Effect of Rice Husk Ash on Mechanical properties of High-Performance Concrete

Mr. Mahesh V. Tatikonda[1], Mrs Sukhada Shelar[2], Mrs Mrunalini Shewale[3], Mrs Sharmistha Chakraborty[4], Mrs Rohini Khandelwal[5]
[1,2,3 4 5] *Assistant Professor, Department of Civil Engineering, DYPCOE Akurdi, Pune*

***Abstract*—In the last decade, the use of supplementary cementitious materials (SCMs) has become an integral part of high-strength and high-performance concrete mix design. These materials may be natural resources, industrial by-products, or wastes, or materials that require comparatively less energy and time for production. Commonly used SCMs include fly ash, silica fume (SF), ground granulated blast furnace slag (GGBS), and rice husk ash (RHA).Rice husk ash is a by-product obtained from the controlled combustion of rice husk and mainly consists of non-crystalline silicon dioxide with a high specific surface area and excellent pozzolanic reactivity. Owing to these characteristics, RHA has been widely used as a pozzolanic material in mortar and concrete and has demonstrated a significant influence in enhancing both mechanical and durability properties. Although silica fume contributes to high strength development, its cost has increased considerably in recent years, making its large-scale use uneconomical for meeting the growing demands of the construction industry.In the present study, RHA is used as a partial replacement of cement in high-performance concrete (HPC) at different replacement levels. The effect of cement replacement with RHA on the mechanical properties of HPC is investigated. Concrete cube, cylinder, and beam specimens of various HPC grades, within the strength range of 60–100 MPa, are cast and tested to evaluate compressive strength, tensile strength, and flexural strength.**

***Index Terms*—High performance concrete, Rice Husk Ash (RHA), Mechanical Properties**

I. INTRODUCTION

The cement and concrete industry have been using more mineral admixtures during the 20th century. It is anticipated that this rate will rise. Cement is partially replaced in order to meet the growing demand for concrete and cement. A lot of work was done to replace the cement in concrete. Among these materials include fly ash, silica fume, metakaolin, rice husk ash, and so forth. Over the past few decades, the usage of mineral additions in concrete has increased significantly. Fly ash is undoubtedly the most popular of these additions because it is widely available and inexpensive. But other pozzolanas, such rice husk ash (RHA), have recently garnered particular attention. [1]

II. EXPERIMENTAL METHODS

2.1. Materials and Mix Proportion

2.1.1. Rice Husk Ash

One plant that takes up silica from the soil and incorporates it into its structure while growing is the rice plant. The outer layer of the rice plant's grain, known as rice husk, has a high silica content—typically more than 80–85%.[5]. This husk is currently utilized as fuel, which adds to pollution. Rice husk ash was used as an additional cementation material in an attempt to address this environmental problem. Due to variations in the type of paddy, crop year, climate, and geographic conditions, it is discovered that the chemical composition of rice husk ash varies from sample to sample. Ash containing silica in an amorphous form can be produced by burning the husk at a regulated temperature below 8000C. [3]. Rice husk ash (RHA), produced by the controlled burning of rice husk and was used as a highly reactive pozzolanic material, leading to a significant improvement on strength and durability of normal concretes. [4].

2.1.2. Cement

Since High Strength Range Ordinary Portland

Cement 53 Grade is the desired strength, the study was conducted in accordance with the applicable Indian standard code IS 12269-1987.

2.1.3. Coarse Aggregate (CA)
Six distinct stone crusher quarries in the Bagalkot area provided the CA samples. The CA was chosen and purchased following visual inspection of the shape, size, texture, sieve analysis, and crushing value test. 20 mm down size and 12.5 mm down size CA are employed in this work. Every test has been conducted in accordance with IS: 383-1970.

2.1.4. Fine Aggregate (FA)
FA samples were gathered. FA was obtained following visual inspection of the silt, clayey material, sieve analysis test, fineness modulus, and grading zone confirmation. Every test was conducted in accordance with IS: 383-1970.

2.1.5. Super plasticizer
Concrete with a high strength will have a very low w/c ratio, so using a high range water reducer or super plasticizer is crucial. Glenium B276, a third-generation super plasticizer based on polycarboxylate ether, was utilized in this work. Nearly any kind of cement can be used with this plasticizer.

2.1.6. Mineral admixture
Rice husk ash is a fine, grey powder that is produced by carefully burning the rice grain's outer layer. Among the available SEMs (Scanning Electron Microscope), RHA has a low carbon content and a high silica content.

2.1.7. Water
Particularly in HPC, a small amount of extra water—three to five liters—will lower the compressive strength by 10 to 20 MPa and may cause segregation. According to IS: 456 article 4.3, water used for mixing and curing must be devoid of harmful substances. For mixing and curing concrete, potable water with a pH of 7 to 7.5 is usually regarded as enough.The Structural Engineering Laboratory, BEC, Bagalkot used tap water for mixing and curing. A pH strip was used to measure the water's pH (pH=7, neutral).

Table 2.1 Final Mix Proportion

Sr. No.	Particulars	M60	M80	M100
1	W/C	0.35	0.30	0.25
2	Cement (kg/m^3)	457	517	552
3	Coarse Aggregates (kg/m^3)	1158	1302	1325
	20 mm Down (%)	60	60	0
	12.5 mm Down (%)	40	40	100
4	Fine Aggregates (kg/m^3)	695	550	539.84
5	Superplasticizer Dosage (%)	0.4	0.4	0.8
6	Superplasticizer Dosage (lit/m^3)	4.81	5.44	11.62
7	Water (lit/m^3)	160	155	138
8	Density (kg/m^3)	2471.95	2525.91	2559.26
9	Slump (mm)	210	200	190
10	No. of Trials	3	4	10

III. RESULTS

3.1 Compressive Strength Results

3.1.1 Cube Compressive Strength Results of M60, M80 and M100

Table 3.1 Compressive strength of cubes 100X100X100(mm) for M-60, M-80 & M-100 in (MPa)

% of RHA	3 days			7 days			28 days		
	M60	M80	M100	M60	M80	M100	M60	M80	M100
0	34.2	45.4	54.3	46.3	59.3	73.8	65.4	84.3	101.4
5	37.3	53.4	60.8	51.4	65.4	79.4	69.7	87.4	105.8
10	33.4	43.5	51.4	44.2	55.2	75.8	63.8	82.2	94.3
15	31.4	40.2	49.3	42.3	52.7	64.3	61.1	80.3	91.8

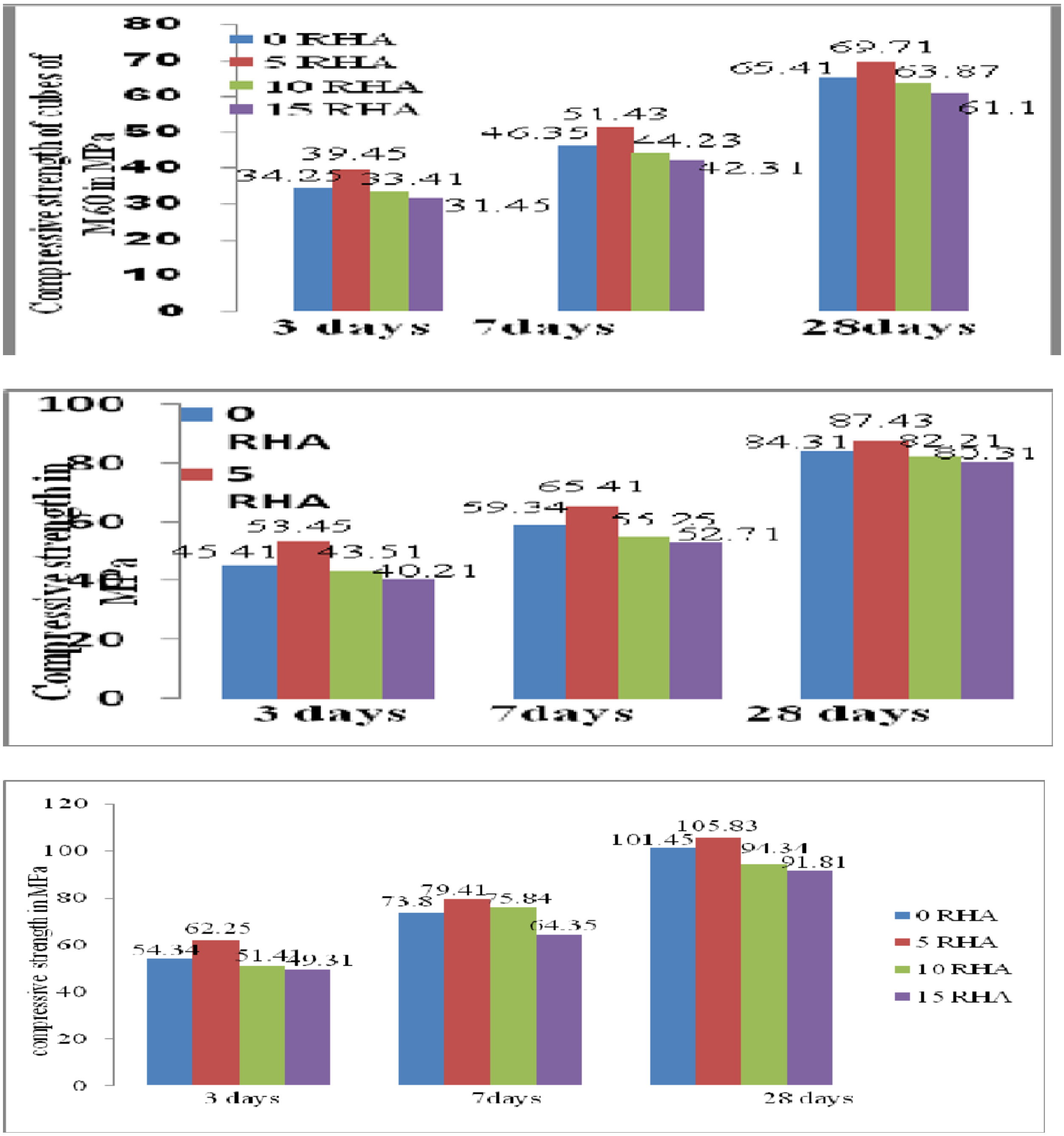


Fig 3.1 Variation of cube strength of M60, M80 & M100 at 3, 7 and 28 days of curing.

Figure 3.1 shows that, in comparison to reference concrete, at three days, the strength of M-60 is raised by 15% in 5% RHA replacement, for M-80 it is increased by 18%, and for M-100 it is increased by 14% in 5% RHA replacement. In comparison to reference concrete, it is reduced by 2% and 8% in 10% and 15% for M-60 and 4% and 11% in 10% and 15% RHA replacement for M-80. However, in comparison to reference concrete, it is reduced by 5% and 9% in 10% and 15% RHA replacement for M-100.

Figure 3.1 shows that, in comparison to reference concrete, at 7 days, the strength of M-60 is improved by 11% in 5% RHA replacement, that of M-80 is increased by 10%, and that of M-100 is increased by 7% in 5% RHA replacement. In contrast, it is reduced by 7% and 11% in 10% and 15% RHA replacement for M-80 compared to reference concrete, and by 5% and 9% in 10% and 15% for M-60. However, in comparison to reference concrete, it is reduced by 3% and 13% in 10% and 15% RHA replacement for M-100.

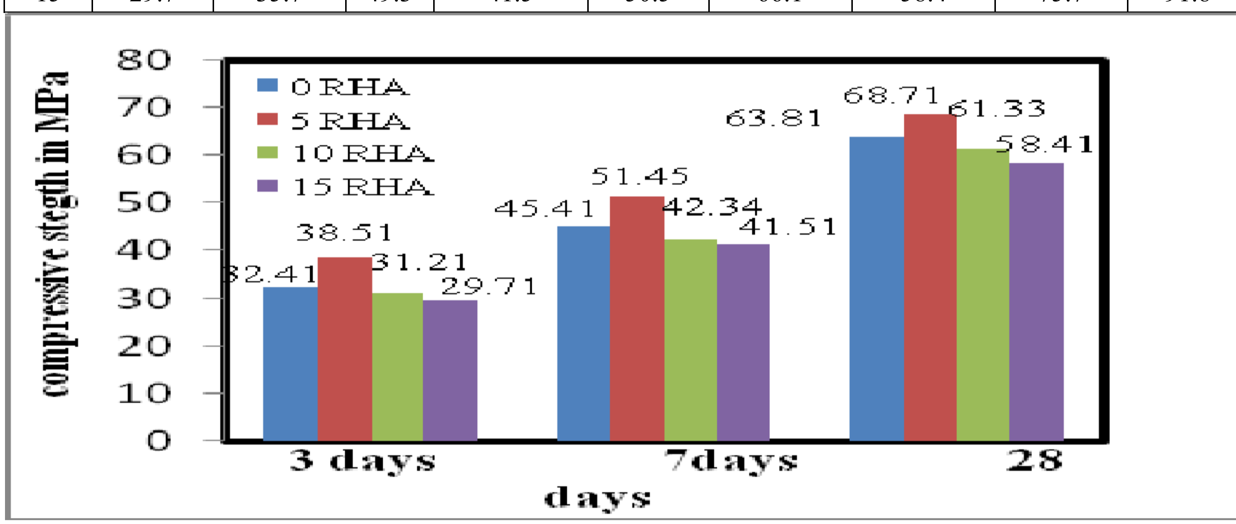
Figure 3.1 shows that, in comparison to reference concrete, at 28 days, the strength of M-60 is improved by 7% in 5% RHA replacement, M-80 is increased by 4% in 5% RHA replacement, and M-100 is increased by 4% in 5% RHA replacement. In contrast, it is reduced by 2% and 7% in 10% and 15% RHA replacement for M-60 and 2% and 5% in 10% and 15% RHA replacement for M-80 relative to reference concrete. However, in comparison to reference concrete, it is reduced by 7% and 10% in 10% and 15% RHA replacement for M-100.

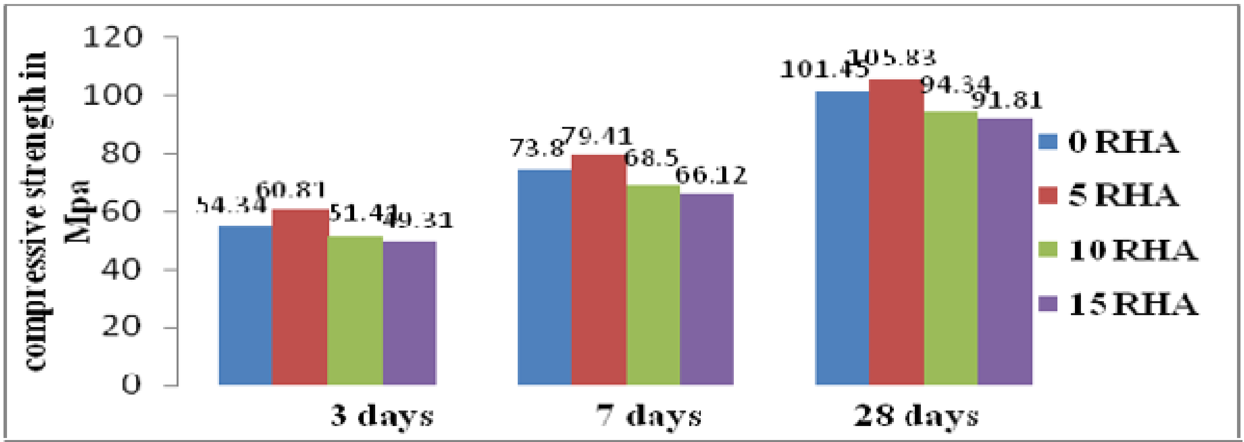
The bar chart shows that all of the M60, M80, and M100 mixtures have attained the desired strength. At all curing ages, a mix containing 5% RHA-replaced concrete is stronger than reference concrete and other percentage-replaced concrete.

3.2.1 Cylinder Compressive Strength Results of M60, M80 and M100

Table 3.2 Compressive strength of Cylinder 100X200 (mm) for M-60, M-80 &M100 in (MPa)

% of RHA	3 days			7 days			28 days		
	M60	M80	M100	M60	M80	M100	M60	M80	M100
0	32.4	41.4	54.3	45.4	55.8	73.8	63.8	84.5	101.4
5	38.5	48.5	60.8	51.4	63.4	79.4	68.7	88.7	105.8
10	31.2	40.1	51.4	42.3	51.9	68.5	61.3	80.4	94.3
15	29.7	35.7	49.3	41.5	50.5	66.1	58.4	75.7	91.8





Discussion of Cylinder Compressive Strength Results of M60, M80 and M100

Figure 3.2 shows that, in comparison to reference concrete, at three days, the strength of M-60 is enhanced by 19% in 5% RHA replacement, M-80 by 17% in 5% RHA replacement, and M-100 by 12% in 5% RHA replacement. In contrast, it is reduced by 3% and 14% in 10% and 15% RHA replacement for M-80 compared to reference concrete, and by 4% and 8% in 10% and 15% for M-60. However, in comparison to reference concrete, it is reduced by 5% and 9% in 10% and 15% RHA replacement for M-100.

After seven days, 5% RHA replacement increases the strength of M-60 by 13%, M-80 by 14%, and M-100 by 8% when compared to reference concrete. In contrast, it is reduced by 7% and 8% in 10% and 15% RHA replacement for M-60 and 7% and 9% in 10% and 15% RHA replacement for M-80 relative to reference concrete. However, in comparison to reference concrete, it is reduced by 7% and 10% in 10% and 15% RHA replacement for M-100.In comparison to reference concrete, at 28 days, the strength of M-60 is raised by 8% in 5% RHA replacement, M-80 is increased by 5% in 5% RHA replacement, and M-100 is increased by 4% in 5% RHA replacement. However, in comparison to reference concrete, it is reduced by 4% and 8% in 10% and 15% for M-60 and 5% and 10% in 10% and 15% RHA replacement for M-80. However, in comparison to reference concrete, it is reduced by 7% and 10% in 10% and 15% RHA replacement for M-100.

All of the M60, M80, and M100 mixtures have attained the desired strength, according to the bar chart. At all curing ages, a mix containing 5% RHA-replaced concrete yields greater strength than other percentages of replaced concrete and reference concrete.

In comparison to the reference mix and the 5% RHA replaced mix, the rate of strength increase is slower in the 10% and 15% RHA replaced mixes.

3.3 Modulus of Rupture Strength Results

3.3.1 Modulus of Rupture Strength Results of M60

Table 3.3 Beam modulus of Rupture strength 100X100X500 (mm) for M60, M80 & M100

% of concrete	7 days			28 days		
	M60	M80	M100	M60	M80	M100
0	5.56	5.41	6.1	6.4	7.81	8.34
5	6.41	6.24	6.92	7.56	8.94	9.24
10	5.67	5.85	6.23	6.78	8.25	8.51
15	4.21	5.1	5.8	5.81	7.25	7.75

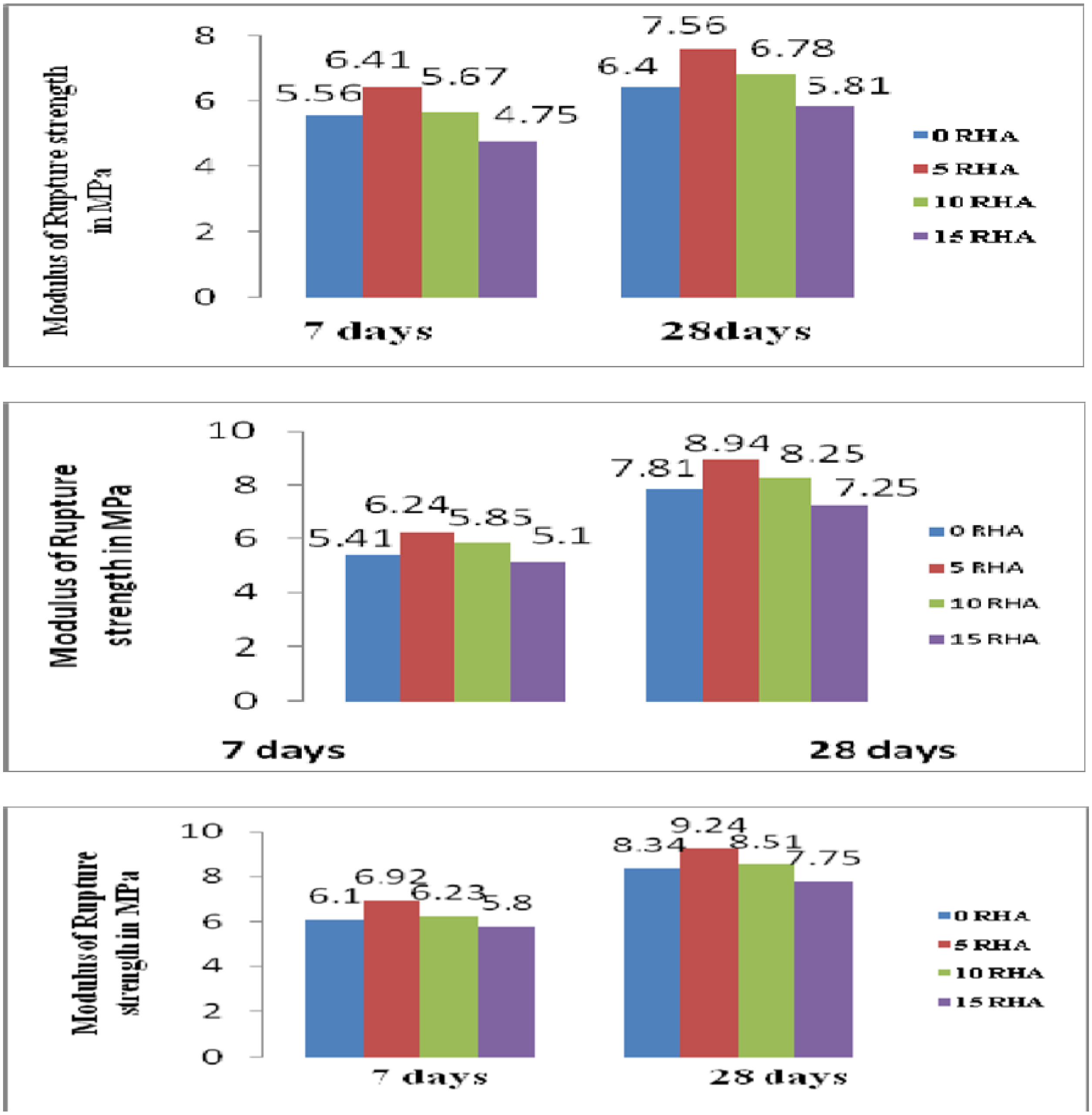


Fig3.7 Variation in Modulus of Rupture Strength at Various Ages of M60 M80 and M100

Discussion on Modulus of Rupture Strength Results of M60

With reference to Figure 3.3After seven days, the modulus of rupture strength for M60 is increased by 15% and 2% in 5% and 10% RHA replacement compared to reference concrete, for M80 it is increased by 15% and 8% in 5% and 10% RHA replacement compared to reference concrete, and for M100 it is increased by 13% and 2% in 5% and 10% RHA replacement compared to reference concrete. In comparison to reference concrete, the modulus of rupture strength is reduced by 15% for M60, 6% for M80, and 5% for M100 in 15% RHA replacement.
After 28 days, the modulus of rupture strength for M60 is higher than reference concrete by 18% and 6% in 5% and 10% RHA replacement, for M80 it is higher than reference concrete by 14% and 6% in 5% and 10% RHA replacement, and for M100 it is higher than reference concrete by 11% and 2% in 5% and 10%

RHA replacement. In comparison to reference concrete, the modulus of rupture strength decreases by 9% for M60, 7% for M80, and 7% for M100 after 15% RHA replacement.

IV. CONCLUSIONS

1. To increase the strength of concrete and partially replace cement, rice husk ash can be added as an additive with super plasticizers.
2. When compared to reference concrete, RHA concrete's compressive strength is rising. Among all M60, M80, and M100 replacements, it is more at 5%. For M60, M80, and M100, the maximum strengths attained after 28 days are 69.71 MPa, 87.43 MPa, and 105.83 MPa.
3. The cylindrical compressive strength of the High Performance concrete examined in this work was 0.92 times that of the cube.
4. Compared to reference and 5% RHA replacements for M60, M80, and M100, the strength improvement is slower in 10% and 15% RHA replacements.

REFERENCES

[1] Mauro M. Tashima, Carlos A. R. Silva, Jorge L. Akasaki and Michele B. Barbosa. ”influence of rice hush ash in mechanical characteristics of concrete”. ACI Supplementary Materials, Paper XII.08-p. 780-790 ISBN 85-98576-08-5.
[2] Shetty M. S., Concrete technology, S. Chand and company Ltd., Ram nagar, New Delhi, 624 pp.
[3] Ghassan Abood Habeeb, Hilmi Bin Mahmud. “Study on properties of rice husk ash concrete and its use as cement replacement material”. Materials Research Journal 2010: 185-190
[4] Andres Salas, Silvio Delvasto, Ruby Mejia de Gutierrez, David Lange. “Comparision of two process for treating rice husk ash for use in high performance concrete”. A Review.Cement and Concrete Research Journal 2009: 773-778
[5] Alireza Naji, Suraya Abdul, Rashid, Farah Nora A. Aziz, Mohamad Amran Mohd Salleh. “Contribution of rice husk ash to the properties of mortar and concrete”. Journal of AmericanScience 2010: 157-165
[6] D.S Rajendra Prasad, S.M. Maheshwarappa, S.Suresh. “Effect on compressive strength of replacing cement by Fly-ash and RHA with CO2 curing”. International Journal Of Earth Sciences and Engineering, ISSN 0974-5904, Volume 04, No 06 SPL, October 2011,: pp. 959-964.