Effect of Rice Husk Ash on Mortar

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Abstract-
Through this work, different cement replacement materials were employed as a partial replacement of cement with percentage of 10% in mortar mixes. The mechanical properties of control cement mortar, Cement dust mortar, Silica Fume (SF) mortar, Slag(S) mortar, Calcite clay (grog) mortar; Fly Ash (FA) mortar and Rice Husk Ash (RHA) mortar were tested to determine the effect of these materials on mortar properties. Mortar specimens were cured in water for 28 days, through which, compression strength were tested at ages 3, 7 and 28 days. Through this period, the specimens were tested for compressive strength at 1, 2 and 3 months to investigate its durability. The obtained results show that the compressive strength of the mortar containing cement dust, silica fume, slag, grog, fly ash and rice husk ash were better than that of the control cement mortar and the silica fume was the best pozzolana used in this research. It was also found that magnesium sulfate has a more severe effect on the durability when compared with sodium sulfate.

Keywords **- Rice husk ash, compressive strength, pozzolana, mortar.**

1. Introduction

Up to 1972, all the researches were concentrated to utilize ash derived from uncontrolled combustion Controlled combustion influence the surface area of RHA, so that time, temperature and environment to be considered to produce ash of maximum reactivity. However, from the review of literature, it was found that some works already done to find out the effect of RHA in cement mortar and they collect the RHA by Bangladesh is one of the largest rice producing countries and per capita rice consumption is higher than that in any other countries. There are main three biomass by product comes from rice viz. rice straw, rice husk and rice bran. Rice straw and rice bran are used as feed for cattle, poultry, fish etc. and the rice husk is used for energy production. In Bangladesh there are so many small rice mills, where rice husk is burned in uncontrolled manner. After burning a huge amount of rice husk ash is produced and dumped it as waste which creates an environmental problem. For increase the cost of construction materials and raising environmental concerns urge, considerable efforts are being taken worldwide to utilize local natural waste and by product materials to improve the performance of construction materials. Conventional building materials are beyond the reach of a majority of the world population due to their poor affordability. Rice husk is one of the major agricultural by-products and available all parts of the world except Antarctica (FAO, 2002). During growth, rice plants absorb silica from the soil and accumulate it into their structures. It is this silica, concentrated by burning at high temperatures removing other elements, Mortar Incorporating Rice Husk Ash: Strength and Porosity 472 which make the ash so valuable.

Chemical composition:

As per the Indian standard 1344-1968 the pozzolana shall conform to the following chemical requirements:

Constituents	contents
Silica+ Alumina+ Iron oxide (SiO_2+Al_2O_3+Fe_2O_3)	Not less than 70 per cent
Silica(SiO_2)	Not less than 40 per cent
Calcium Oxide (CaO)	Not less than 10 per cent
Magnesium Oxide (MgO)	Not less than 3 per cent
Sulphuric anhydride (SO_2)	Not less than 3 per cent
Soda and potash (Na_2O, K_2O)	Not less than 3 per cent
Water –Soluble alkali	Not less than 0.1 per cent
Water –soluble material	Not less than 1 per cent
Loss on ignition	Not less than 5 per cent

To improve the properties of cement, admixtures are added with it and these are either naturally occurring compounds or chemicals produced in industrial process. Most admixtures are pozzolans. A pozzolan is a powdered material, which when added to the cement in a concrete mix reacts with the lime, released by the hydration of the cement, to create compounds which improve the strength or other properties of the concrete . After chemical analysis of the used RHA, the total percentage composition of Iron oxide (Fe2O3=1.38) Silicon oxide (SiO2 = 90.2) and Aluminium oxide (Al2O3 =0.85) was found to be

92.43%, so RHA used in this work is an active pozzolan.

2. Materials used

Rice Husk Ash:

The Rice Husk Ash Used in this work was made in the laboratory by burning the husk using a Ferro cement furnace, with incinerating temperature not exceeding 7000 c. The ash was grinded using Los Angeles mill for 180, 270 and 360 minutes, The XRD analysis were performed to determine the silica form of the produced RHA Powder samples. RHA samples were scanned by electron microscope to show the RHA's multi layered and micro porous surface.

Other Materials:

Other materials used in the concrete mixture were Portland cement, coarse aggregate of 20 mm maximum size and mining sand of 5 mm maximum size as fine aggregate. The fineness modulus for the coarse aggregate and fine aggregate were 2.43 and 4.61 respectively. The Sp used is sulphonated naphthalene formaldehyde condensed polymer based admixture.

Mix proportion:

The purpose of this investigation was to make the concrete with targets of 28-day Compressive strength of at least 40 MPa. Proportion of mixtures was selected basing on these targets. The RHA was trialed to replace for cement with various ratios, namely 0, 12.5, 25, and 37.5 % by mass of cement. Ratio of water per total cement binder (cement plus RHAs) was fixed at 0.48.

3. Effects of adding RHA on the properties of concrete

3.1 Effect of RHA APS on Workability & Density of concrete

The fresh properties of all the concrete mixtures are given. The slump was in the range of (210-230 mm), bleeding was negligible for the control mixture. For concretes incorporating RHA, no bleeding or segregation was detected. The fresh density was in range of (2253-2347 kg/m3), the lowest density values were for mixture this is due to the low specific gravity of RHA which lead to reduction in the mass per unit volume. The concrete incorporating finer RHA resulted in denser concrete matrix.

The SP content had to be increased along with the RHA fineness and percentage, this due to the high specific surface area of RHA which would increase the water demand therefore, to maintain high workability, Sp content rose up to 2.00 % for the mixture.

3.2 Water absorption

The results reveal that higher substitution amounts results in lower water absorption values, its occur due to the RHA is finer than cement. Adding 10% of RHA to the concrete, a reduction of 38.7% in water absorption is observed when compared controlled mixture.

3.3 Static Modulus of Elasticity:

The values of the static modulus of elasticity were in the range of 29.6 - 32.9 GPa. It can be noted that the addition of RHA to concrete exhibited marginal increase on the elastic properties, the highest value was recorded for mixture due to the increased reactivity of the RHA. Concretes incorporating pozzolanic materials usually show comparable values for the elastic modulus compared to the OPC concrete.

3.4 Splitting tensile strength

All the replacement degrees of RHA researched, achieve similar results in splitting tensile strength. According to the results, may be realized that there is no interference of adding RHA in the splitting tensile strength.

3.5 Drying Shrinkage

The results showed that the RHA average particle size had a significant effect on the drying shrinkage, the 37.5% concrete Mixture exhibited higher shrinkage value than the control. 25% concrete was comparable, while the shrinkage for 12.5% was lower compared to the control. The reduction in the RHA particle size increased the pozzolanic activity and contributed to the pore refinement of the RHA concrete paste matrix. Thus, it can be concluded that the addition of micro fine particles to concrete would increase the drying shrinkage. Many researchers showed that concretes incorporating pore refinement additives will usually show higher shrinkage and creep values. On the other hand, others showed that using pozzolanic materials as cement replacement will reduce the shrinkage.

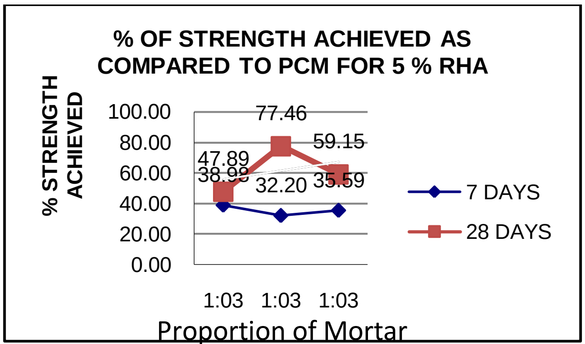
3.6 Compressive Strength:

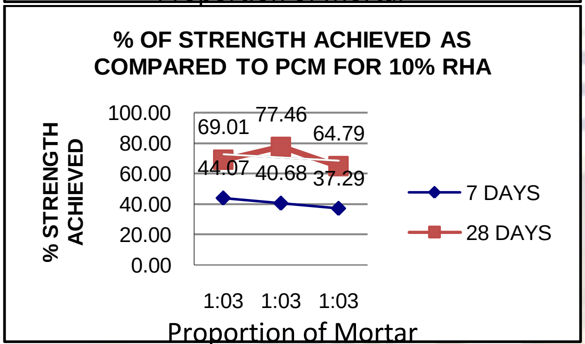
The strength development at various ages is given below. It can be noted that at early ages the strength was comparable, while at the age of 28 days, finer RHA exhibited higher strength than the sample with coarser RHA. This is due to the higher fineness of RHA which may allowed the RHA particles to increase the reaction with $Ca(OH)_2$ to give more calcium silicate hydrate (C-S-H) resulted in higher compressive strength.

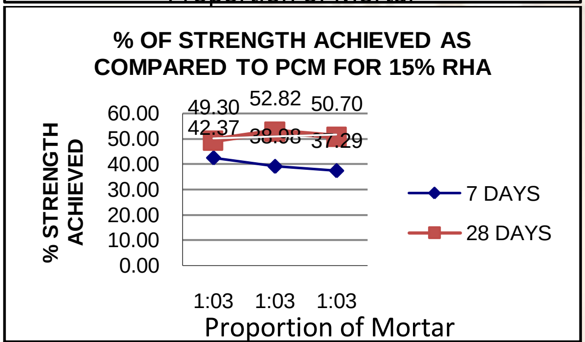
4. Results and discussion

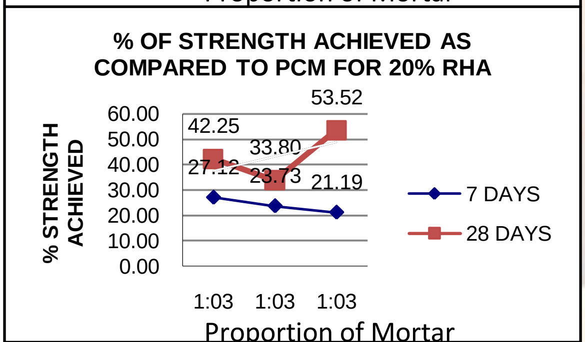
Following results shows the effect of percentage and fineness of RHA on the compressive strength of concrete,

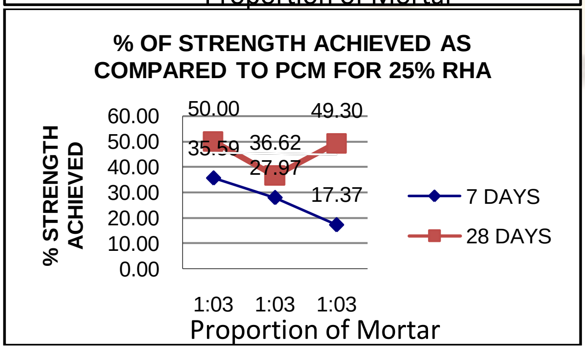
4.1 Compressive strength of mortar for %age of RHA for 1:3 proportions:

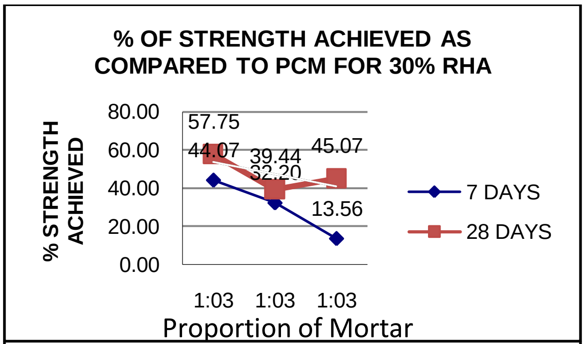

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 5 % RHA
% STRENGTH ACHIEVED
100.00
80.00
60.00
40.00
20.00
0.00
77.46
59.15
47.89
38.99
32.20
35.59
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

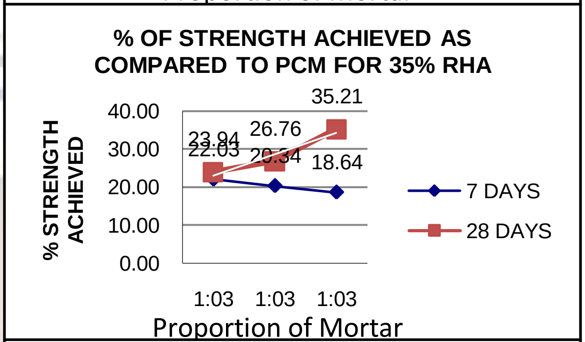

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 10% RHA
% STRENGTH ACHIEVED
100.00
80.00
60.00
40.00
20.00
0.00
69.01
77.46
64.79
44.07
40.68
37.29
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

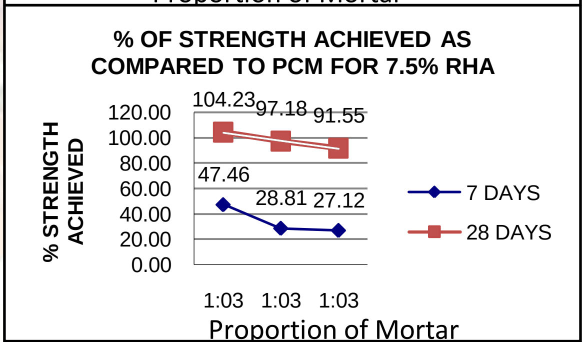

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 15% RHA
% STRENGTH ACHIEVED
60.00
50.00
40.00
30.00
20.00
10.00
0.00
49.30
52.82
50.70
42.37
38.98
37.29
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

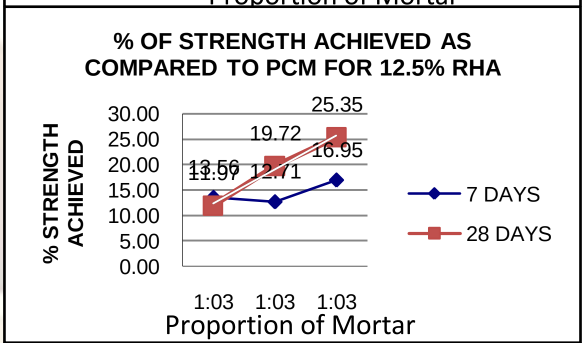

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 20% RHA
% STRENGTH ACHIEVED
60.00
50.00
40.00
30.00
20.00
10.00
0.00
53.52
42.25
33.80
27.12
23.73
21.19
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

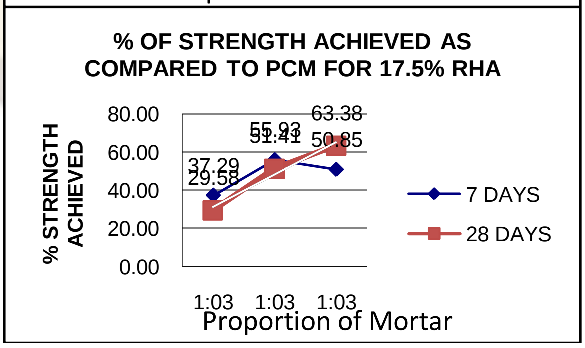

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 25% RHA
% STRENGTH ACHIEVED
60.00
50.00
40.00
30.00
20.00
10.00
0.00
50.00
49.30
35.59
36.62
27.97
17.37
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

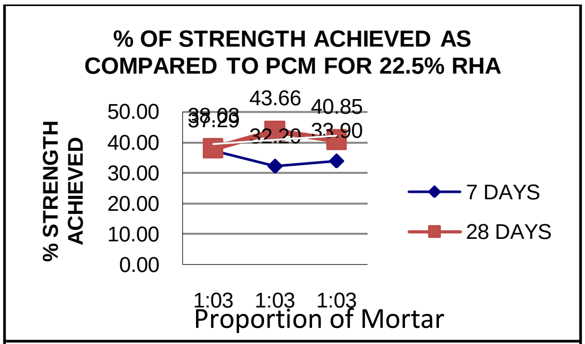

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 30% RHA
% STRENGTH ACHIEVED
80.00
60.00
40.00
20.00
0.00
57.75
44.07
39.44
32.20
45.07
13.56
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

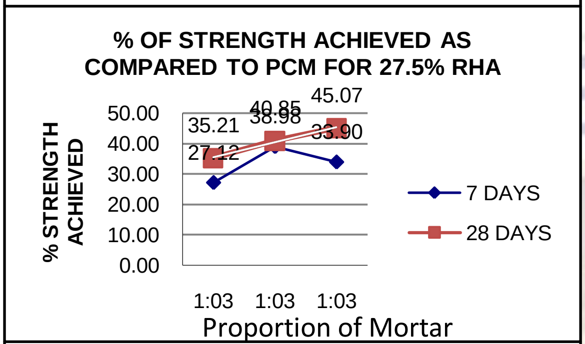

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 35% RHA
% STRENGTH ACHIEVED
40.00
30.00
20.00
10.00
0.00
35.21
23.94
22.03
26.76
20.34
18.64
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

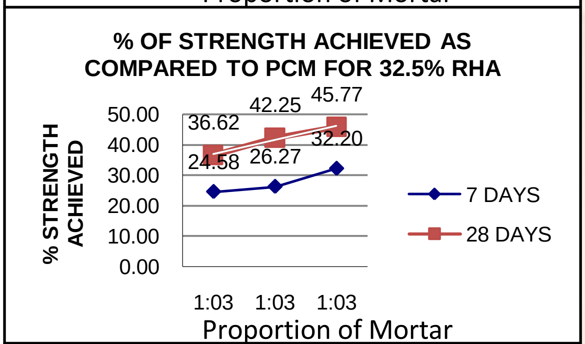

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 7.5% RHA
% STRENGTH ACHIEVED
120.00
100.00
80.00
60.00
40.00
20.00
0.00
104.23
97.18
91.55
47.46
28.81
27.12
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS

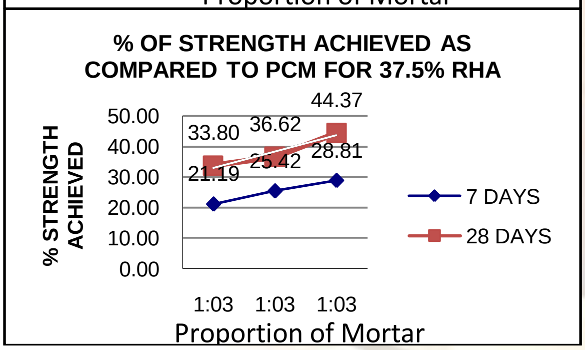

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 12.5% RHA
% STRENGTH ACHIEVED
30.00
25.00
20.00
15.00
10.00
5.00
0.00
25.35
19.72
16.95
13.56
11.97
12.71
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS


% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 17.5% RHA
% STRENGTH ACHIEVED
80.00
60.00
40.00
20.00
0.00
63.38
55.93
51.41
50.85
37.29
29.58
1:03 1:03 1:03
Proportion of Mortar
7 DAYS
28 DAYS









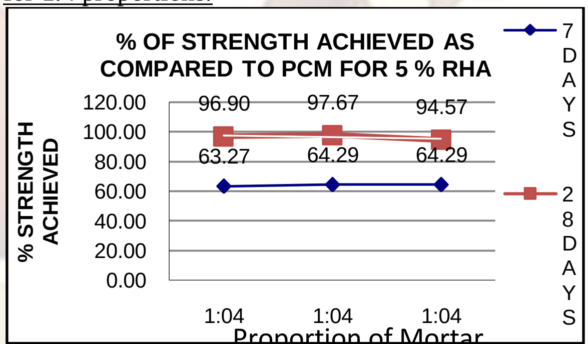
The maximum average compressive strength for 7 days is found for 17.5% of RHA which is 11.33 N/mm2, which is 48.02% of PCM.
The minimum average compressive strength for 7 days is found for 35% of RHA which is 4.80 N/mm2, which is 20.34% of PCM.
It is found that the average comp. strength is increasing up to 17.5% of RHA and then started decreasing from 20% of RHA up to 37.5% of PCM.
Whereas for 28 days the maximum average compressive strength is found for 7.5% of RHA which is 27.73 N/mm2, which is 97.65% of PCM.
Similarly, the minimum average compressive strength for 28 days is found as 5.40 N/mm2 for 12.5% of RHA, which is 19.01% of PCM.
But actually the minimum average compressive strength for 28 days could be 8.13 N/mm2 which is for 35% of RHA, which is 28.64% of PCM.
The minimum average compressive strength for 12.5% of RHA which is 5.40 N/mm2 which might be due to some reasons such as workmanship, mixing, compaction, curing, etc.
In case of 28 days of compressive strength, the strength is increasing only for two readings for 5% and 7.5%, then after it kept varying reading after reading.

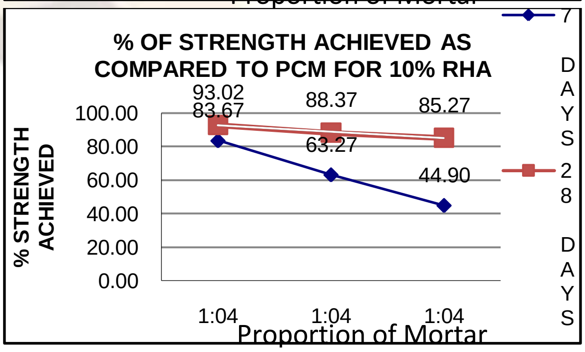
From the discussion drawn above it is observed that, the percentage of strength achieved for 7 days is less with consideration to that of PCM, whereas it is found more with consideration to that of PCM in case of 28 days. It is also observed that, in some cases the results are not as per consideration that it will be in increasing manner it is because of the factors such as workmanship, quality of material and weather conditions etc.

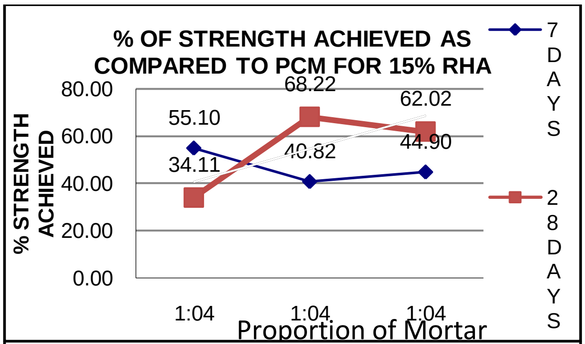
Therefore from all above discussion it can be said that mortar will tend to gives more percentage of compressive strength to that of PCM after 28 days as when percentage of RHA is used. It can be said that mortar will attain the strength slowly or its reaction becomes slow when RHA is used, therefore mortar gives more strength after 28 days.

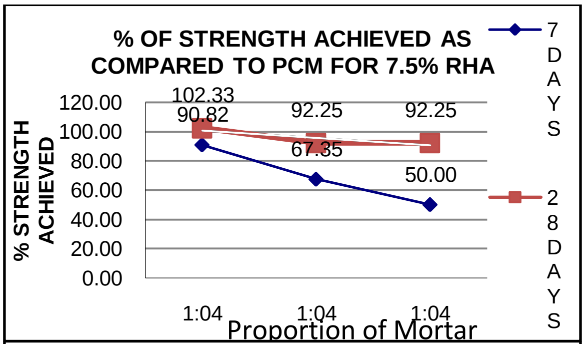
The maximum percentage of compressive strength is achieved in percentage range of 15% to 17.5% of RHA in case of 7 days. And for 28 days it is achieved in percentage range of 5% to 10% of RHA.

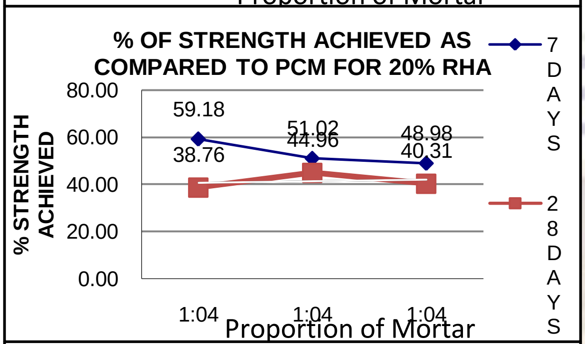
4.2 Compressive strength of mortar for %age of RHA for 1:4 proportions:

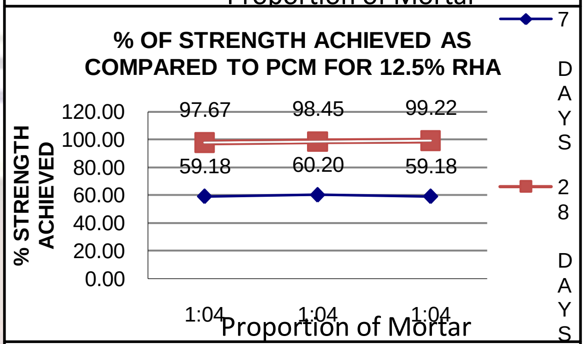


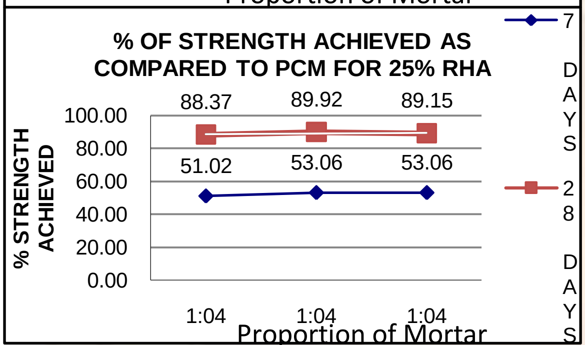


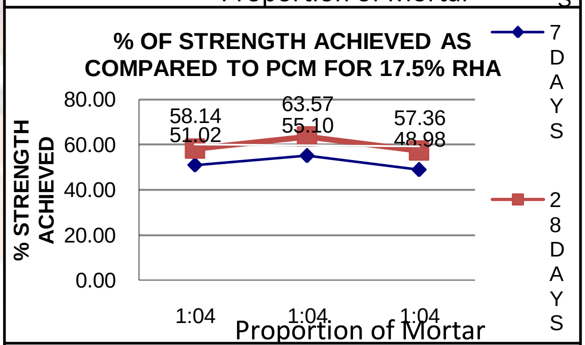

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 15% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
55.10
40.82
44.90
34.11
68.22
62.02
7 DAYS
28 DAYS

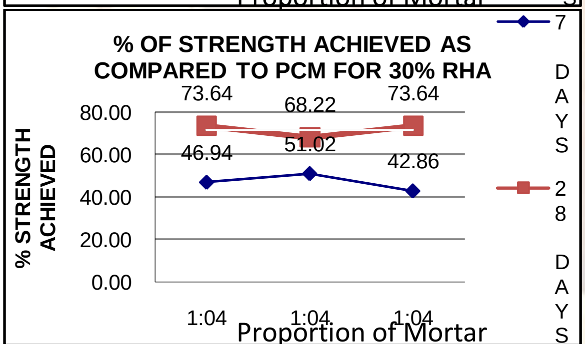

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 7.5% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
90.82
67.35
50.00
102.33
92.25
92.25
7 DAYS
28 DAYS

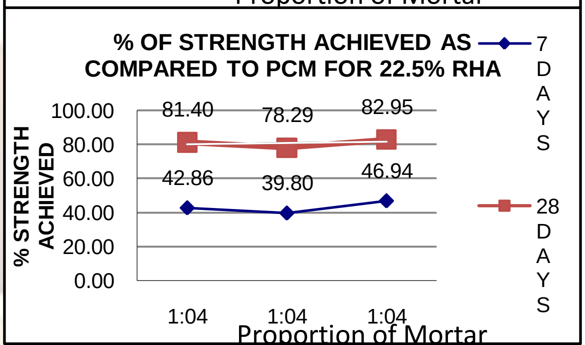

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 20% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
59.18
51.02
48.98
38.76
44.96
40.31
7 DAYS
28 DAYS

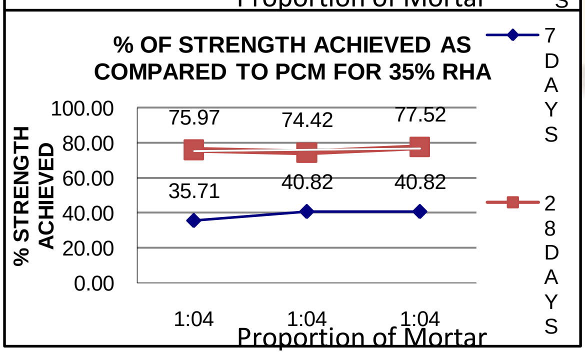

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 12.5% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
59.18
60.20
59.18
97.67
98.45
99.22
7 DAYS
28 DAYS

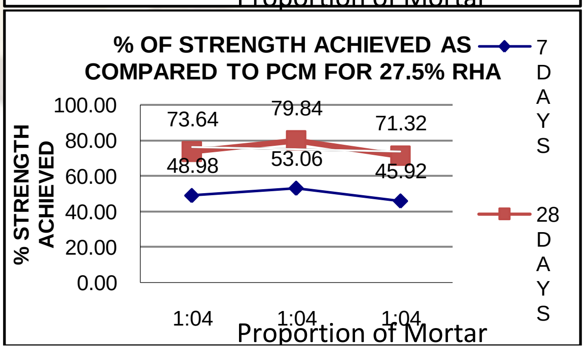

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 25% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
51.02
53.06
53.06
88.37
89.92
89.15
7 DAYS
28 DAYS

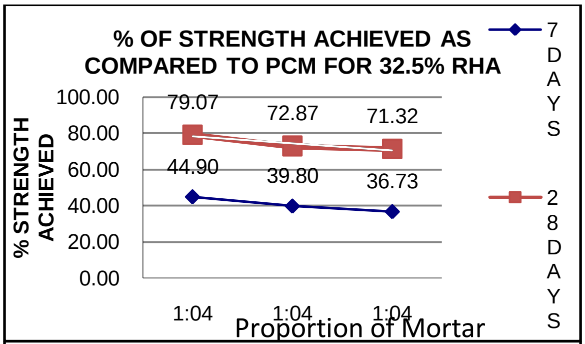

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 17.5% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
51.02
55.10
48.98
58.14
63.57
57.36
7 DAYS
28 DAYS

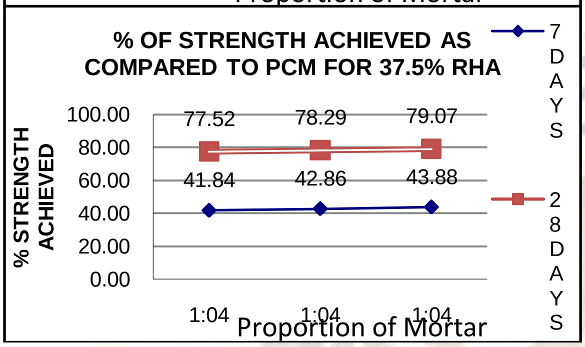

% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 30% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
46.94
51.02
42.86
73.64
68.22
73.64
7 DAYS
28 DAYS


% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 22.5% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
42.86
39.80
46.94
81.40
78.29
82.95
7 DAYS
28 DAYS


% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 35% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
35.71
40.82
40.82
75.97
74.42
77.52
7 DAYS
28 DAYS


% OF STRENGTH ACHIEVED AS COMPARED TO PCM FOR 27.5% RHA
% STRENGTH ACHIEVED
Proportion of Mortar
1:04
1:04
1:04
48.98
53.06
45.92
73.64
79.84
71.32
7 DAYS
28 DAYS





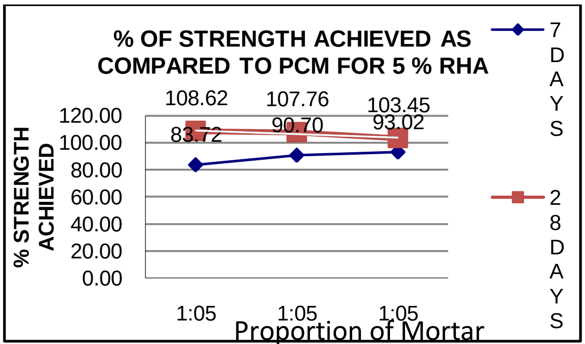
The maximum average compressive strength for 7 days is found for 7.5% of RHA. It is 69.39% of PCM. The minimum average compressive strength for 7 days is found for 35% of RHA It is 39.12% of PCM.
For 28 days the maximum average compressive strength is found for 12.5% of RHA which is 25.40 N/mm^2. It is 98.45% of PCM.
Similarly, the minimum average compressive strength for 28 days is found for 20% of RHA. It is 41.34% of PCM.
It is also found that the compressive strength is increasing up to 20% of RHA and then starts decreasing.

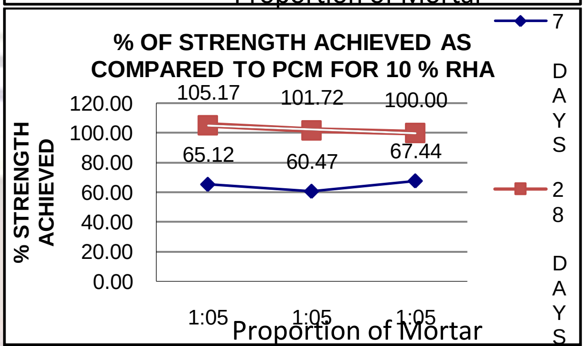
As compared to 1:03 proportion the percentage increase in compressive strength of 1:04 proportion for 7 days is found in higher side.

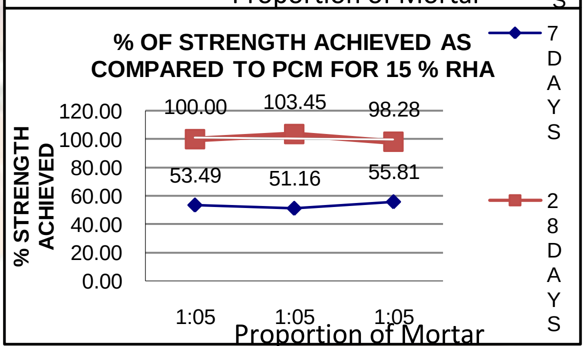
Similarly, for 28 days, as the proportion of mortar changes in higher ratio with addition to percentage of RHA the percentage achieved compressive strength is also increasing for 7 days and 28 days.

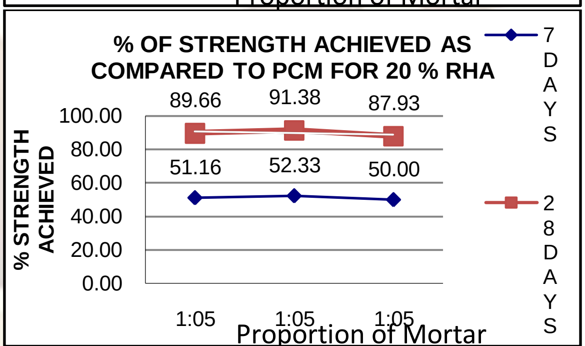
It is also seen that the maximum percentage of achieved strength is in between 5% to 12.5% of RHA both for 7 days and 28 days. In case of 28 days of percentage achieved strength it is found that only for the range of 15% to 20% of RHA.

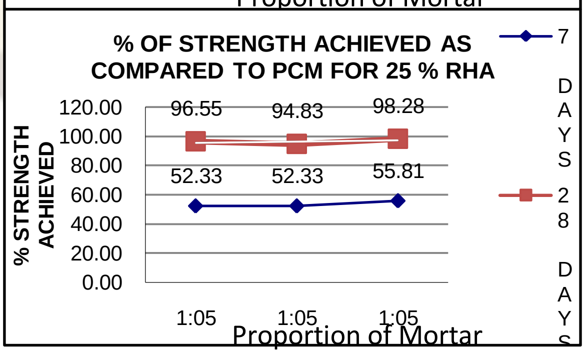
4.3 Compressive strength of mortar for %age of RHA for 1:5 proportions:

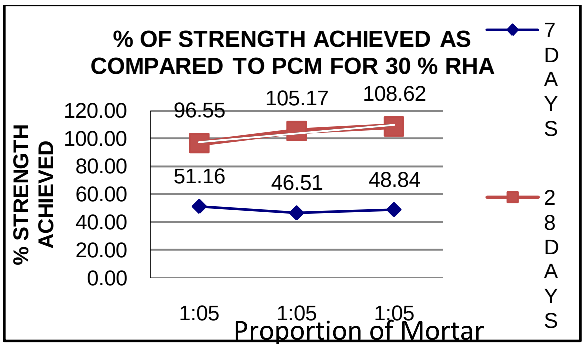


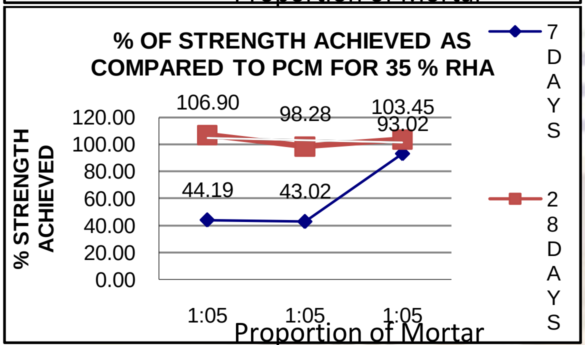


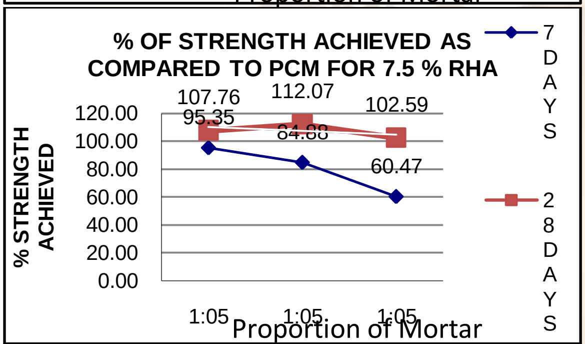


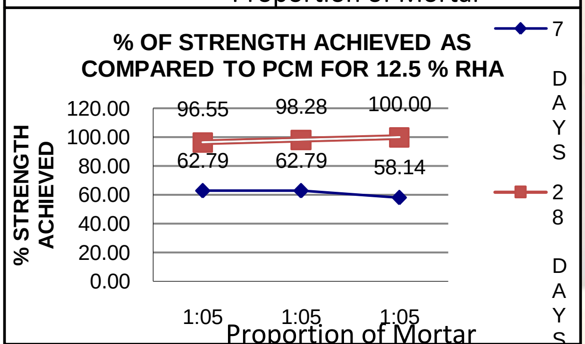


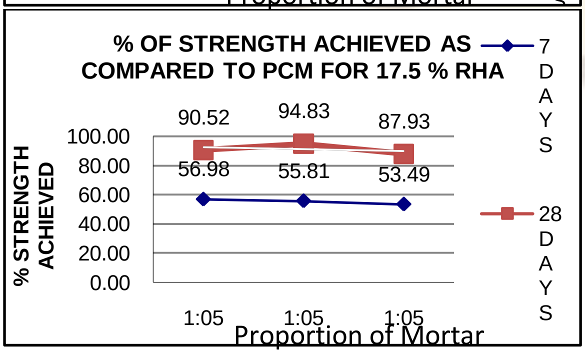


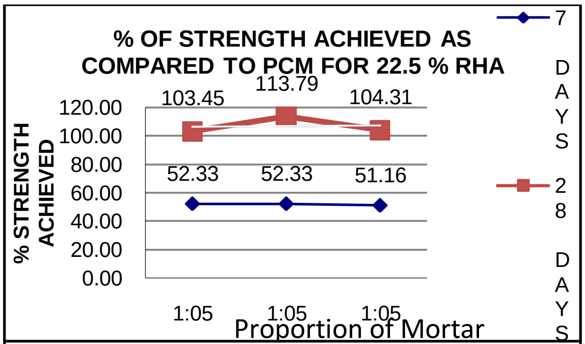


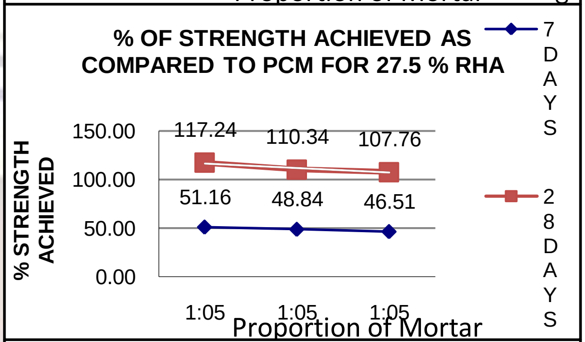


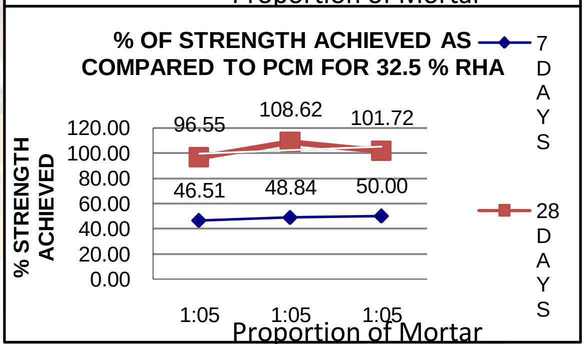


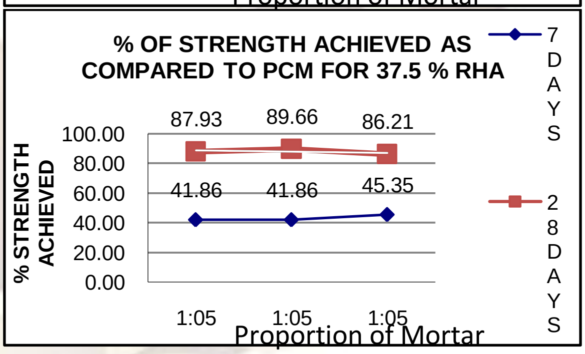












The maximum average compressive strength for 7 days is found for 5% of RHA It is 89.15% of PCM.

The minimum average compressive strength for 7 days is found for 37.5% of RHA. It is 43.02% of PCM.

For 28 days the maximum average compressive strength is found for 27.5% of RHA. It is 111.78% of PCM.

Similarly, the minimum average compressive strength for 28 days is found for 37.5% of RHA. It is 87.93% of PCM.

It is also found that the compressive strength decreases linearly for all % of RHA.

As compared to 1:03 and 1:04 proportion the percentage increase in compressive strength of 1:05

proportion for 7 days and 28 days is found in higher side as compared to that of PCM.

It is also seen that the maximum percentage of achieved strength is in between 5% to 12.5% of RHA for 7 days. In case of 28 days it is found that only for the few percentage of RHA the compressive strength is in lower side except this range it has given the very good percentage achieved compressive strength to that of PCM.

It is also seen that for this proportion the maximum percentage achieved strength for 28 days is above 100% which is good.

5. CONCLUSION

Base on above results of concrete mixes, the following conclusions can be drawn,

- Mixes show higher compressive rather than normal concrete.
- Replacement of 12.5 % of cement with rice husk ash in matrix causes reduction in utilization of cement, and
 expenditures, also can improve quality of concrete at the age of 90 days.
- Results indicate that pozzolanic reactions of rice husk ash in the matrix composite were low in early ages, but by aging the specimens to 90 days, considerable effect have been seen in strength.
- According to study, addition of pozzolans like rice husk ash to the concrete, can improve the mechanical properties of specimens

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