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Study of Strength of Concrete by Partial Replacement of Cement with Rice Husk Ash and Chemically Curing with Polyethylene Glycol-400

Dontamsetti Srimanoj[1], Alamanda Sai Kumar[2],Dr. Dumpa Venkateswarlu[3]

[1]P.G Scholar, Department of civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, Andhra Pradesh, India
[2]Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A), Rajahmundry, Andhra Pradesh, India
[3]Professor & Head of the Department, Department of Civil Engineering, Godavari Institute of Engineering & Technology (A),Rajahmundry, Andhra Pradesh, India

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KEYWORDS
Concrete, RHA, PEG-400, self-curing.

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 oncylinder, 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.

Introduction

Presently the construction industries and companies are booming with the advancement andso there is a high demand of buildings – residential buildings, and important buildings like hospitals, schools, communication buildings/towers, power plant structures. Civil engineeringis 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 isnot 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 onthe concrete is evaluated. We should also note that usage of these admixtures not onlyreduces 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.

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 andagain 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 usedfor 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.

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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 tomake structures like bridges, arches, and aqueducts. One material that was widely and commonly used as an admixture during that time was consolidated volcanic ash/tuff which they termed it as "Pozzolana." It was later coined into a new term as "pozzolan" to define any material that shows cementitious/binding property.

Rice Husk Ash

Rice Husk Ash is an agricultural by- product produced by burning the husks of rice which are comprised 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, environmentally 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.

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 -

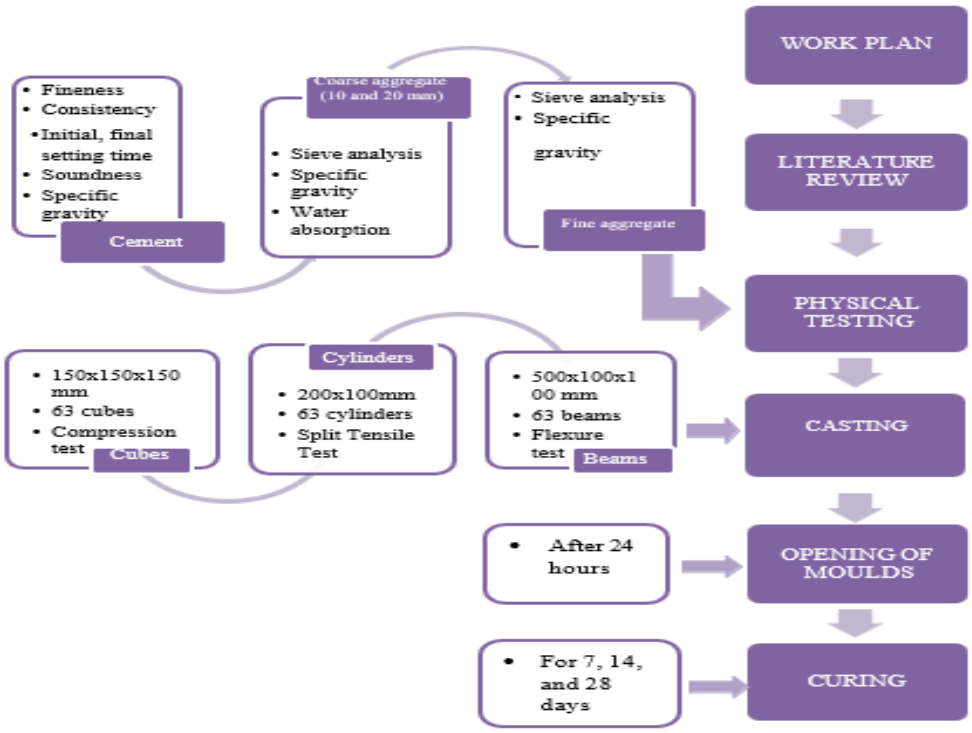
$H(OCH_2CH_2)nOH$

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, colorless, odorless, lubricating, and does not cause irritation. It is widely used for various pharmaceutical purposes.

2.0 RESEARCH METHODOLOGY

2.1 Work Plan and Methods used.



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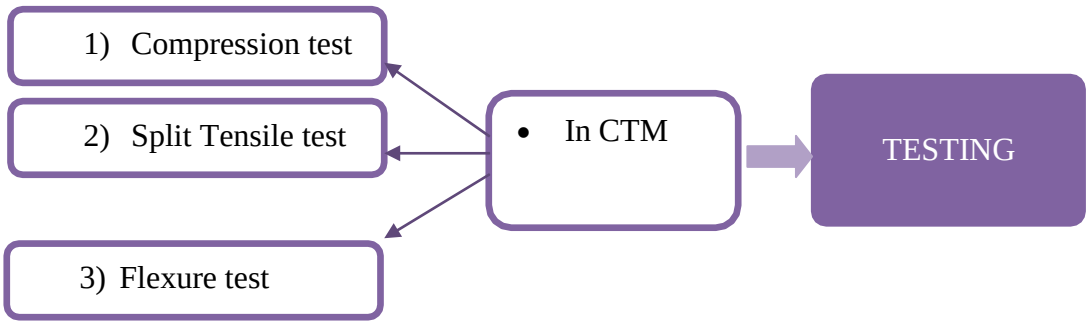

Figure3.1. Work Plan and Methods used

Materials used

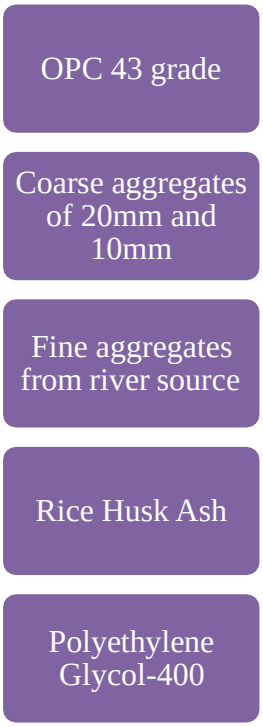

Figure3.2. Materials used

2.2 Experimental Investigation

Two types of tests are conducted –

- 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.
- Strength analysis test which includes compression test on cubes, split tensile test on cylinders, and flexure test on beams.

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3.0 RESULTS AND DISCUSSIONS

3.1Comparison of results

For the compressive test of cube

- When replaced with RHA only

Replacement (in %)	Strength in 7 days (inN/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

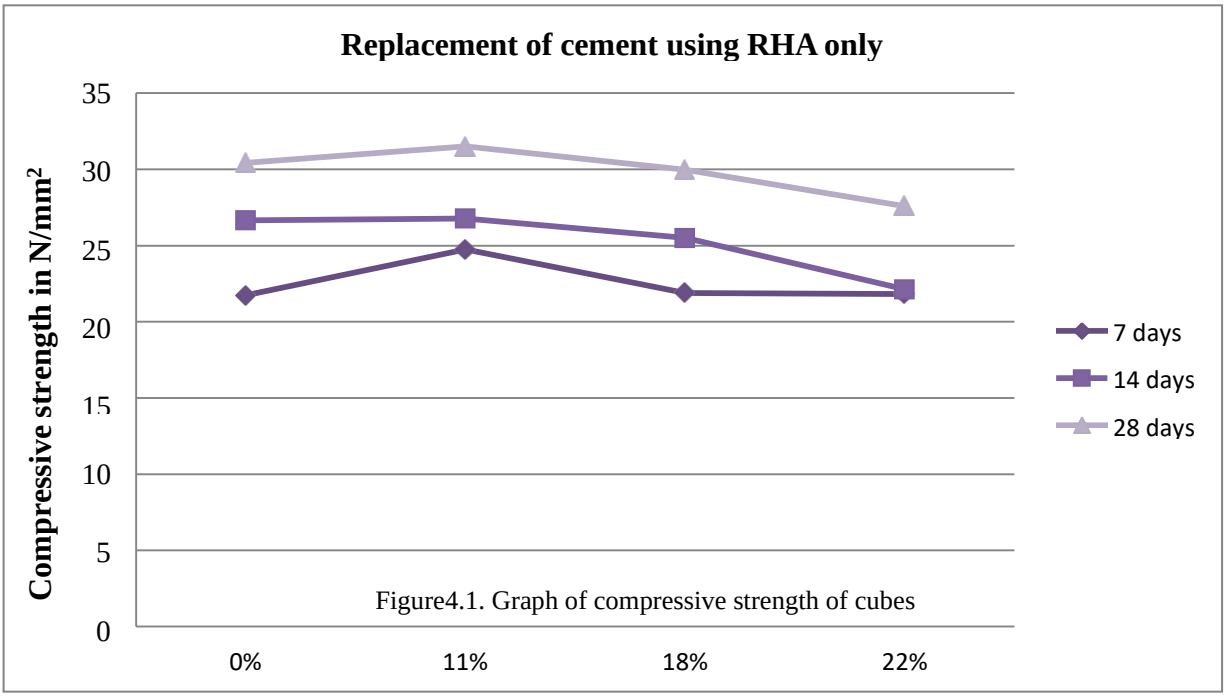

Figure4.1. Graph of compressive strength of cubes

- 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 26.773N/mm^2 for 11% replacement, and it increases to 31.506 N/mm^2 for 11%.

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4. However it is observed that RHA cannot be replaced from 20% and above as it makes thestrength weaker.
5. Therefore, we can conclude that RHA as an admixture performs best when 11% of it isreplaced.

- When replaced with RHA and PEG – 400

Replacement(in %)	Strength in 7 days (inN/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

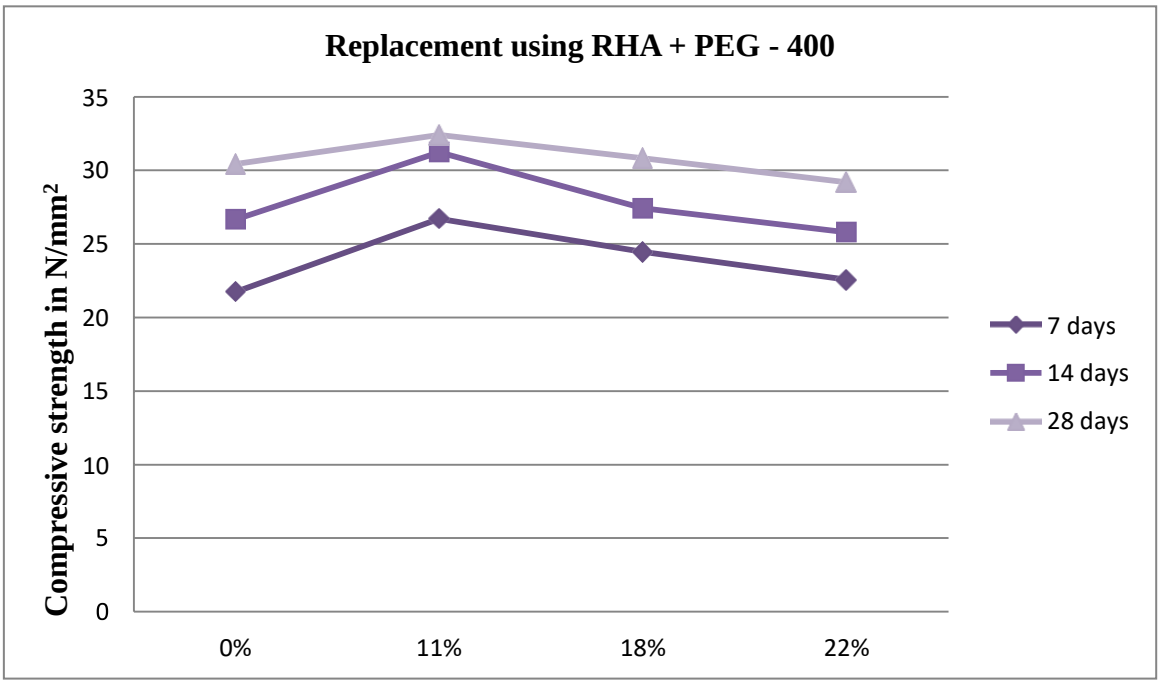

Figure4.2. Graph of compressive strength of cubes with RHAand PEG-400

- 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 togetherin the mix.
3. It is also observed that as the curing days increases the strength also increases for thesame 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 as32.395 N/mm^2 for the same replacement.

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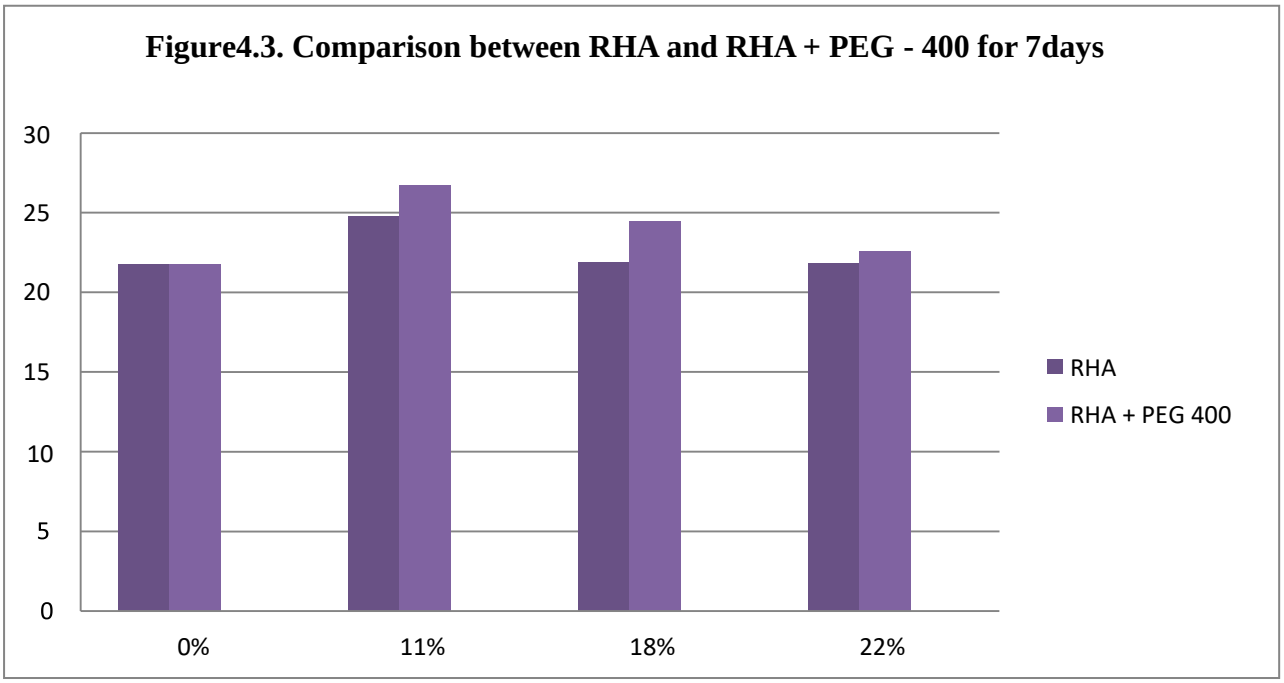

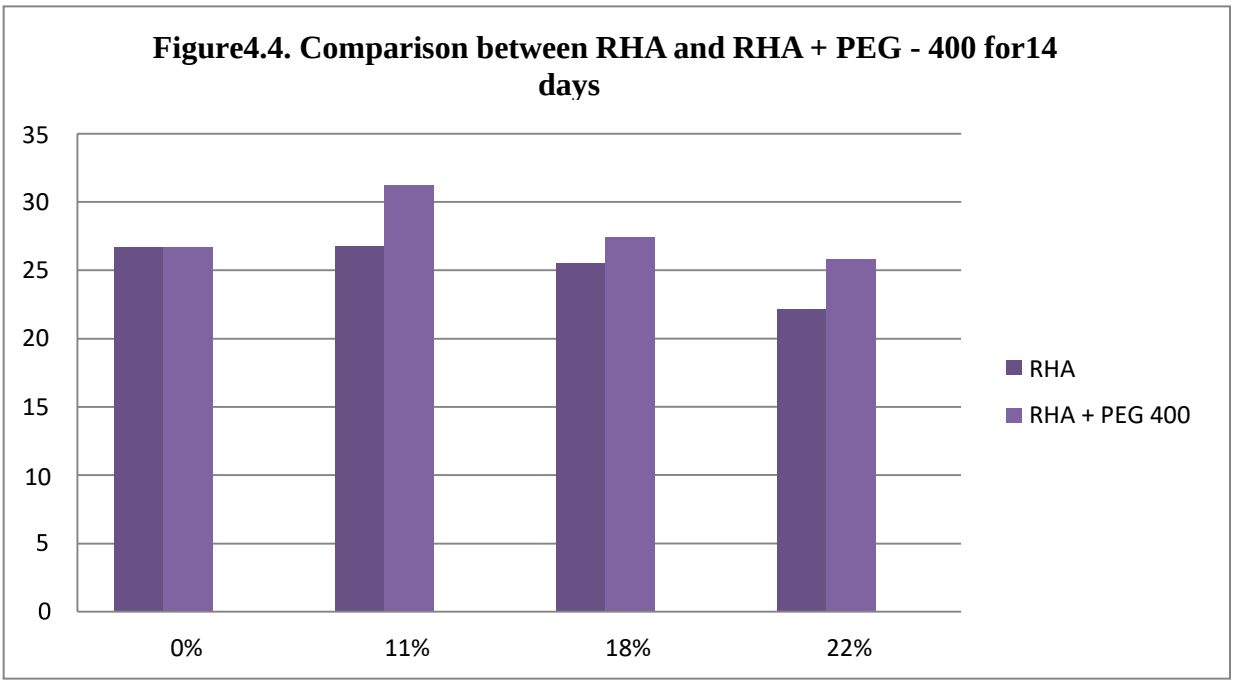

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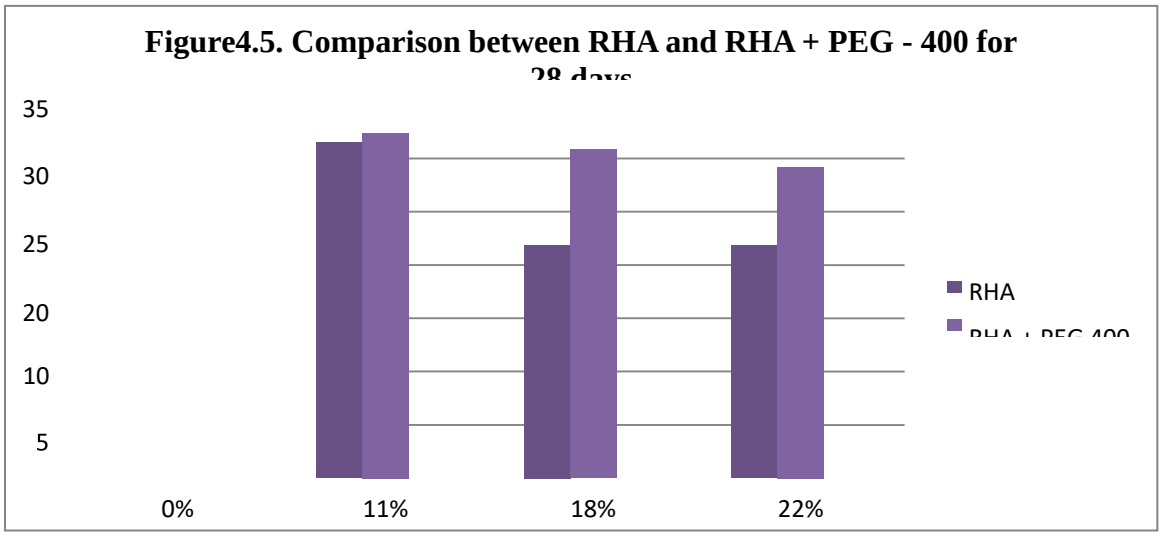

3.2Split Tensile Test

- 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

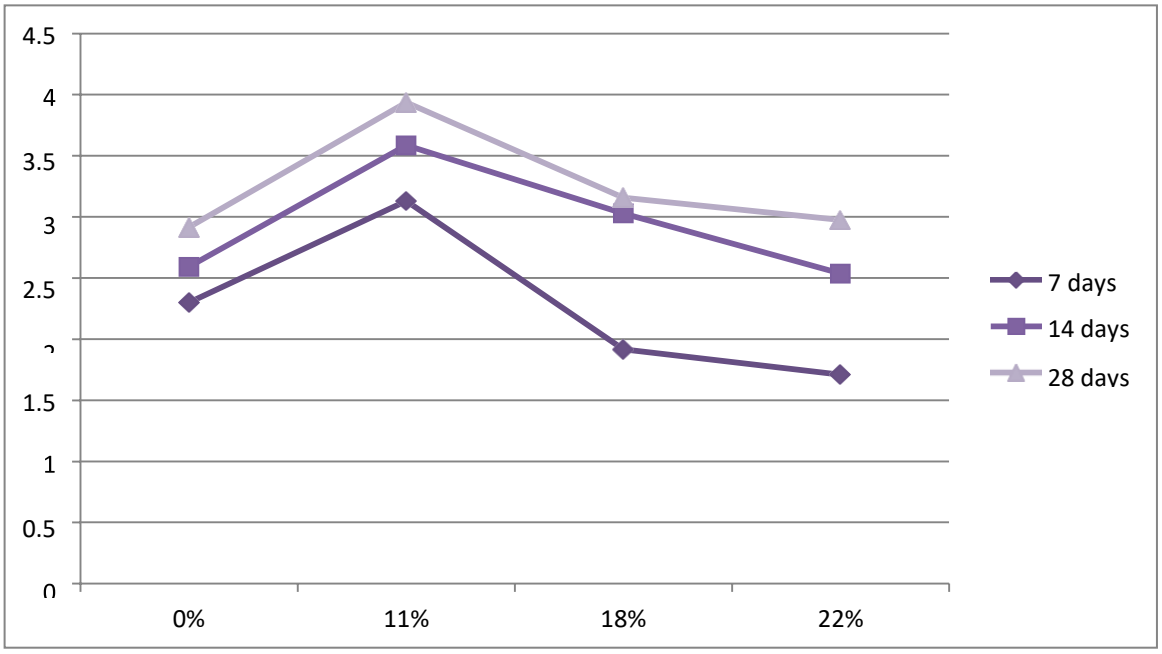

Figure4.6. Graph for split tensile strength on cylinders

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- Conclusion:

1. The tensile strength of concrete increased as the replacement of RHA increased only till18% 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 asthe curing days increased.
4. For 11% replacement, the strength after 7 days is 3.130 N/mm^2, for 14 days it is 3.585N/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 (inN/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

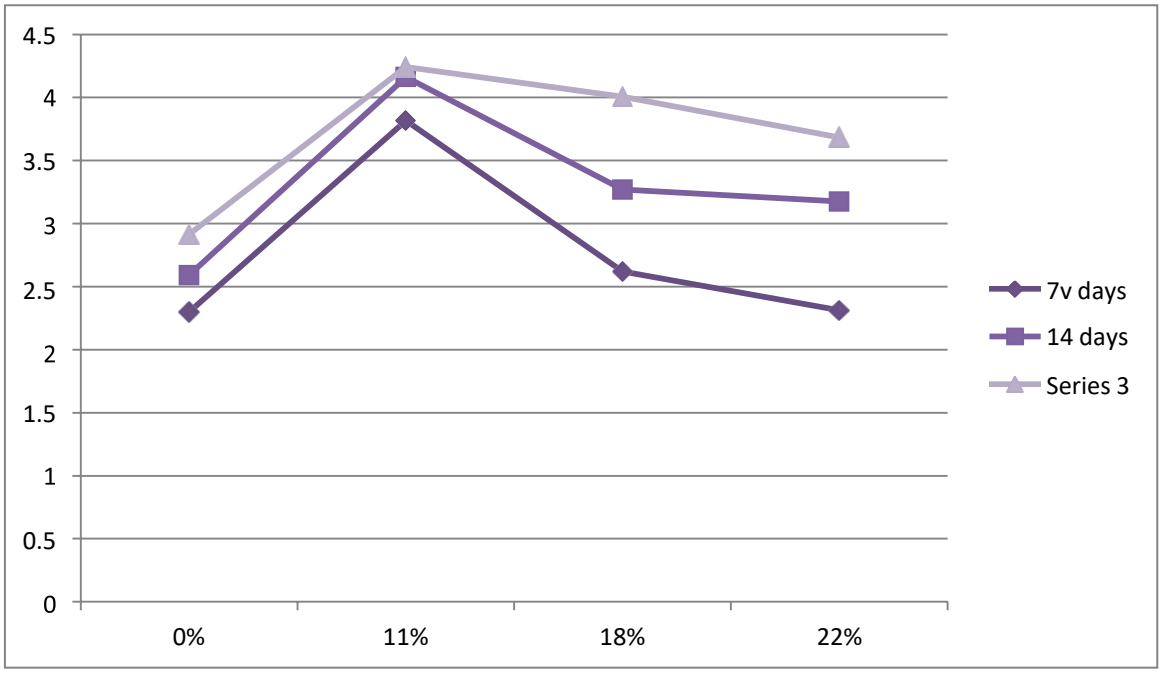

Figure4.6. Graph for Slit tensile test on cubes

- Conclusion:

1. The tensile strength is maximum when 11% of RHA with 0.5% of PEG-400 is addedtogether.
2. From the above result and graph, we can see that as the replacement of RHA and PEG-400 increased the strength increased.

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3. The strength is maximum when 11% of RHA with 0.5% of PEG – 400 is added togetherin the mix.
4. It is also observed that as the curing days increases the strength also increases for thesame percentage replacement.
5. For 7 days of curing with 11+0.5% replacement, the strength recorded is 3.815N/mm^2, for14 days it increased to 4.162N/mm^2, and for 28 days the strength is observed as4.242N/mm^2 for the same replacement

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

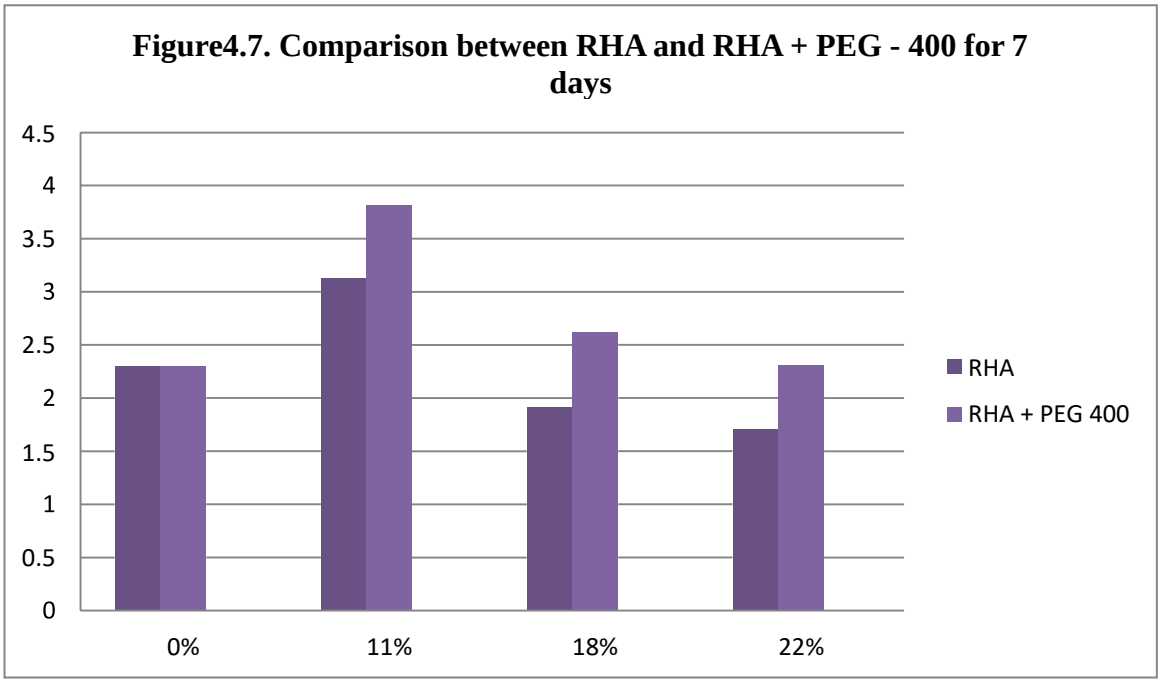
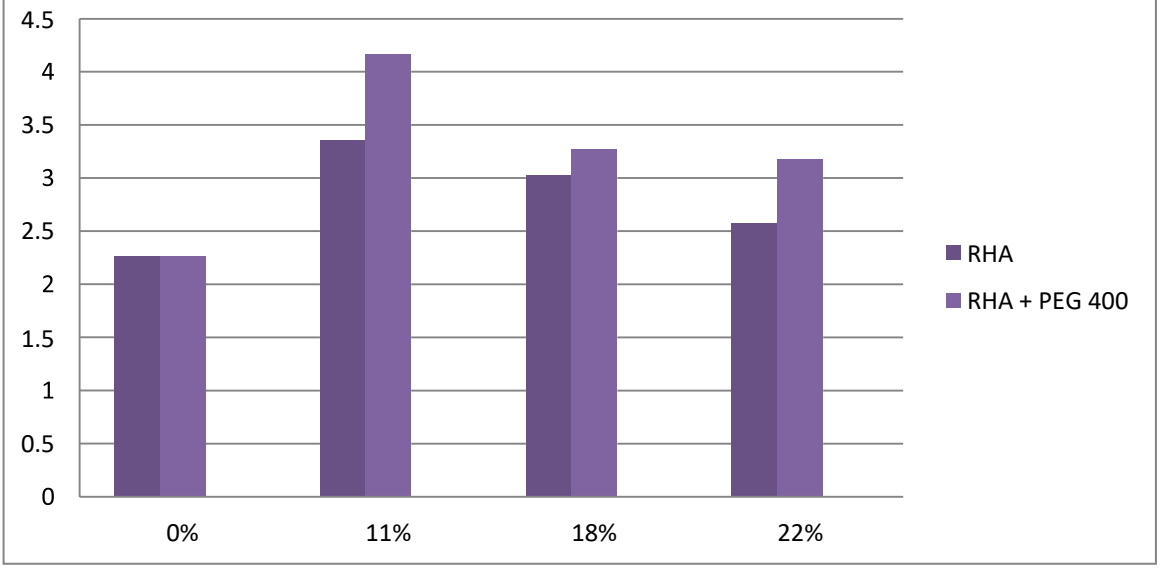


Figure4.8. Comparison between RHA and RHA + PEG - 400 for 14 days



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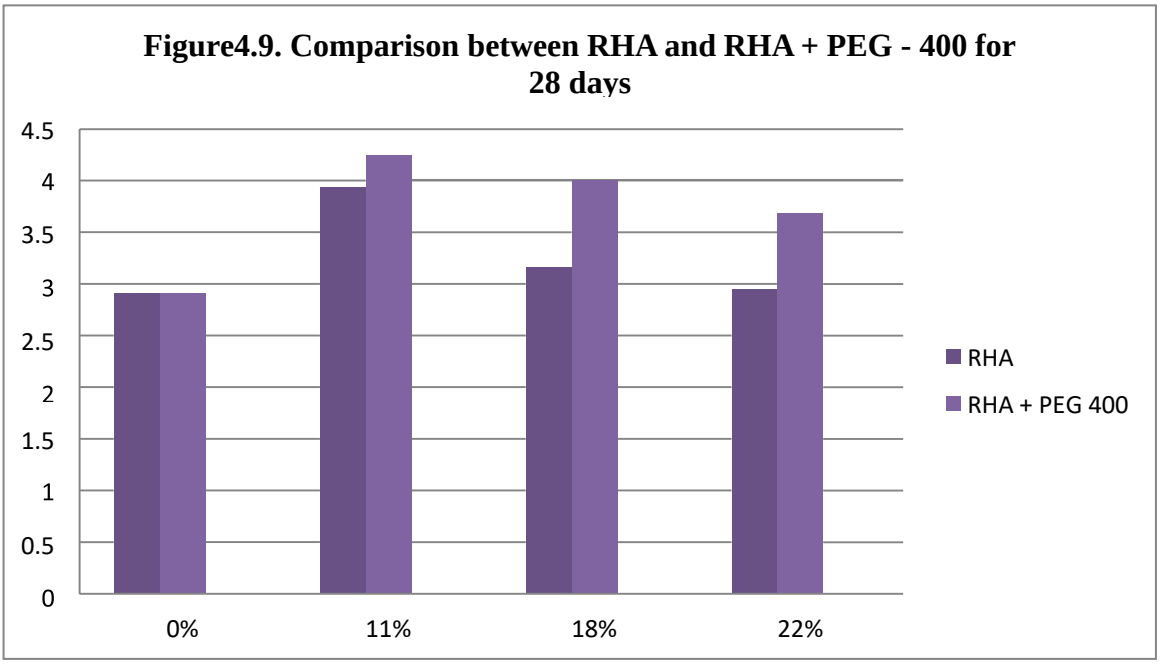

3.3Flexure test of Beam

- When replaced with RHA only

Replacement (in %)	Strength in 7 days (inN/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

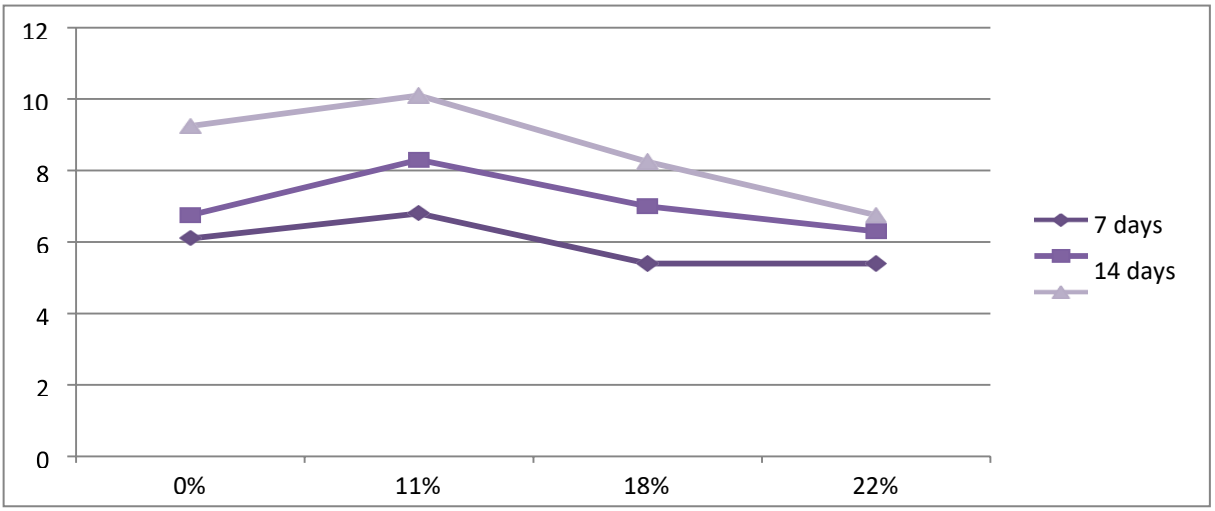

Figure4.10. Graph of Flexure test on beams

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- 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, themaximum 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 thestrength weaker.
5. Therefore, we can conclude that RHA as an admixture performs best when 11% of it isreplaced.

- 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

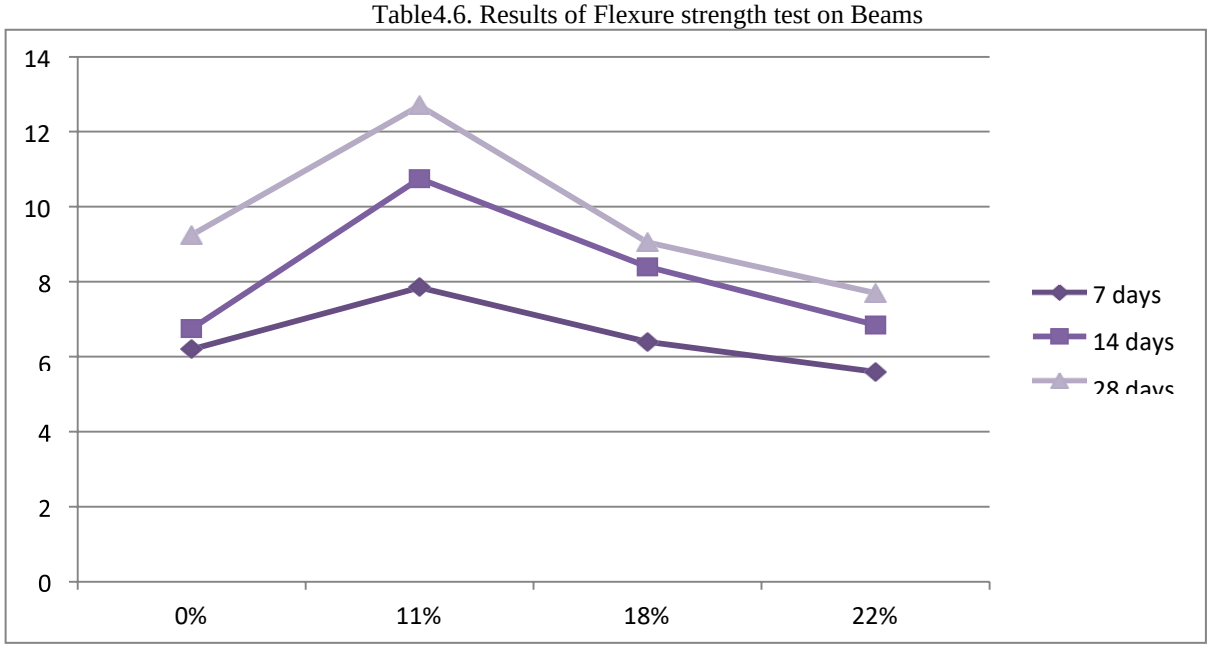

Figure4.11. Graph of Flexure strength test on beams

- 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.

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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

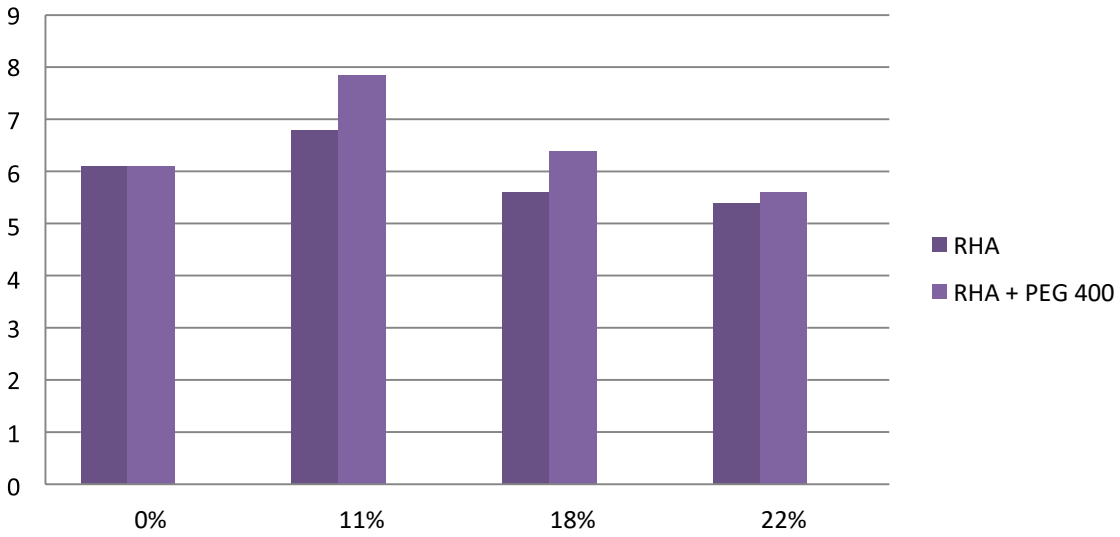
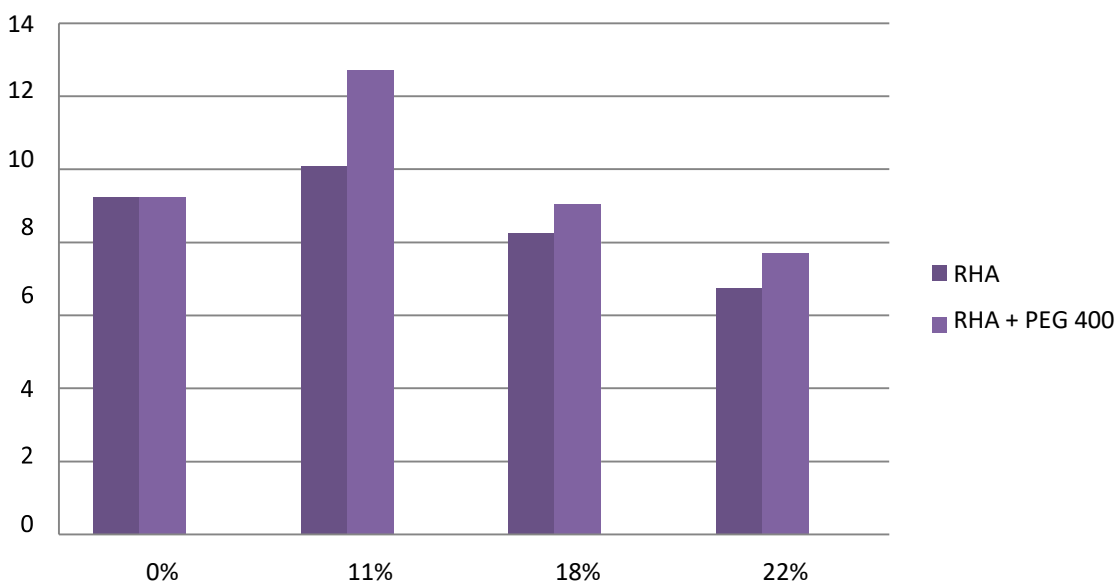


Figure4.13. Comparison between RHA and RHA + PEG - 400 for 28 days



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4.0 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-400for a concrete mix design of M25.
5. The compressive strength, tensile strength, and flexure strength increased as the dosage ofadmixtures 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 thecuring 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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