack of proper curing. Self-Curing Concrete is an alternative to conventional concrete in desert regions, where lack of water is a major problem.

Patnaikuni Chandan Kumar et al. (2013)[9] studied "the strength of concrete due to RHA on different grades of concrete." It was concluded that almost all samples of M30 and 40 RHA concrete and normal concrete showed zero resistance at 1000 ° C. It shows that concrete cannot withstand temperatures of 1000 ° C and higher. It also concludes that the compressive strength of the RHA concrete was higher at a temperature below 500 ° C and a reduction greater than 500 ° C. The following readings were drawn from this study.

Replacement → Age ↓	0%	5%	7.50%	10%	12.50%
28	30, 28	31.4, 31.2	32.33, 33.74	32, 33	31.5, 32
56	30, 26	31.33, 31.11	32.02, 32.18	30, 28	29.8, 30
90	31, 25	30.8, 30.2	31.6, 31.89	29.1, 26.7	28.2, 27.84

A comparative study with various RHA replacement showed that a 7.5% RHA replacement performed and showed better compressive strength than other substitutions. Hence, 7.5% replacement RHA was recommended as the best replacement level. Concrete cubes of (100 × 100 × 100) mm sizes were casted and tested for compressive strength and the results are showed in Table 5 for 0%, 5%, 7.5%, 10% and 12.5% of RHA replacement of cement for M30 & 40 grades of concrete at room temperature, after 28 days of water curing. The conclusion made was that for the M30 and M40 mixes, the strengths decreased with increase in the duration of heating. This may be due to rupture of bond molecules in the concrete matrix due to prolonged heating. Therefore, RHA concrete can be used in place of concrete due to adequate performance for construction purposes.

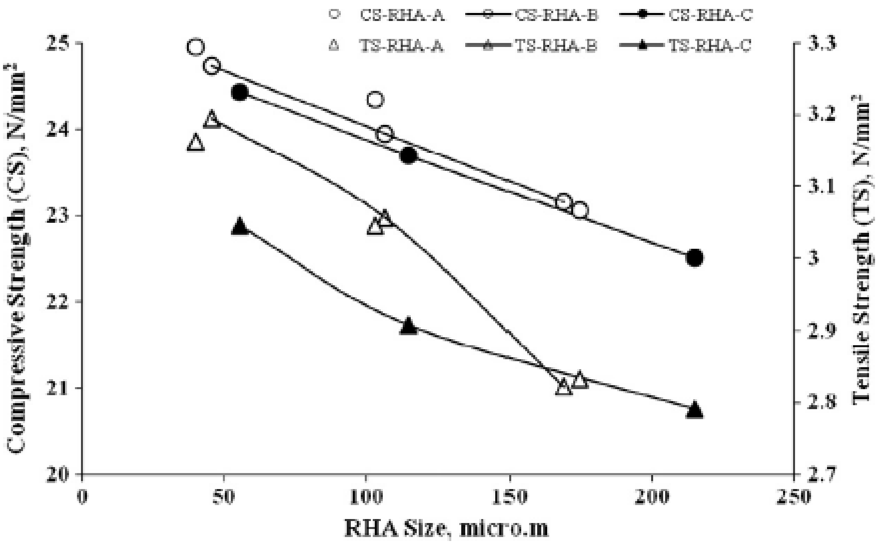
Sourav Ghosal et al. (2015)[10] studied "replacement of rice husk ash in concrete." In this paper a review about rice husk ash was presented. It explained how to use RHA, a waste material, in construction purposes by replacing to a certain percentage of RHA with cement. They studied how this RHA can have an impact on the strength properties of concrete and whether we can use this as a material in the long term. They also concluded that since this material has a light weight it can be used for constructing and that they improve the strength and durability of concrete.

Shikha Tyagi (2015)[11] studied "self curing of concrete using polyethylene glycol." In this report, it involves the use of shrink-reducing mixtures such as PEG 400 as the internal curing compound. This hardening compound used in concrete which helps to heal oneself and helps in a better hydration and therefore to a good resistance to the compression. They trap moisture in the structure and prevent evaporation that normally occurs due to the hydration process. The effect of the curing compound on the workability (retarding and compacting factor) and the compressive strength is studied. It is in this experiment that PEG 400 assists in automatic polymerization by strengthening the conventional curing method and improving viability. The optimal dose of PEG400 for maximum strength was estimated to be 1% for M25 and 0.5% for the M40 score.

P V Rambabu et al. (2015)[12] studied "replacement of rice husk with cement in concrete and effect of sulphuric acid attack on concrete." The study revealed that compressive strength decreased with increase in concentration of sulphuric acid for 28days, 60days and 90days. Other than that at 6% replacement, RHA showed good resistance to sulphuric acid attack. The conclusions that were made was - compressive strengths of concrete with 0%, 5%, 6%, 7%, 8%, 9% and 10% replacement of RHA cured for 28 days in normal water reached the target mean strength. Comparative study on Rice Husk Ash in concrete showed that replacement of 6% RHA performed and showed better strength than other replacements because of high pozzolanic activity. M35 grade RHA concrete exposed to sulphuric acid attack for 28 days, 60 days and 90 days showed that 6% replacement gave better compressive strengths and also at 6% replacement showed good resistance against the chemical. Increase in concentrations of sulphuric acid in curing water decreased the compressive strength.

S. Azhagarsamyet l. (2016)[13]An average increase in compressive strength of 12.73% was found when the self-curing concrete of PEG 400 was used for curing rather than conventional concrete curing. The tensile strength of self-hardened concrete using PEG-400 showed an increase of 13.31% when compared with conventional concrete. Therefore, self - hardened concrete showed better performance in terms of strength characteristics. Also, the durability characteristics of self - hardened concrete showed a promising effect when exposed to acidic conditions. An increase of 10.68, 16.07 and 7.78% was observed when the self-hardened concrete with PEG 400 was exposed to HCl, H2SO4 and Na2SO4 solutions. Therefore, self-hardened concrete has lower porosity than conventional types. Self-hardening concrete shows that it can withstand extreme conditions and corrosion effects. The stiffness and durability characteristics suggest that self-hardening concrete is a better choice in field conditions with water shortage.

Josephin Alex et al. (2016)[14] studied "the replacement of RHA on concrete." On the basis of the experimental results, the following conclusions were made; the average particle size decreased with increase in grinding while the specific area increased with the increase grinding time for all types of RHA samples. RHA type A, ground for 60 minutes was considered the best of all with an average size of 39.94 lm and specific surface area of 109.38 m2 / kg. The bulk density also followed a similar trend to average particle size and RHA type A subjected to 60 minutes of grinding; being the best sample showed a higher bulk density of all samples this study. The grinding time does not have a significant impact on the loss when igniting RHA samples. C-type RHA comparatively carbon content more fixed. The pozzolanic activity of the material can be improved by grinding activity. The finer RHA fractions present a better Chapelle activity. The type of RHA used in this the study had no significant impact on mechanical strength concrete development since the RHA composition tested is identical to each other. Although samples of soil samples of 15 minutes better results, grinding of the ORS for 60 minutes was revealed to transmit more resistance to concrete. In the case of development of the compressive strength, partial replacement of 20% by weight RHA soil samples may be considered appropriate and for RHAs 15% unoccupied could be considered satisfactory. For the development of the tensile strength, 20% by weight replacement was considered optimal. Thus, it can be concluded that the addition of RHA as SCM proves being the best option for sustainable development, solving negative impacts during the cement manufacturing process as CO2 emissions, resource depletion, high cost and also the solid waste disposal problem associated with agricultural waste activity at a certain limit. The following readings were drawn from their study.



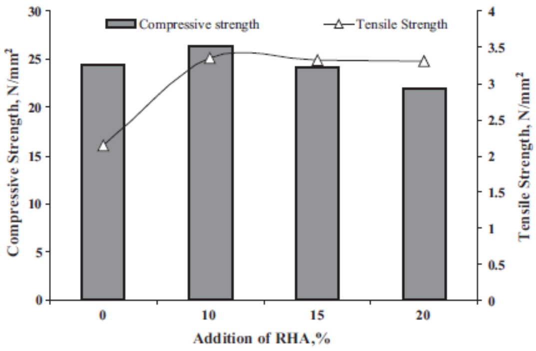


Fig. 13. Effect of % addition of RHA on compressive and tensile strength.

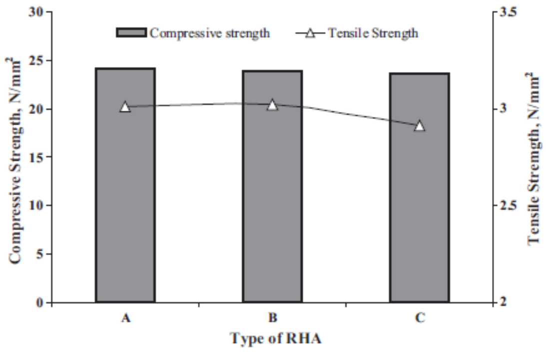


Fig. 15. Effect of type of RHA on compressive and tensile strength.

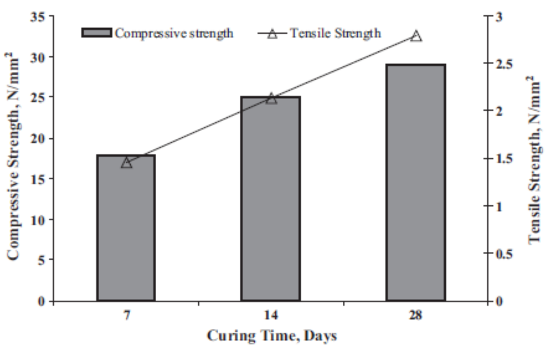


Fig. 14. Effect of curing time on compressive and tensile strength.

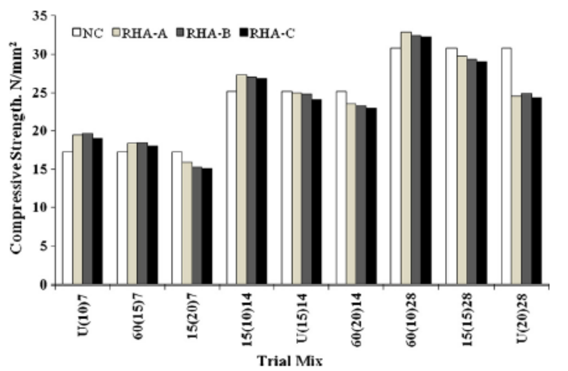


Fig. 16. Comparison on the compressive strength development of various RHA mixes and normal concrete (NC).

M.V. Jagannadha Kumar et al. (2016)[15] It involves the use of the polyethylene glycol reducing mixture (PEG 400) in the concrete which helps in self-curing and helps in better hydration and therefore strength. In the present study the effect of the blend (PEG 400) on the compressive strength, split fracture strength and the modulus of rupture were studied by varying the percentage of PEG by weight of cement from 0% to 2% both for mixtures M20 as

M40. It was found that PEG 400 could aid in self-curing by giving torque at the same time as conventional curing. It was also found that 1% of PEG 400 by weight of cement was optimal for M20, while 0.5% was optimum for M40 grade concretes to achieve maximum strength without compromising workability. The optimum dose of PEG400 for the maximum strengths (compression, tensile strength and rupture modulus) was 1% for M20 and 0.5% for M40 grades of concrete. The percentage of PEG400 increased with the increase of concrete of M20 and M40 grade.

Olesia Mikhailova et al. (2016)[16] The purpose of this research was study the effect of polyethylene glycol with relative molecular weight between 400-20000 on properties geopolymer mortars composed of metakaolin and sodium silicate. Maximum compressive and flexural strengths were achieved by the addition of 10% PEG 400. Compression and flexural strength value for specimens containing PEG 1000 at the 1% dose and PEG 20000 at a dosage of 0.5%, respectively. These results were confirmed by SEM and porosity measurements. The sample (10% PEG 400) with the highest strength had dense structure and was less porous.

Snehal Bhosale et al. (2016)[17] the effect of the self-hardening agent on the compressive strength is examined by variable percentage addition of PVA & Rice Husk Ash. PVA mixed in water of 0.5%, 1%, 2%, 3%, 4% and 5% by weight of cement. It has been found that PVA could help heal itself by giving strength tied with conventional hardening. It was also found that 3% PVA by weight of cement was optimal for M20 quality concretes for maximum strength (compressive nature) without compromising viability. Rice Husk Ash mixed with water from 5%, 10%, 15% and 20% by weight of cement. It was found that Rice Husk Ash could help in personal healing by giving strength to conventional curative treatment. It was also found that 10% of Rice Husk Ash by the weight of the cement was optimal for maximum strength. In this paper, consider the elasticity of self-hardening concrete.

Gemma Rodrı´guez de Sensale (2016)[18] studied “the development of strength of concrete due to RHA.” This paper studies the development of compressive strength of up to 91 days by addition of rice husk ash (RHA) collected from a rice mill in Uruguay and RHA produced by controlled US incineration were studied in comparison. Two replacement percentages were used for this – 10% and 20% with three different w/c ratios of 0.5, 0.4, and 0.32. The result is compared with control mix for compressive test, split tensile test, and air permeability test.

The following readings were drawn from the study.

w/(c + RHA)	RHA		f_c (MPa)			$f_{t,d}$ (MPa) 28d	K_t (m^2) 28d
	Type	%	7d	28d	91d		
0.32		0	48.4	55.5	60.6	3.63	1.08×10^{-16}
	UY	10	51.1	60.4	64.3	3.57	0.23×10^{-16}
		20	44.3	54.8	62.7	3.34	0.05×10^{-16}
	USA	10	39.5	51.4	64.5	3.62	0.08×10^{-16}
		20	30.5	47.4	68.5	3.54	0.03×10^{-16}
0.40		0	35.8	42.3	45.6		
	UY	10	41.1	50.4	54.9		
		20	27.9	40.7	51.4		
	USA	10	29.7	40.8	51.5		
		20	23.6	39.4	57.3		
0.50		0	24.6	32.9	35.9	2.85	28.20×10^{-16}
	UY	10	24.1	31.5	35.5	2.32	71.82×10^{-16}
		20	24.9	34.9	37.9	2.63	49.10×10^{-16}
	USA	10	22.7	34.5	44.4	2.92	26.36×10^{-16}
		20	20.8	35.9	52.9	3.00	14.20×10^{-16}

It was concluded that addition of RHA gave positive impact on the compressive strength of the concrete but it was not suggested to use for a long term purpose. The maximum compressive strength was shown for 91 days and on the contrary for 7 and 28 days it showed different results for both the RHA used. The paper also concluded that the compression strength of concrete was due to the filler property of RHA (a physical property) and not due to its pozzolanic property (a chemical property) for both the RHA. But the increase in compressive strength due to the incinerated RHA was due to its pozzolanic property. And the results that were obtained from split tensile test and air permeability test disclosed the impact of filler and pozzolanic property for both the residual RHA and incinerated RHA.

M. Poovizhiselvi et al. (2017)[19] the mixing effect (PEG 400) on the compressive strength, the tensile strength, the bending strength and the durability test by varying the percentage of polyethylene glycol (PEG) by weight of cement of 0 % To 2% were studied for mixtures M20 and M30. Super plasticizers are water reducers capable of reducing the water content by about 30%. It was also found that 1% PEG 400 per cement weight was optimal for M20, while 0.5% was optimal for M30 grade concretes to achieve maximum strength without compromising workability. The maximum strength of PEG400 for maximum strength (compressive strength, tensile strength and flexural strength) was estimated at 1% for M20 and 0.5% for the M30 concrete qualities. The strength and durability properties of the internally treated concrete with PEG proved to be the best among the percentage of alternatives and proved to be the best with respect to external hardening. The strength of the self-hardening concrete is at the par of conventional concrete. While considering the internal hardening with that of the external hardening, the cost of the internal hardening is cheaper compared to that of the external hardening. The performance of the self-hardening agent will be affected by the mixing proportions mainly of the cement content and the w / c ratio.

2.2. Literature Summary

Replacement of cement by RHA and PEG-400 is done by making different concrete mixes say M25, M30, and M45. The strength is analyzed by performing the compression test on the concrete cube specimen with a dimension of (150 x 150 x 150) mm. The percentage replacement of cement by RHA is 5%, 10%, 15%, 20%, 25%, and 30%. The optimal dosage of RHA is between 10% to 20% with curing days of 7, 14 and 28. While PEG – 400 is replaced in percentages of 0.5%, 1.0%, 1.5%, and 2.0%. The optimal dosage of PEG – 400 is between 0.8% to 1.5% with curing days of 7, 14, and 28 days. The strengths are taken as an average of 3 or more cubes for each curing day and replacement. The maximum strength that was recorded in the literature was shown on the 28thday. It is concluded that the strength of the concrete increased as the curing days increased. It is also concluded in the literature that addition of these admixtures increased the compressive strength of the concrete for both RHA and PEG – 400. The chemical admixture PEG – 400 also helped in maintaining the water in concrete by its self-curing property. However, addition of more than the optimal dosage of the admixtures showed a declination in the strength of concrete. It can therefore be concluded that only up to some percentages of the admixtures should be added to show the ultimate compressive strength. Also lastly, usage of these admixtures showed that it can be advantageously used as cheap replacement of conventional cement. These admixtures reduced the total cost as they are cheap and easily available. RHA and PEG – 400 can be used as an alternate material for cement effectively.

2.3. Research Gap

In all the previous researches that have been done so far, check of compressive strength of concrete only has been performed. The optimal dosage of RHA was 10-20% and for PEG – 400, it was 1-1.5%. Also, study on curing of concrete by using RHA and PEG – 400 has not been done by many. While on this research course, not only check for compression is performed but also check for tensile and flexure is done. The replacement of RHA is done in different percentages of 11%, 18%, and 22% as oppose to others and the maximum strength of concrete will be studied.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Work Plan and Methods used

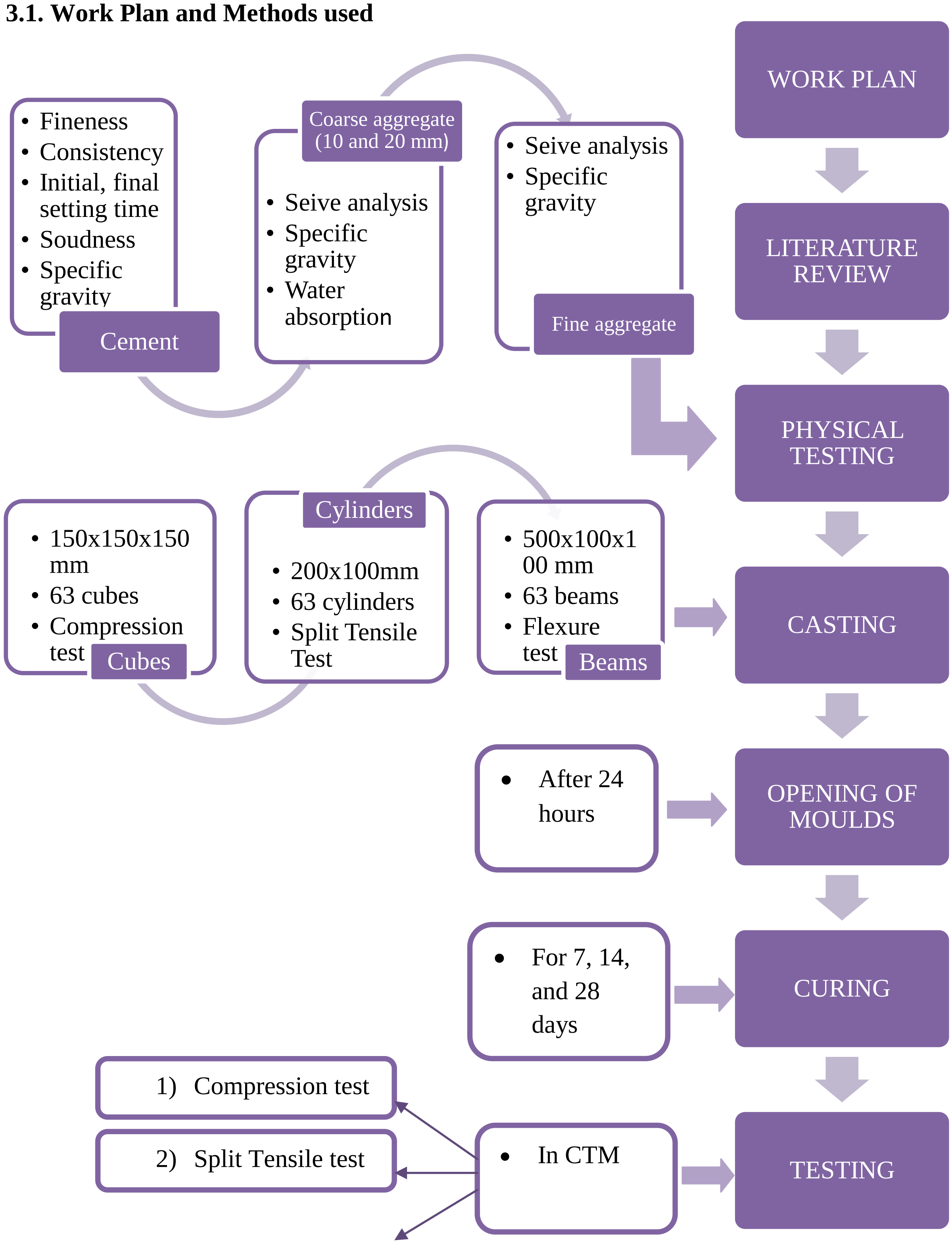


Figure3.1. Work Plan and Methods used

3.2. Materials used

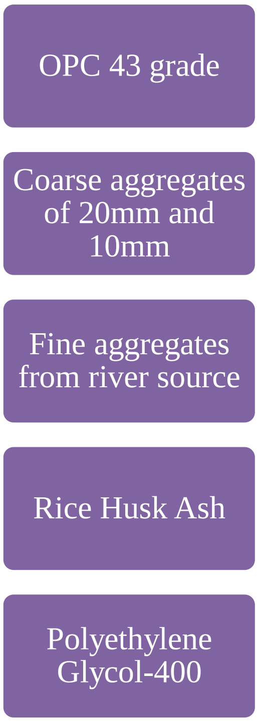


Figure3.2. Materials used

3.3. Experimental Investigation

Two types of tests are conducted –

1. Physical properties test which further includes fineness test, consistency test, initial and final setting time, soundness test, specific gravity test, sieve analysis test, and water absorption test. These tests are done cement, coarse and fine aggregates.
2. Strength analysis test which includes compression test on cubes, split tensile test on cylinders, and flexure test on beams.

3.3.1. Test for Ordinary Portland cement (OPC)

3.3.1.1. Fineness Test

The fineness of cement contributes to three important factors-

i. Rate of hydration – greater the surface area, greater the heat of hydration.

ii. Rate of gain of strength – due to rate of hydration.

iii. Rate of evolution of heat.

Fineness tests can be done in two ways – either by sieve analysis or by air permeability method. Here the sieve method is conducted. To perform this test, we can simply take a certain amount of cement, here 300g is taken and take it on a standard sieve with the number 9 i.e., 90. After placing the cement on the sieve, shake it continuously in a vertical direction for fifteen minutes. After the cement is sieved, weigh the cement. The weight should not surpass ten percent of the total weight (here 300g).

- The results obtained after the test is given below:

Weight of cement	Weight of retained cement
300g	4.5 g < 10% of 300 g

Table3.1. Fineness test of cement

3.3.1.2. Consistency test

Before finding out the initial and final setting time, and soundness of cement, it is required to first perform the consistency test. We can say that cement is consistent if it allows the Vicat plunger needle with diameter of 10mm and 50mm long is able to pierce through it at a distance of 33-35mm. The apparatus used is called Vicat apparatus which is used to determine the water percentage needed to make the paste of cement standard in consistency.

The test is performed by first taking 300g of cement and water of 24%, 25%, 29%, and 29.5% by total weight of the cement. Put the paste in the mould for all the different percentages, and shake it so that the air voids disappear. After that test by plunging the Vicat needle and note down the reading.

- The observation and reading recorded:

Weight of cement = 300g

% of water added	Weight of water(g)	Initial Reading(mm)	Final Reading(mm)
25	75	37	34
28	84	37	16
29	87	37	10
29.5	88.5	37	7

Table3.2. Consistency test of OPC

- Consistency of cement is 29.5%

3.3.1.3. Initial and Final Setting Time

The time when the cement paste is plastic in nature is the initial setting time, and the time when it loses its plastic nature is final setting time. When cement loses its plasticity, it becomes firm and can resist pressure.

To perform this test, take 300 g of cement, and gauge it 0.85 times the required water quantity. Fill the Vicat mould with the paste. The initial time is the time taken by the needle to penetrate in the paste at a depth of 33-35mm. And the final time is the time taken when the needle when released makes a mark on the surface of the paste. It should be noted that the needle does not perforate more than 0.5 mm.

Weight of cement	**Weight of water**
300 g	40.85*0.295*300 = 75.5g

Table3.3. Initial and final setting time

- Initial setting time of cement is 32 minutes.
- Final setting time of cement is 278 minutes.

3.3.1.4. Soundness of Cement

The main purpose of testing the soundness of cement is to ensure that there is no expansion in volume. Cement after setting expands once after the cement is set which will hamper the durability of the structures. Hence, soundness testing is necessary. It is done in a Le-Chtelier apparatus.

Soundness is calculated by –

Soundness = $((D_3-D_1) + (D_4-D_2)) / 2$

- The observation and reading recorded is as follows:

Initial distance	**Weight of Cement**	**Weight of water added**	**After 24 hours of cement in water**	**After 3 hours of boiling of cement in water**
1cm	100g	0.78*0.295*100 = 23g	D_1 = 1.6cm D_2 = 1.5cm	D_3 = 1.9cm D_4 = 1.8cm

Table3.4. Soundness of OPC

- Soundness = 0.3cm or 3mm < 10m

3.3.1.5. Specific Gravity Test of cement

Ratio between the weights of a given volume of substance to the ratio of weight of an equal volume of water gives the specific gravity of cement. Kerosene is used for determining this value.

Specific gravity is mathematically calculated by –

- S.G. = $(W_2-W_1) / ((W_2-W_1) – (W_3-W_4)*0.92)$

Weight of cement	Weight of empty flask W_1	Weight of flask and cement W_2	Weight of flask, cement and diesel W_3	Weight of flask and diesel W_4
50g	109g	159g	395g	358.5g

Table3.5. Specific gravity of OPC

- Specific Gravity of OPC = 3.045

3.4. Test for Sand

3.4.1. Sieve Analysis Test

Sieve analysis of fine aggregates is done to check the fineness of the sand. Usually it is done by allowing the sand to pass through different sizes of sieve. It is a simple and very easy method.

The observations and calculations recorded are as follows:

- Weight of sand = 2 kg
- Sum of % Cumulative Weight = 205.475
- Fineness Modulus = 2.05475 < 2
- Type of sand – very fine

Sieve Size(mm)	Weight Retained(g)	Cumulative Weight (g)	% Cumulative Weight
4.75	6	6	0.3
2.36	4.5	10.5	0.525
1.18	5	15.5	0.775
600	7	22.5	1.125
300	155	177.5	8.875
150	1720	1897.5	94.875
90	82.5	1980	99
pan	20	2000	-

Table3.6. Sieve Analysis for Sand

3.4.2. Specific Gravity Test

Specific gravity of sand is done by using a pycnometer. Firstly, take 500g of sand. We then weigh the dry pycnometer. Next we put the sand in the pycnometer and put them in the water and then check the weight of the sand and pycnometer in the water which is denoted by W. Next we weigh only the pycnometer in water and denote it as W_1. We then oven dry the wet sand for 24 hours and then check the weight of the dry sand which is denoted by W_2.

The formula is given by –

- S.G. = $W_2 / (W_2 - (W - W_1))$

Weight of dry pycnometer	Weight of sand	Weight of sand, pycnometer, and water W	Weight of water and pycnometer W_1	Weight of sand after 24 hours of oven drying W_2
639g	500g	1846g	1534g	485g

Table3.7. Specific gravity for Sand

- Specific gravity = 2.66

3.5. Test for 10mm Aggregates:

3.5.1. Sieve Analysis Test

The purpose of doing this test is for two reasons –

1. Dividing the aggregate into groups of same sizes.
2. To grade the aggregate according to its size.

This test is also simple and easy to perform. We just take 2.5 Kg of the aggregates and allow them to pass through different sieve sizes by shaking them.

- The observation table and calculations are given:
- Weight of aggregate taken = 2.5kg

Sieve Size(mm)	Weight Retained(g)	% Weight Retained	% Cumulative passing	Nominal size for % passing
25	0	0	100	-
20	0	0	100	100
16	21	0.84	99.16	-
10	640	25.6	73.56	40-85
6.3	880	35.2	38.36	-
4.75	360	14.4	23.96	0-10
Pan	20	8.4	15.56	-

Table3.8. Sieve Analysis for 10mm aggregate

3.5.2. Specific Gravity and Water Absorption Test

The methods for performing these tests are the same as explained above. The formula for finding the specific gravity (S.G) and water absorption (W.A) is given by:

- S.G. =W3 / (W4-(W1-W2))
- W.A. = ((W3-W4) / W3) *100

Weight of aggregates taken	Weight of basket and aggregates in water W_1	Weight of basket in water W_2	Weight of aggregates before oven drying W_3	Weight of aggregates after oven drying W_4
4000g	3500g	1000g	4020g	3980g

Table3.9. S.G and W.A test for 10mm aggregate

- S.G = 2.71
- W.A = 0.99%

3.6. Test for 20mm Aggregates:

3.6.1. Sieve Analysis Test

The purpose of doing this test is for two reasons –

3. Dividing the aggregate into groups of same sizes.
4. To grade the aggregate according to its size.

This test is also simple and easy to perform. We just take 2.5 Kg of the aggregates and allow them to pass through different sieve sizes by shaking them.

- The observation table and calculations are given:
- Weight of aggregate taken = 2.5kg

Sieve Size(mm)	Weight Retained(g)	% Weight Retained	% Cumulative passing	Nominal size for % passing
20	0	0	100	-
16	60	0.84	100	100
12.5	1.3	0.50	99.16	-
10	750	25.6	73.56	40-85
6.3	630	35.2	38.36	-
4.3	20	14.4	23.96	0-10
Pan	-	-	-	-

Table3.10. Sieve Analysis for 20mm aggregate

3.6.2. Specific Gravity and Water Absorption Test

The methods for performing these tests are the same as explained above. The formula for finding the specific gravity (S.G) and water absorption (W.A) is given by:

- S.G. =W3 / (W4-(W1-W2))
- W.A. = ((W3-W4) / W3) *100

Weight of aggregates taken	Weight of basket and aggregates in water W_1	Weight of basket in water W_2	Weight of aggregates before oven drying W_3	Weight of aggregates after oven drying W_4
4000g	3500g	1000g	4010g	3970g

Table3.11. S.G and W.A test for 20mm aggregate

- S.G = 2.72
- W.A = 0.99%

3.7. Workability of concrete

A fresh concrete or also called as a plastic concrete is a material that can be shaped into any form because of its flowing property. The w/c ratio can also be determined by checking the workability of concrete. When we compact concrete very nicely there is no air voids present in it and so it leads to high strength of the structure. If compaction is not done properly, air voids will be formed and capillary cavities will be formed. Full compaction can be achieved by taking a slightly higher w/c value than that of theoretical w/c ratio that we have calculated. We can say that concrete is workable when it satisfies the following requirements –

1. Handling the concrete without any segregation.
2. There is no loss of homogeneity when concrete is placed.
3. The concrete is easily compacted without much effort.

If the above requirements are fulfilled, we can say that a concrete is workable. Workability can be measured in different ways. Here, slump test is performed to check the workability of concrete.

3.7.1. Slump test

It is a very common test and easy to perform anywhere, be it in the lab or at the site. It is, however, not the most accurate method to check if the concrete mix extremely dry or wet. It is done on a cone like apparatus with a 20cm and 10 cm diameter at the bottom and top respectively, and with a height of 30 cm. The freshly prepared concrete is poured in the cone in three layers, each layer being tamped twenty five times by a tamping rod. After it is filled, we immediately remove the cone slowly and carefully. Care should be taken while removing the cone. The slump value can be measured by checking the pattern of the concrete. If it stays upright and does not fall, it is called true slump which means that the w/c ratio used was neither too much not too less. But if on one side of the cone, it slides off, it is called as a shear slump which indicates that the concrete shows features of segregation and that the concrete is not cohesive. And in such a case, we measure the slump value by taking a difference of the total height and the height at which the concrete slid off.

Figure3.3. Slump of concrete

3.8. M25 Concrete Mix Design as per IS:10262-2009

3.8.1. Stipulation for proportioning

Grade designation	M25
Type of cement	OPC grade 43 (IS:8112-1982)
Minimum cement content	320Kg/m^3
Maximum cement content	540Kg/m^3
Maximum nominal aggregate size	20mm
Maximum w/c ratio	0.45
Workability	100

3.8.2. Test Data for Materials

Specific gravity of cement	3.15
Specific gravity of coarse aggregate of 10mm	2.71
Specific gravity of coarse aggregate of 20mm	
Specific gravity of fine aggregate	2.66
Specific gravity of water	1

3.8.3. Target Strength and Mix Proportioning

From IS: 10262-2009

$f'_{ck} = f_{ck} + 1.65 \times S$

Where, f'_{ck}= Target average compressive strength at 28 days.

f_{ck}= Characteristic compressive strength at 28 days.

S = Standard deviation

$f'_{ck} = 25 + 1.65 x4 = 31.6\ N/mm^2$

3.8.4. Selection of Water Cement Ratio

From IS 456: 2000, for M25 mix concrete,

Minimum cement content = $320 Kg/m^3$

Maximum Water Cement Ratio = 0.45

Adopted Water Cement Ratio = 0.40

Here, 0.4<0.45

Hence, it is okay to use 0.40 as w/c ratio

3.8.5. Selection of Water Content

Maximum Water content (10262-table-2) = 186 lit.

Estimated Water content = 186 + 186 *6/100

= 197.16 liter

3.8.6. Calculation of Cement Content

Water Cement Ratio = 0.40

Cement Content = (197.16/0.40)

= 490 kg/m^3

From table 5 IS 456-2000,

Minimum cement content = 320 kg/m^3

Here, 490 Kg/m^3> 320 kg/m^3

Hence, use 490 Kg/m3.

3.8.7. Proportion of Volume of Coarse Aggregate and Fine Aggregate

As per IS 10262-2009

For volume of CA

w/c = 0.40 = 0.62

For pumpable concrete these values should be reduced by 10%

Adopted vol. of coarse aggregate = 0.62x0.9 = 0.56 m^3

Adopted Vol. of Fine Aggregate = 1-0.56 = 0.44 m^3

3.8.8. Mix Calculation

Volume of Concrete in m^3 = 1

Volume of Cement in m^3 = $\frac{\text{(Mass of Cement)}}{\text{(Sp. Gravity of cement x 1000)}}$

= 490/3.15 x 1/1000

= 0.155 m^3

Volume of Water in m^3 = $\frac{\text{(Mass of Water)}}{\text{(Sp. Gravity of Water) x1000}}$

= 197.16/1 x 1/1000

= 0.197 m^3

Volume of all in aggregate in m^3 = 1- (0.155+0.197)

= 0.648 m^3

Mass of Coarse Aggregate in m^3 = 0.648 x0.56 x2.74 x1000

= 1000 Kg/m^3

Mass of fine Aggregate in m^3 = 0.648 x0.44 x2.74x1000

= 790Kg/m^3

Therefore, volume of cement = 490 Kg/m^3

Water = 197.16 lit

CA = 1000 Kg/m^3

FA = 790 Kg/m^3

w/c = 0.40

- Therefore, the design mix ratio for M-25 = 1:1.61:2.04

Water cement ratio w/c	Cement C (kg)	Fine aggregate F.a (kg)	Coarse aggregate C.a (kg)
0.4	490	790	1000
	1	1.61	2.04

3.9. Tests for hardened concrete

3.9.1. Compression test

- Test done on concrete cubes with a dimension of (150 x 150 x 150)mm.
- The test was performed on a Compression Testing Machine.
- The total number of cubes that was tested was 63.
- The curing days were 7, 14, and 28 days.
- The test was conducted in two ways – first on replacement of cement with RHA in percentages of 11%, 18%, and 22%. And secondly with replacement of RHA and PEG-400 added together in combined percentages of 11+0.5%, 18+1%, and 22+1.5%.

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	22.842 20.734 21.698	21.758
11%	24.751 25.658 25.762	25.390
18%	21.897 21.470 21.864	21.743
22%	21.835 20.365 21.903	21.367

Table3.12. 7 days compression test of cubes with RHA

Replacement of RHA (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	26.657 26.864 26.530	26.683
11%	26.773 26.628 26.702	26.701
18%	25.497 24.605 25.489	25.197
22%	22.128 20.652 22.233	21.671

Table3.13. 14 days compression test of cubes with RHA

Replacement of RHA (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	30.422 30.233 30.894	30.516
11%	31.506 31.424 31.973	31.634
18%	29.937 28.782 29.142	29.287
22%	27.591 27.352 27.447	27.463

Table3.14. 28 days compression test of cubes with RHA

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	21.758	26.683	30.516
11%	25.390	26.701	31.634
18%	21.743	25.197	29.287
22%	21.367	21.671	27.463

Table3.15. Compression test of cubes for 7, 14, and 28 days with RHA

Replacement of RHA+PEG400 (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	22.842 20.734 21.698	21.758
11+0.5%	26.710 26.958 26.645	26.771
18+1.0%	24.437 26.360 24.364	25.053
22+1.5%	22.560 20.761 21.463	21.594

Table3.16. 7 days compression test of cubes with RHA and PEG-400

Replacement of RHA+PEG400 (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	26.657 26.864 26.530	26.683
11%	31.235 31.654 31.786	31.558
18%	27.408 27.762 27.493	27.554
22%	25.791 25.923 25.280	25.664

Table3.17. 14 days compression test of cubes with RHA and PEG-400

Replacement of RHA (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	30.422 30.233 30.894	30.516
11%	32.395 32.985 32.801	32.727
18%	30.808 30.324 30.631	30.587
22%	29.191 30.461 29.687	29.779

Table3.18. 28 days compression test of cubes with RHA and PEG-400

Replacement of RHA+PEG400(%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	21.758	26.683	30.516
11%+0.5%	26.771	31.558	32.727
18%+1.0%	25.053	27.554	30.587
22%+1.5%	22.560	25.791	29.191

Table3.19. Compression test of cubes fro 7, 14, and 28 days
with RHA and PEG-400

3.9.2. Split Tensile test

4. Test done on concrete cylinders with a dimension of (200 x 100) mm.
5. The test was performed on a Compression Testing Machine.
6. The total number of cylinders that was tested was 63.
7. The curing days were 7, 14, and 28 days.
8. The test was conducted in two ways – first on replacement of cement with RHA in percentages of 11%, 18%, and 22%. And secondly with replacement of RHA and PEG – 400 added together in combined percentages of 11+0.5%, 18+1%, and 22+1.5%.

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	2.299 2.454 2.877	2.543
11%	3.130 3.393 3.753	3.425
18%	1.917 1.642 2.872	2.143
22%	1.710 1.867 1.098	1.555

Table3.20. 7 days split tensile test of cylinders with RHA

Replacement of RHA (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	2.592 2.793 2.339	2.547
11%	3.585 3.899 3.272	3.585
18%	3.028 3.115 3.083	3.075
22%	2.573 2.982 2.056	2.537

Table3.21. 14 days split tensile test of cylinders with RHA

Replacement of RHA (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	2.914 2.782 2.579	2.758
11%	3.936 3.761 3.303	3.667
18%	3.028 3.165 3.389	3.194
22%	2.972 2.781 2.560	2.771

Table3.22. 28 days split tensile test of cylinders with RHA

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	2.543	2.547	2.758
11%	3.425	3.585	3.667
18%	2.143	3.075	3.194
22%	1.555	2.537	2.771

Table3.23. Split tensile test of cylinders for 7, 14, and 28 days with RHA

Replacement of RHA+PEG400 (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	2.299 2.454 2.877	2.543
11%	3.815 3.511 3.782	3.702
18%	2.621 2.411 2.598	2.543
22%	2.312 2.640 2.422	2.458

Table3.24. 7 days split tensile test of cylinders with RHA and PEG-400

Replacement of RHA+PEG400 (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	2.592 2.793 2.339	2.574
11%	4.162 4.122 4.642	4.308
18%	3.270 3.466 3.221	3.319
22%	3.175 3.221 3.095	3.635

Table3.25. 14 days split tensile test of cylinders with RHA and PEG-400

Replacement of RHA+PEG400 (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	2.914 2.782 2.579	C
11%	4.242 4.491 4.611	4.448
18%	4.006 4.126 4.065	4.065
22%	3.684 3.781 3.440	3.623

Table3.26. 28 days split tensile test of cylinders with RHA and PEG-400

Replacement of RHA +PEG400(%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	2.543	2.574	2.574
11%+0.5%	3.702	4.308	4.308
18%+1.0%	2.543	3.319	3.319
22%+1.5%	2.458	3.635	3.635

Table3.27. Split tensile test of cylinders for 7, 14, and 28 days
with RHA and PEG-400

3.3.7. Flexure Test

- Test is done on concrete beams with a dimension of (500 x 100 x 100)mm.
- The test was performed on a Compression Testing Machine.
- The total number of beams that was tested was 63.
- The curing days were 7, 14, and 28 days.
- The test was conducted in two ways – first on replacement of cement with RHA in percentages of 11%, 18%, and 22%. And secondly with replacement of RHA and PEG – 400 added together in combined percentages of 11+0.5%, 18+1%, and 22+1.5%.

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	6.1 6.03 6.25	6.126
11%	6.8 6.65 6.9	6.783
18%	5.6 4.98 5.7	5.426
22%	5.4 5.27 5.37	5.346

Table3.28. 7 days flexure test of beams with RHA

Replacement of RHA (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	6.75 6.44 6.9	6.696
11%	8.3 8.21 8.7	8.403
18%	7.0 7.32 7.17	7.163
22%	6.3 6.21 6.68	6.396

Table3.29. 14 days flexure test of beams with RHA

Replacement of RHA (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	9.25 9.51 9.3	9.353
11%	10.1 10.43 10.25	10.26
18%	8.25 8.19 8.4	8.28
22%	6.75 6.38 6.65	6.593

Table3.30. 28 days flexure test of beams with RHA

Replacement of RHA (%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	6.126	6.696	9.353
11%	6.783	8.403	10.26
18%	5.426	7.163	8.28
22%	5.346	6.396	6.593

Table3.31. Flexure test of beams for 7, 14, and 28 days with RHA

Replacement of RHA+PEG400 (%)	Strength in 7 Days (N/mm^2)	Average strength in 7 Days (N/mm^2)
0%	6.1 6.03 6.25	6.126
11%	7.85 7.60 7.74	7.73
18%	6.4 6.32 6.65	6.456
22%	5.6 5.2 5.45	5.416

Table3.32.7 days flexure test of beams with RHA and PEG-400

Replacement of RHA+PEG400 (%)	Strength in 14Days (N/mm^2)	Average strength in 14Days (N/mm^2)
0%	6.75 6.44 6.9	6.696
11%	10.75 10.43 10.69	10.623
18%	8.4 8.21 8.5	8.37
22%	6.85 6.21 6.70	6.586

Table3.33. 14 days flexure test of beams with RHA and PEG-400

Replacement of RHA (%)	Strength in 28Days (N/mm^2)	Average strength in 28Days (N/mm^2)
0%	9.25 9.51 9.3	9.353
11%	12.7 12.54 12.9	12.713
18%	9.05 9.3 9.18	9.176
22%	7.7 7.0 7.98	7.56

Table3.34. 28 days flexure test of beams with RHA and PEG-400

Replacement of RHA +PEG400(%)	Strength in 7 Days (N/mm^2)	Strength in 14Days (N/mm^2)	Strength in 28Days (N/mm^2)
0%	6.126	6.696	9.353
11%+0.5%	7.73	10.623	12.713
18%+1.0%	6.456	8.37	9.176
22%+1.5%	5.416	6.586	7.56

Table3.35. Flexure test of beams for 7, 14, and 28 days with RHA and PEG-400

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Comparison of results

4.1.1. For the compressive test of cube

- When replaced with RHA only

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	21.758	26.683	30.516
11	25.390	26.701	31.634
18	21.743	25.197	29.287
22	21.367	21.671	27.463

Table4.1. Compressive strength of cube

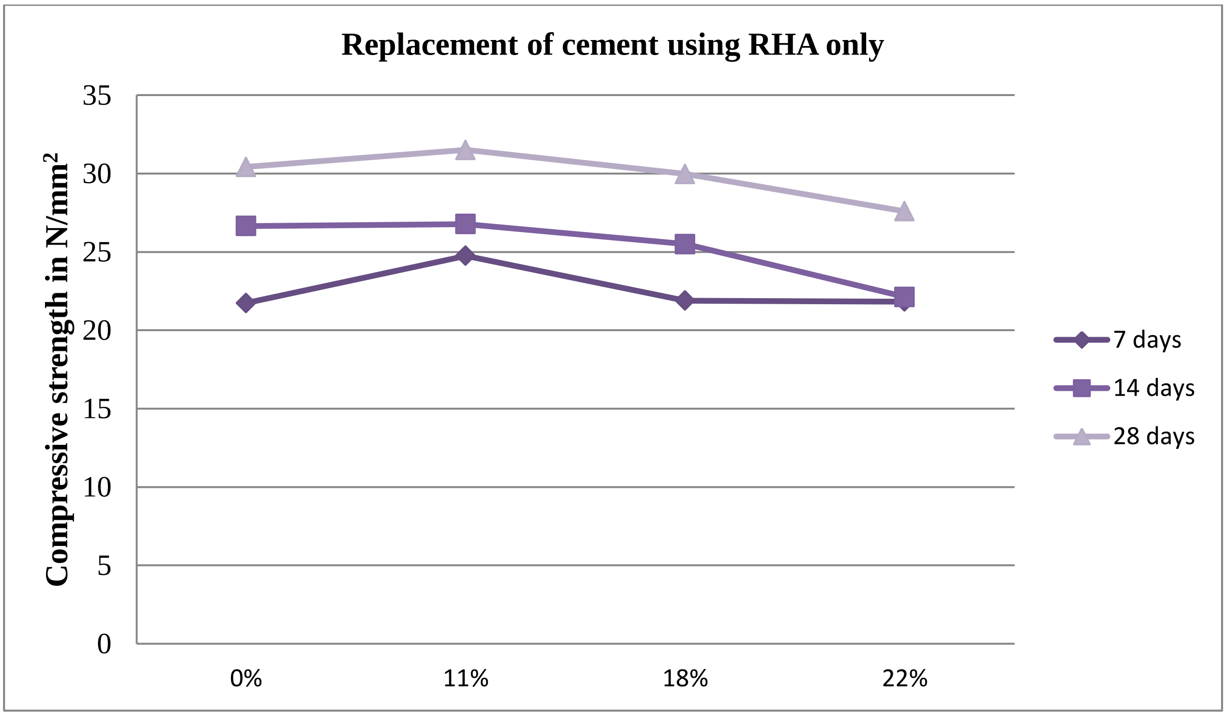


Figure4.1. Graph of compressive strength of cubes

- Discussion:

1. The compressive strength is maximum when 11% of RHA is replaced.
2. The compressive strength also increased as the curing days increased. For every curing day, the maximum strength is shown for 11% replacement.
3. After 7 days the strength is 24.751N/mm^2 for 11% replacement, for 14 days it is 26.773 N/mm^2 for 11% replacement, and it increases to 31.506 N/mm^2 for 11%.
4. However it is observed that RHA cannot be replaced from 20% and above as it makes the strength weaker.
5. Therefore, we can conclude that RHA as an admixture performs best when 11% of it is replaced.

- When replaced with RHA and PEG – 400

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	21.758	26.683	30.516
11+0.5	26.771	31.558	32.727
18+1	25.053	27.554	30.587
22+1.5	22.560	25.791	29.191

Table4.2. Compressive strength of cube with RHA and PEG-400

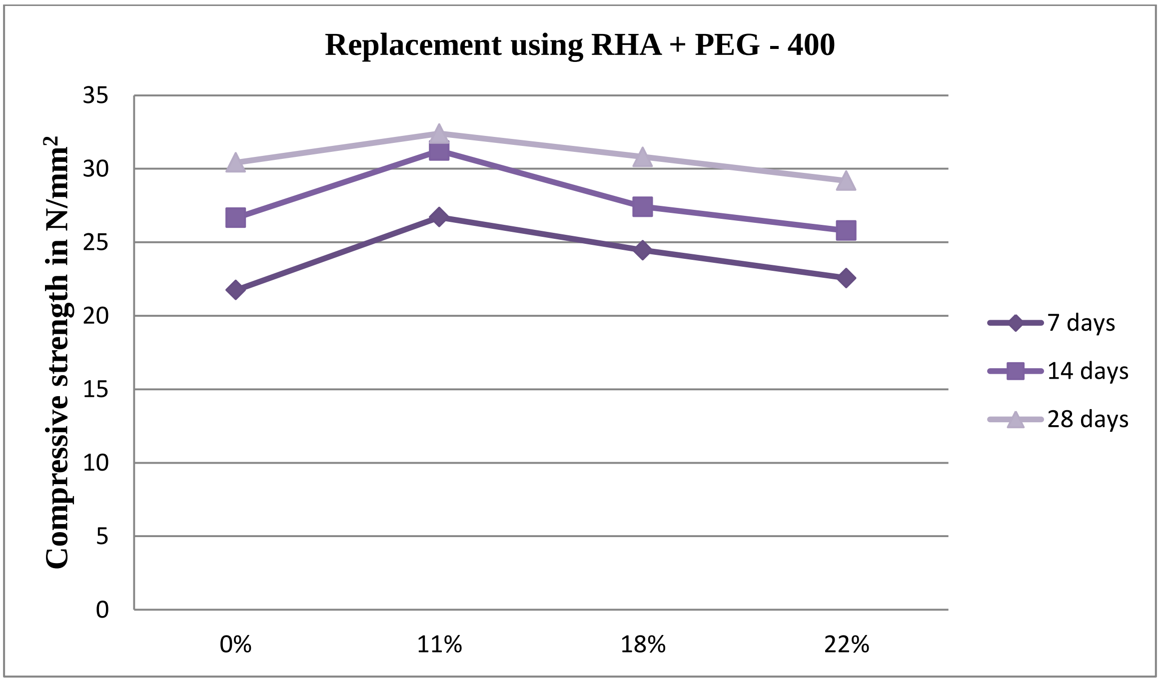


Figure4.2. Graph of compressive strength of cubes with RHA and PEG-400

- Conclusion:

1. From the above result and graph, we can see that as the replacement of RHA and PEG-400 increased the strength increased.
2. The strength is maximum when 11% of RHA with 0.5% of PEG – 400 is added together in the mix.
3. It is also observed that as the curing days increases the strength also increases for the same percentage replacement.
4. For 7 days of curing with 11+0.5% replacement, the strength recorded is 26.710 N/mm^2, for 14 days it increased to 31.235 N/mm^2, and for 28 days the strength is observed as 32.395 N/mm^2 for the same replacement.

Figure4.3. Comparison between RHA and RHA + PEG - 400 for 7 days

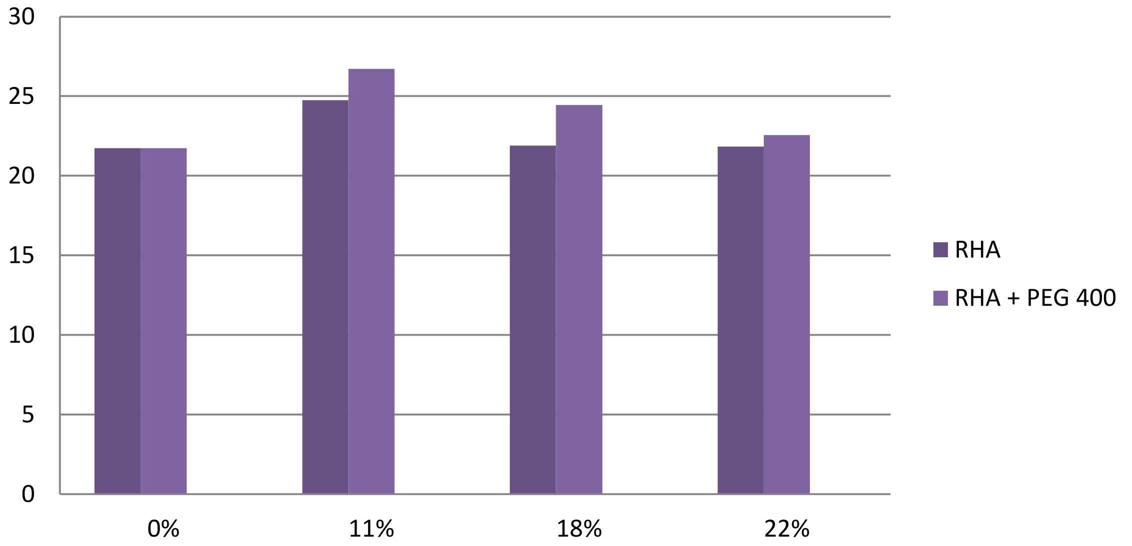


Figure4.4. Comparison between RHA and RHA + PEG - 400 for 14 days

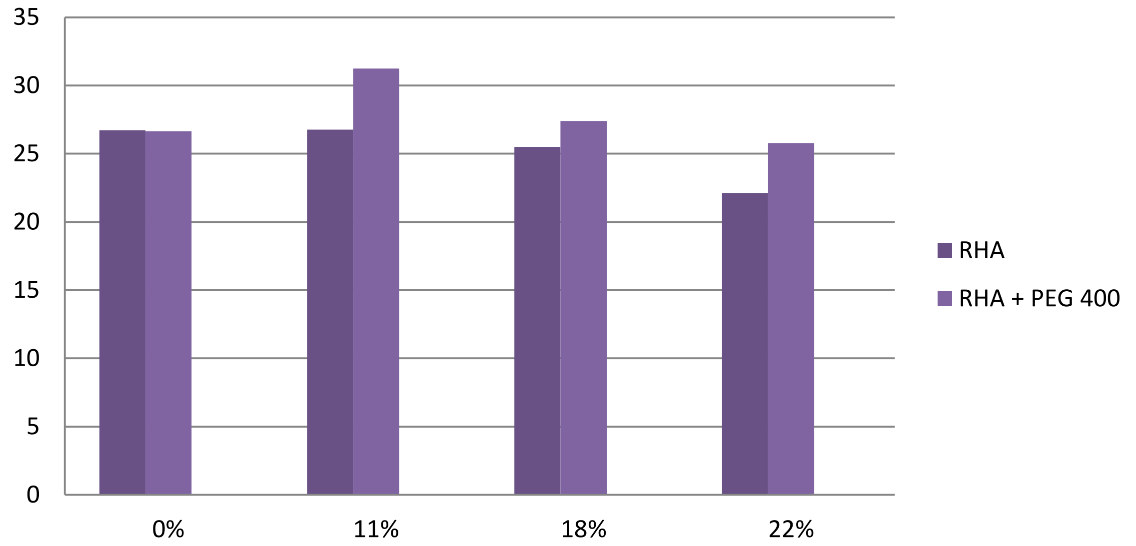
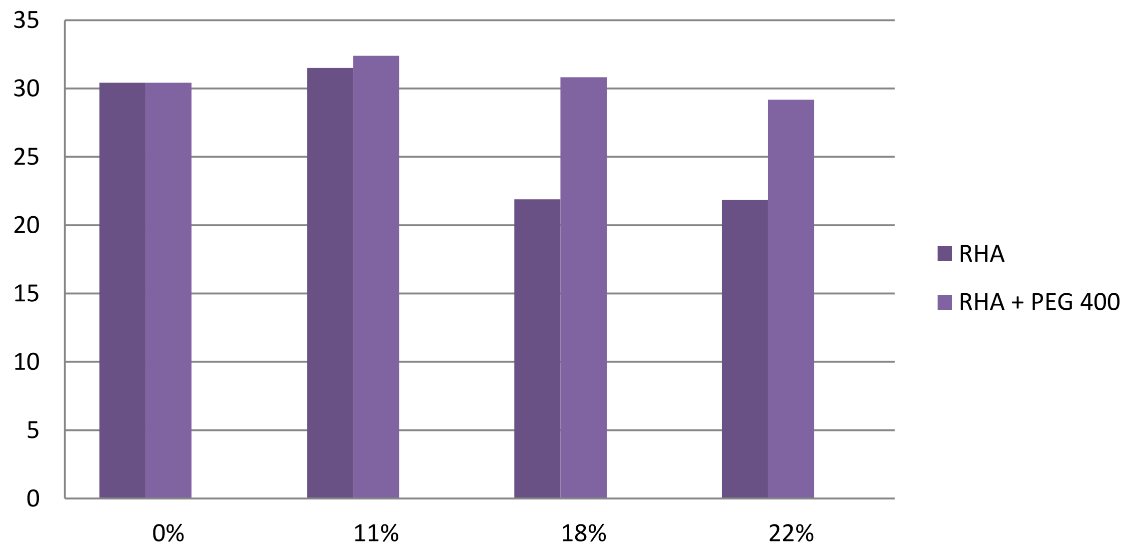


Figure4.5. Comparison between RHA and RHA + PEG - 400 for 28 days



4.1.2. Split Tensile Test

- When replaced with RHA only

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	2.543	2.547	2.758
11	3.425	3.585	3.667
18	2.143	3.075	3.194
22	1.555	2.537	2.771

Figure4.3. Results for split tensile strength on cylinders

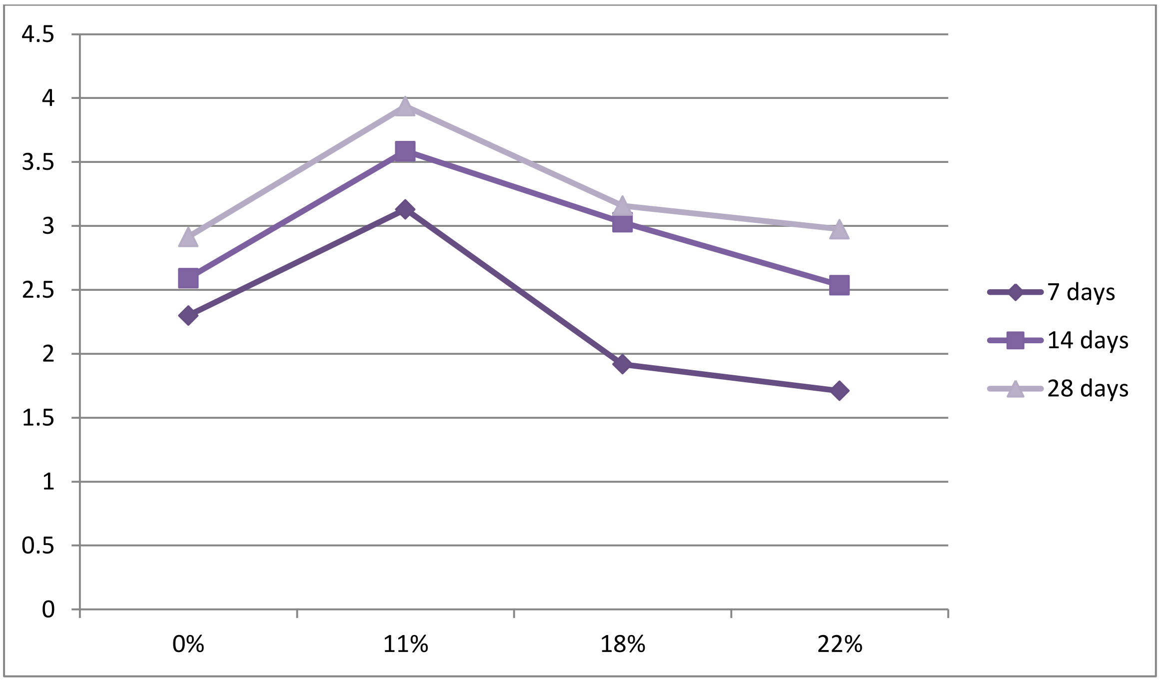


Figure4.6. Graph for split tensile strength on cylinders

- Conclusion:

1. The tensile strength of concrete increased as the replacement of RHA increased only till 18% replacement and then there is fall after replacement of 22%.
2. It is also seen from the above graph that the tensile strength is maximum for 11% replacement.
3. Also for the replacement of 11% only, it shows that the strength keeps on increasing as the curing days increased.
4. For 11% replacement, the strength after 7 days is 3.130 N/mm^2, for 14 days it is 3.585 N/mm^2, and for 28 days it is increased to 3.936 N/mm^2.

- When replaced with RHA and PEG – 400

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	2.543	2.574	2.574
11+0.5	3.702	4.308	4.308
18+1	2.543	3.319	3.319
22+1.5	2.458	3.635	3.635

Table4.4. Results for Split tensile test on cubes

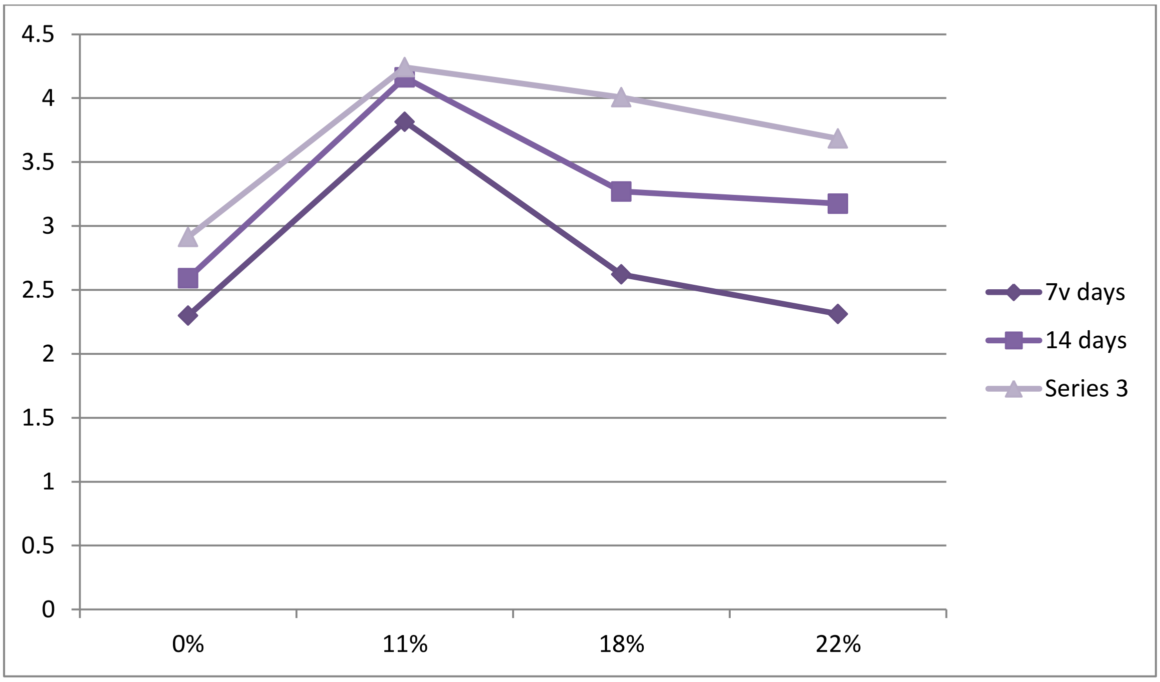


Figure4.6. Graph for Slit tensile test on cubes

- Conclusion:

1. The tensile strength is maximum when 11% of RHA with 0.5% of PEG-400 is added together.
2. From the above result and graph, we can see that as the replacement of RHA and PEG-400 increased the strength increased.
3. The strength is maximum when 11% of RHA with 0.5% of PEG – 400 is added together in the mix.
4. It is also observed that as the curing days increases the strength also increases for the same percentage replacement.
5. For 7 days of curing with 11+0.5% replacement, the strength recorded is 3.815N/mm^2, for 14 days it increased to 4.162N/mm^2, and for 28 days the strength is observed as 4.242N/mm^2 for the same replacement.

Figure4.7. Comparison between RHA and RHA + PEG - 400 for 7 days

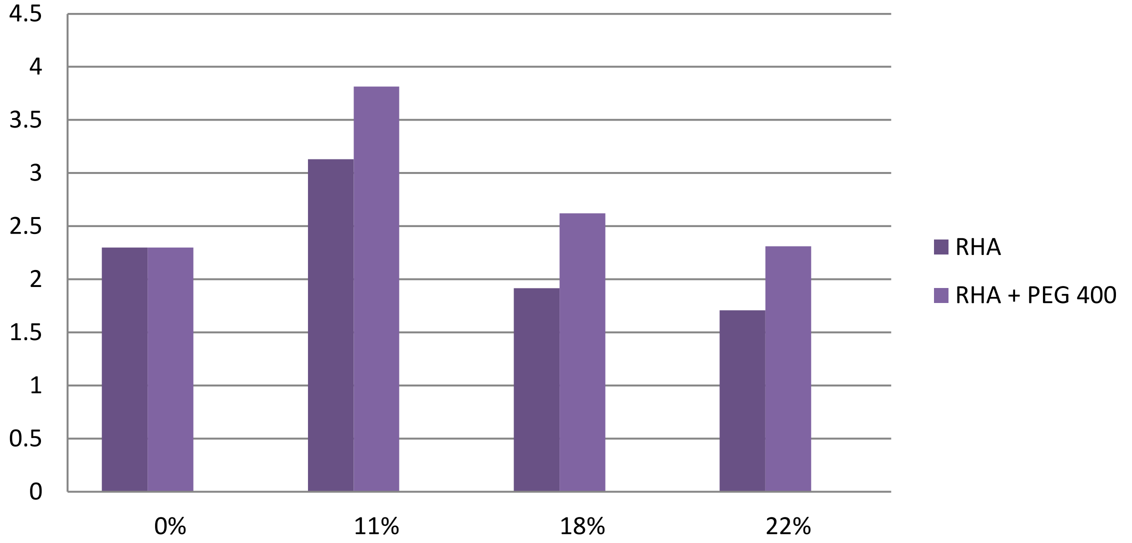
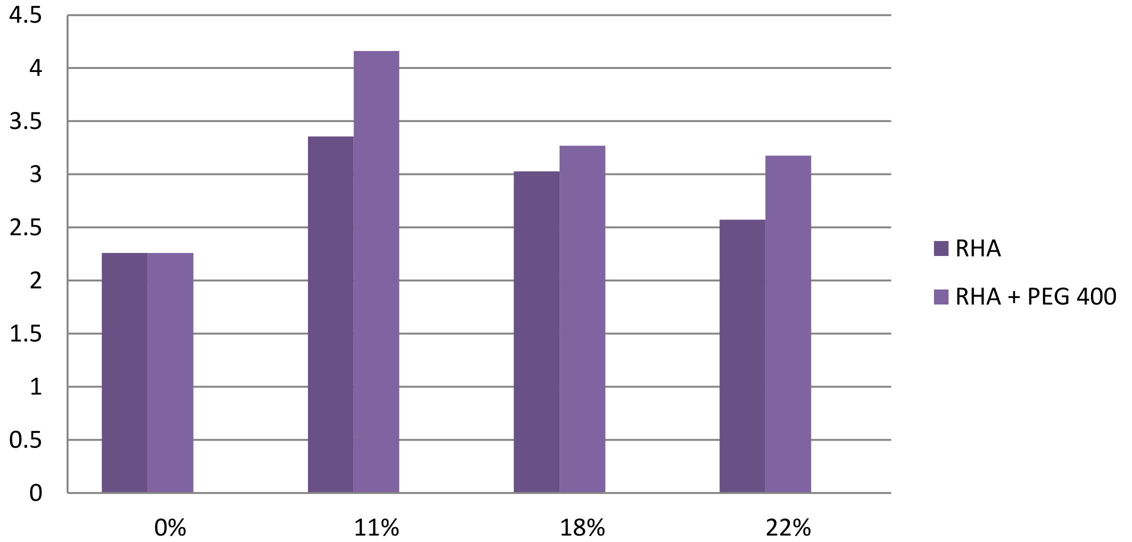
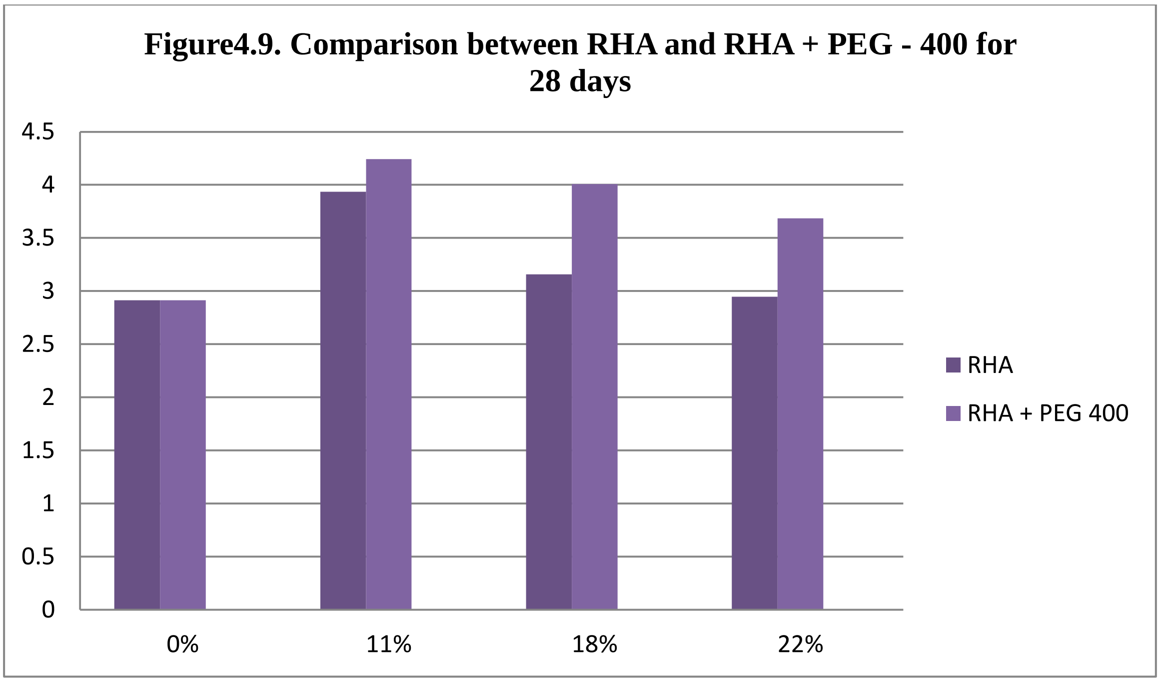


Figure4.8. Comparison between RHA and RHA + PEG - 400 for 14 days





4.1.3. Flexure test of Beam

- When replaced with RHA only

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	6.126	6.696	9.353
11	6.783	8.403	10.26
18	5.426	7.163	8.28
22	5.346	6.396	6.593

Table4.5. Results for Flexure text on Cylinders

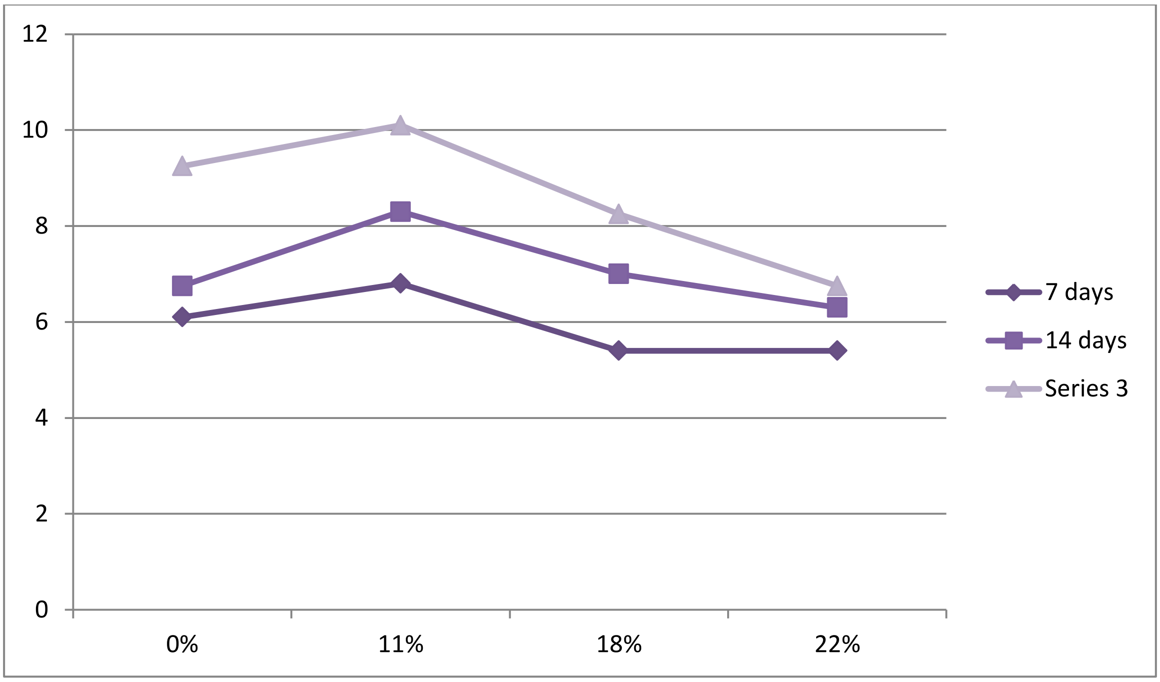


Figure4.10. Graph of Flexure test on beams

- Discussion:

1. The flexure strength is maximum when 11% of RHA is replaced.
2. The flexure strength also increased as the curing days increased. For every curing day, the maximum strength is shown for 11% replacement.
3. After 7 days the strength is 6.3N/mm^2 for 11% replacement, for 14 days it is 8.3 N/mm^2 for 11% replacement, and it increases to 10.1 N/mm^2 for 11%.
4. However it is observed that RHA cannot be replaced from 20% and above as it makes the strength weaker.
5. Therefore, we can conclude that RHA as an admixture performs best when 11% of it is replaced.

- When replaced with RHA and PEG – 400

Replacement (in %)	Strength in 7 days (in N/mm^2)	Strength in 14 days (in N/mm^2)	Strength in 28 days (in N/mm^2)
0	6.126	6.696	9.353
11+0.5	7.73	10.623	12.713
18+1	6.456	8.37	9.176
22+1.5	5.416	6.586	7.56

Table4.6. Results of Flexure strength test on Beams

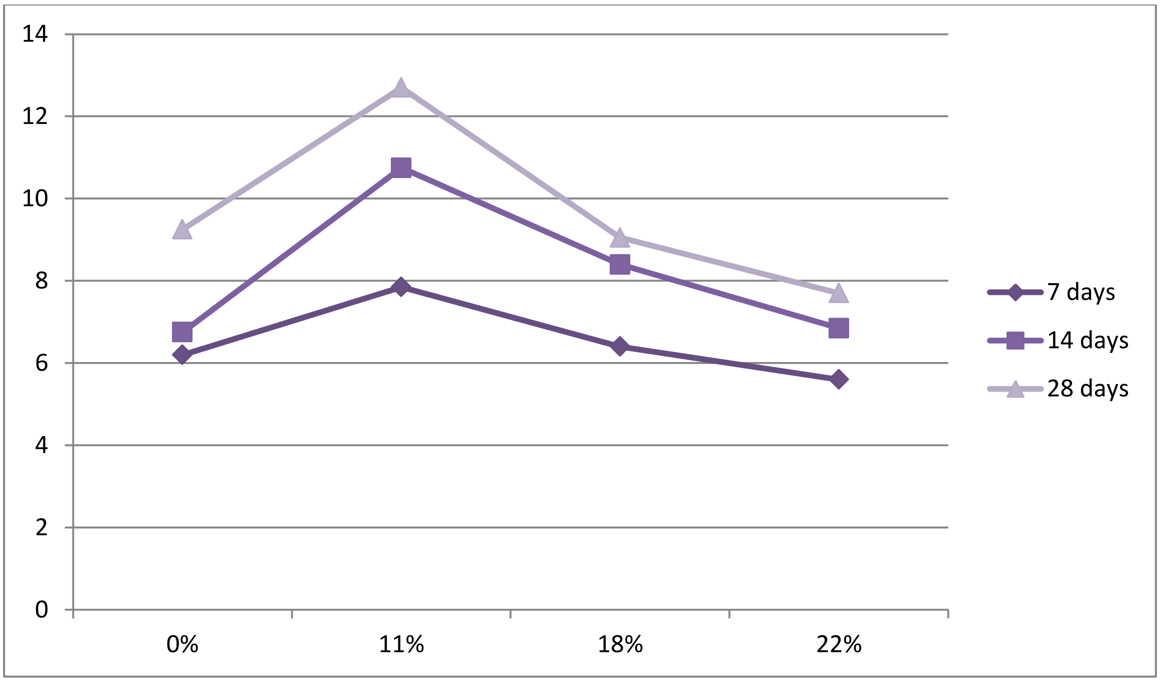


Figure4.11. Graph of Flexure strength test on beams

- Conclusion:

1. The tensile strength is maximum when 11% of RHA with 0.5% of PEG-400 is added together.
2. From the above result and graph, we can see that as the replacement of RHA and PEG-400 increased the strength increased.
3. The strength is maximum when 11% of RHA with 0.5% of PEG – 400 is added together in the mix.
4. It is also observed that as the curing days increases the strength also increases for the same percentage replacement.
5. For 7 days of curing with 11+0.5% replacement, the strength recorded is 7.85N/mm^2, for 14 days it increased to 10.75 N/mm^2, and for 28 days the strength is observed as 12.7 N/mm^2 for the same replacement

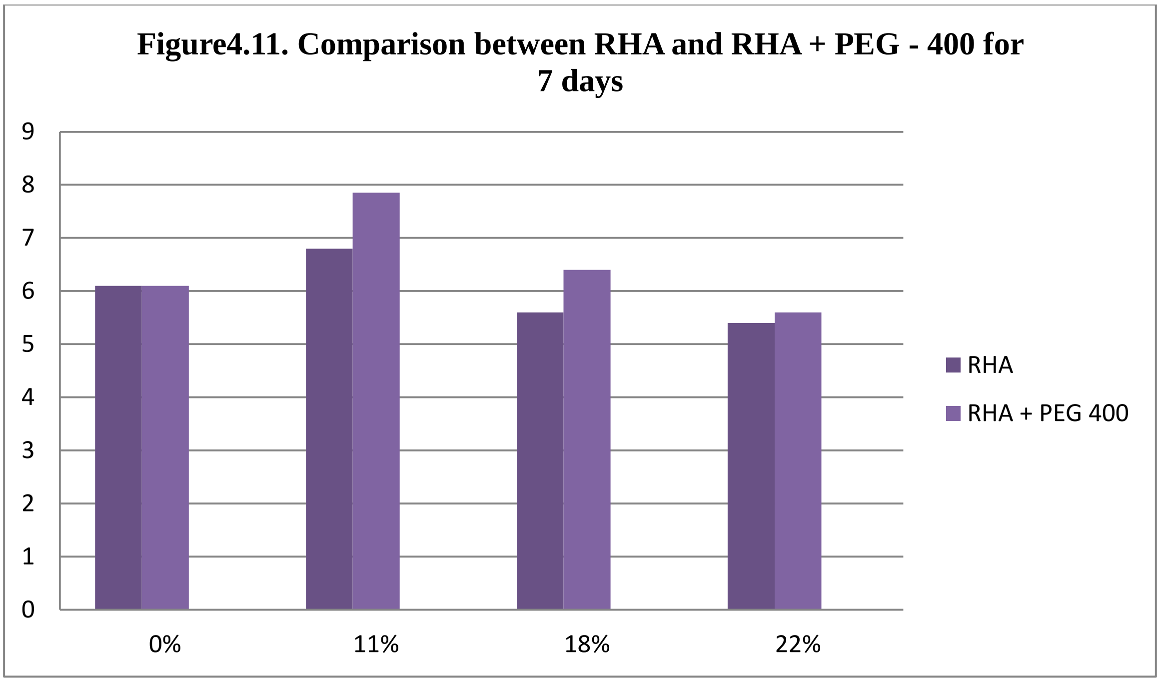


Figure4.11. Comparison between RHA and RHA + PEG - 400 for 7 days
9
8
7
6
5
4
3
2
1
0
0%
11%
18%
22%
RHA
RHA + PEG 400

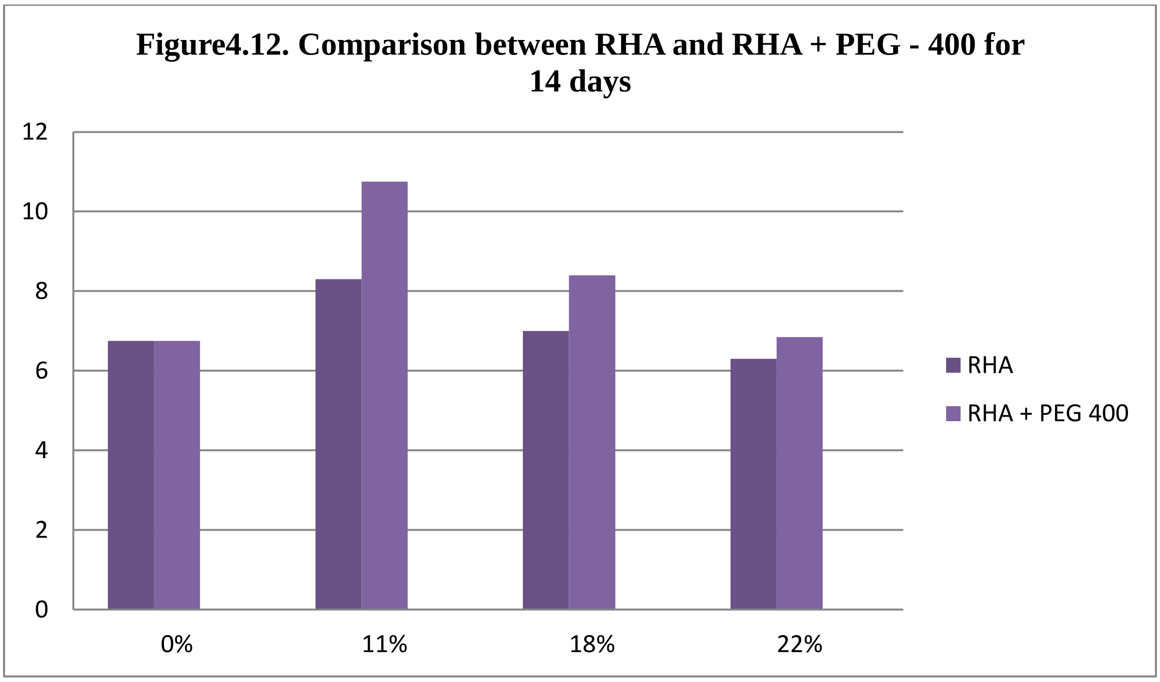


Figure4.12. Comparison between RHA and RHA + PEG - 400 for 14 days
12
10
8
6
4
2
0
0%
11%
18%
22%
RHA
RHA + PEG 400

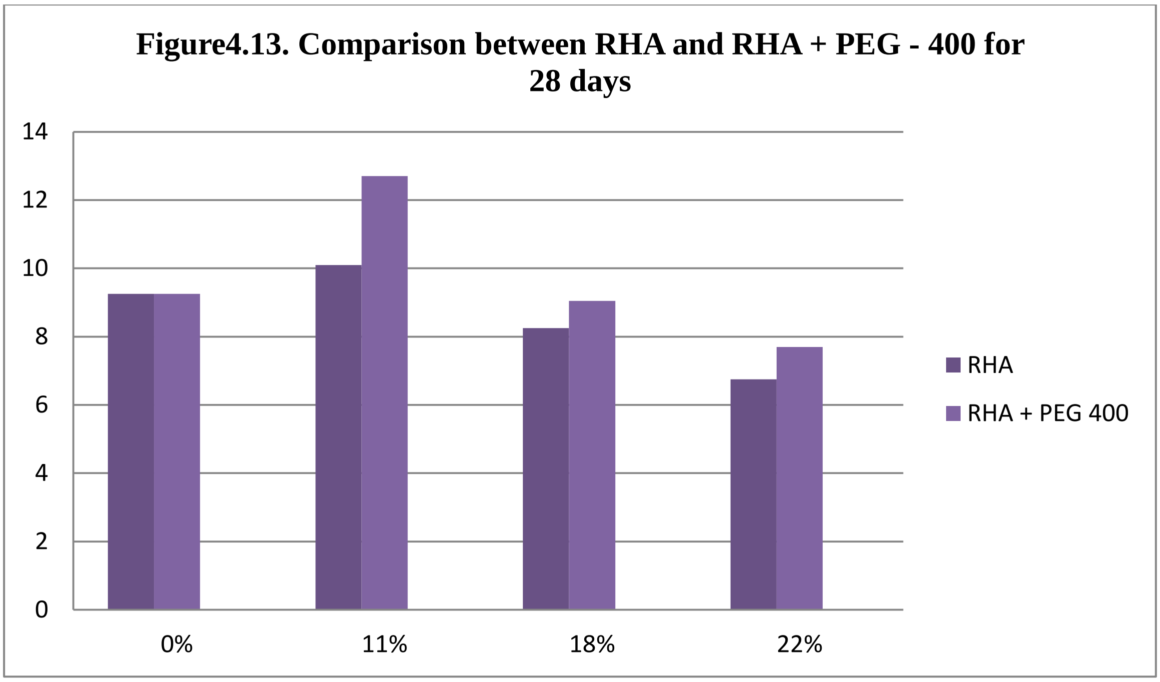


Figure4.13. Comparison between RHA and RHA + PEG - 400 for 28 days
14
12
10
8
6
4
2
0
0%
11%
18%
22%
RHA
RHA + PEG 400

CHAPTER 5

CONCLUSION

5.1. Conclusion

1. In this study, the performances of admixtures namely rice husk ash and polyethylene glycol-400 are studied by replacing them in partial quantity with the total quantity of the cement, thus studying the behavior of the strength of concrete by performing various strength tests. It has been concluded that the admixtures can be used as an effective material in place of cement to improve the strength of the concrete.
2. The concrete cubes were tested on the basis of compressive force and it was seen that it can bear a maximum load of 29.937 N/mm^2 for RHA replacement and 30.808 N/mm^2 for RHA and PEG-400 replacement for a concrete mix of M25.
3. The concrete cylinders were subjected to tensile force and it was seen that it can bear a maximum load of 3.396 N/mm^2 for RHA and 4.006 N/mm^2 for RHA and PEG-400 for a mix design of M25.
4. The concrete beams were subjected to flexure loading and it was observed that it can endure a maximum load of 10.1 N/mm^2 for RHA and 12.7 N/mm^2 for RHA and PEG-400 for a concrete mix design of M25.
5. The compressive strength, tensile strength, and flexure strength increased as the dosage of admixtures increased.
6. The maximum replacement of RHA was found to be 11% which gave the maximum strength performance.
7. The maximum dosage of PEG-400 was found to be 0.5% which gave the maximum strength performance when added with 11% RHA.
8. The strengths also increased as the curing days increased.
9. The use of PEG-400 with RHA showed a better effect than using RHA alone.
10. PEG-400 not only increased the strength of the concrete but it also made an impact on the curing of the concrete. Since RHA consumes a lot of water, addition of PEG-400 maintained the water in the concrete because of its water retention property which showed better results in terms of strength.

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