ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

Feasibility Study of Using Rice Straw Ash as A Construction Material in Concrete

[1] Amanpreet kour Bali, [2] Dr. Harwinder Singh

[1][2] Guru Nanak Dev Engineering College, Ludhiana, India

***Abstract*--- Globalization and Industrialization has changed the scenario of construction industry .The increasing demand of construction material has indirectly caused exploitation of natural material and environmental pollution. The use of agricultural byproducts after burning, grinding and sieving in concrete has been employed as an alternative of cement and fine aggregates. In this research experimental study was made on the effects of using Rice Straw Ash as a replacement of cement and fine aggregates in concrete. M20 Grade of concrete was prepared. The OPC 43 grade cement and fine aggregates were replaced at a replacement level of 0%, 9%, 12% and 15%. Physical, strength and durability properties of concrete incorporated with Rice Straw Ash as a partial replacement of cement and fine aggregates were analyzed after 28 days of curing. The test results showed that workability and carbonation depth of concrete decreased with the increase in percentage of Rice Straw Ash while as compressive strength, flexural strength and abrasion resistance increased with the incorporation of Rice Straw Ash. Finally it was concluded that concrete incorporated with Rice Straw Ash as a replacement of cement gave more pronounced results as compared to fine aggregates.**

***Keywords*--- Rice Straw Ash, pozzolanic, environmental pollution, strength, durability**

I. INTRODUCTION

Concrete is one of the most widely used material in the world , researchers have been working on the techniques and alternatives that can enhance the properties of concrete and can also minimize the emissions during its material production. Concrete is basically made up of cement , coarse aggregates , sand and water . The manufacturing of cement results in the production of large number of green house gases which have adverse effect on the environment . The use of natural materials like aggregates in concrete also results in exploitation of natural resources . Thus work has been carried out to find the alternatives of cement and aggregates so that emission of gases and degradation of natural material could be reduced.

Supplementary Cementitious Materials obtained from industries and agriculture can act as the best alternatives of cement. Indian economy is mostly based on the agriculture and large number of agro wastes are produced . These agro wastes such as rice straw , rice husk , bag ge ash etc utilize large number of minerals from the land and when they are burnt at proper temperature the ash is produced .The ash has pozzolanic properties and can be utilized in concrete as an alternative of cement . The use of such by products can be beneficial to both construction as well as agriculture industry.

This paper relates the partial replacement of cement and fine aggregates with Rice Straw Ash in concrete. The main area of focus of this research was to study the physical , strength and durability properties of concrete incorporated with Rice Straw Ash and to use it as a construction material in concrete.

II. EXPERIMENTAL PROGRAM

2.1 Materials

2.1.1 "CEMENT AND RICE STRAW ASH" : OPC 43 grade cement conforming to IS 8112:2013 was used in all the concrete mixes . The physical properties of cement were analyzed and are mentioned in Table 1.

S.NO	Physical Requirement	Test Results	Specifications as IS 8112-2013
1	Specific gravity	3.11	-
2	Initial setting time	43min	>30 min
3	Final setting time	6 hour and 18 minutes	<600 minutes
4	Standard consistency	32%	-

"Table 1 : Physical properties of Ordinary Portland Cement (OPC 43)."

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

The partial replacement of cement and fine aggregates was done with Rice Straw Ash burnt in furnace at a higher temperature . Rice Straw Ash was used at a replacement level of 9% , 12% and 15% in this experimental program.

2.1.2 AGGREGATES : Locally avaliable coarse aggregates and sand conforming to IS 383:1970 were used in this study . Fine aggregates were sieved through IS sieve 4.7mm. Specific gravity , water asorption , moisture content and zoning of fine aggregates were analysed to meet the reqiurements of IS 383:1970 and are given in table 2.

S.NO	Physical properties of sand	Test Results
1	Grading zone	Zone I
2	Specific gravity	2.47
3	Water absorption	1.2%
4	Moisture content	-

TABLE 2 : Physical properties of Fine Aggregates.

Coarse aggregates were reatained on ISsieve 4.75mm and various properties such as Specific gravity , water asorption , moisture content and shape of the aggregates were examined and are mentioned in table 3.

S.NO	Physical properties of Coarse aggregates (10mm and 20mm)	Test Results
1	Shape	Angular
2	Specific gravity	2.65
3	Water absorption	1%
4	Moisture content	-

TABLE 3: Physical properties of Coarse Aggregates.

2.1.3 CONCRETE MIXES: Rice Straw Ash was used as a partial replacement of cement and fine aggregates at a replacement level of 0% , 9 % , 12% and 15% . Different proportions of concrete mixes were prepared at different replacement level and were then compared with control mix (Table 4) in order to examine the use of Rice Straw Ash as a construction material in concrete.

Description	Cement	Sand	Coarse aggregates	
			10mm	20mm
Trial 1	1	2.155	2.013	1.343

TABLE 4 : Propotions of Control Mix.

2.2 TESTING

2.2.1 "WORKABILITY : Workability of concrete was investigated according to IS 516:1959. The workability of concrete was checked by using slump cone . The slump cone was filled in three layers and each layer was tamped 25 strokes with tammping rod. After filling the whole cone the slump apparatus was removed slowly and concrete was allowed to settle. Finally the slump height was measured by the subtracting the final height of slump from the original height of mould . Fig 1 shows the slump cone used for investigating the workability of concrete."

Fig1:Slump cone

2.2.2 "COMPRESSIVE STRENGTH : The compressive strength of concrete was investigated according to IS516:1959 . The cubical specimen of size 150x150x150mm were cast . The specimens were filled with concrete in three layes and each layer was tamped by providing 35 strokes. Demoulding of specimens were done after 24 hours and were kept for 28 days curing . After curing period the specimens were tested on compression testing machine having capacity of 2000kn (Fig 2). The compressive strength reported was average of three specimens".

Fig2:Compression Testing Machine

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

2.2.3 "FLEXURAL STRENGTH: The flexural strength of concrete was investigated according to IS516:1959 . Flexural strength of concrete was found by casting specimens of size 150x150x700mm . The moulds were filled , tamping was done and were demoulded after 24hours. The specimens were kept for 28 days curing and then flexural strength was checked by using flexural strength testing machine (Fig 3)".

Fig3: Flexure Testing Machine

2.2.4 "ABRASION RESISTANCE: Abrasion resistance of concrete was investigated according to IS 15658:2016. The test was performed by casting a cubical specimens of size 70x70x70mm. The specimens were cast by placing mould in a machine and concrete was poured in it and vibrated. The specimens were demoulded after 24hours and were kept for 28 days curing. After 28 days the speciemen were placed in the mould of abrasion testing machine (Fig 4) and the disc of the machine was runned at the speed of 30rpm and was stopped after a cycle of 22 revolutions . During this process 20grms of abrasive powder was distributed on the testing track and this process was repeated after every cycle. The test was repeated 16 times and specimen was turned 90^0 in clockwise direction after each cycle. The abrasive loss of the specimen after 16 cycles shall be calculated as average loss of specimen volume".

Fig4: Abrasion Testing Machine

2.2.5 "CARBONATION DEPTH : The carbonation depth of concrete was investigated according to BIS1920:12. Cubical specimens of size 100x100x100mm were casted. The mix was preapred and was poured in specimes . The specimens were demoulded after 24hours and placed in curing tank for water curing for 28 days. After water curing the specimens were taken out dried , coated with parrafin wax on top bottom and two end faces (Fig 5) . Accelerated Carbonation Chamber (Fig6) was operated by putting the walves of cylinder on and switching on the switches .The carbondioxide (CO_2) level was mantained at (4±0.5)% by volume , temperature at $(20±2)^0$C and humidity at (55±5)%. After all these settings were done the specimen coated with wax were placed in the chamber .The specimens were taken out after 28days and were broken into thick slice of 50mm and were checked by spraying phenolpthalein indicator. The depth of carbonation was measured at various points on each side and mean depth was calculated".

Fig5 :Specimens Coated with parrafin wax

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

Fig6 :Accelerated Carbonation Chamber

III. RESULTS AND DISCUSSION

3.1 WORKABILITY: The workability of concrete containing Rice Straw Ash as A replacement of cement and fine aggregates at 28 days are plotted in fig 3.1.1 and 3.1.2 respectively. From the given figures it is observed that workability of control concrete is more than that of concrete incorporated with Rice Straw Ash. Thus partial replacement of cement and fine aggregates results in increase in water demand of concrete. The increased water demand of concrete incorporated with Rice Straw Ash is due to the fineness , porosity and hydrophilic nature of Rice Straw Ash.

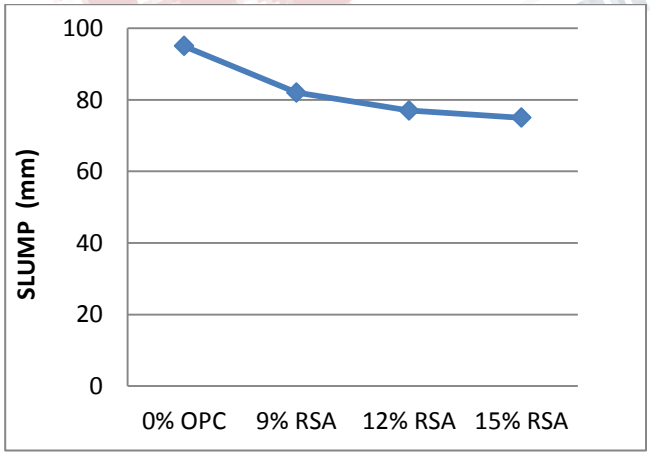

FIG 3.1.1: Effect of replacement of cement with Rice Straw Ash on workability of concrete.

3.2 COMPRESSIVE STRENGTH: The variation of compressive strength of concrete incorporated with Rice Straw Ash as a replacement of cement and fine aggregates at 28 days are given in fig 3.2.1 and 3.2.2 respectively. The compressive strength of concrete incorporated with Rice Straw Ash as a replacement of cement and fine aggregates is more than control concrete at 28 days.The increased compressive strength of concrete is due to the lower water cement ratio and fineness of Rice Straw Ash which fill all the voids of concrete thus resulting in increased strength. The silica content present in Rice Straw Ash also improves the compressive strength of concrete.

3.3 FLEXURAL STRENGTH: The variation of flexural strength of concrete incorporated with Rice Straw Ash as a replacement of cement and fine aggregates at 28 days aregiven in fig 3.3.1 and 3.3.2 respectively. Flexural strength of concrete incorporated with Rice Straw Ash first increases and after attaining peak value it shows a drop in it. The increases in flexural strength can be due to the increased density of concrete .The maximum value of flexural strength was obatained at 12% replacement of cement and sand with Rice Straw Ash.

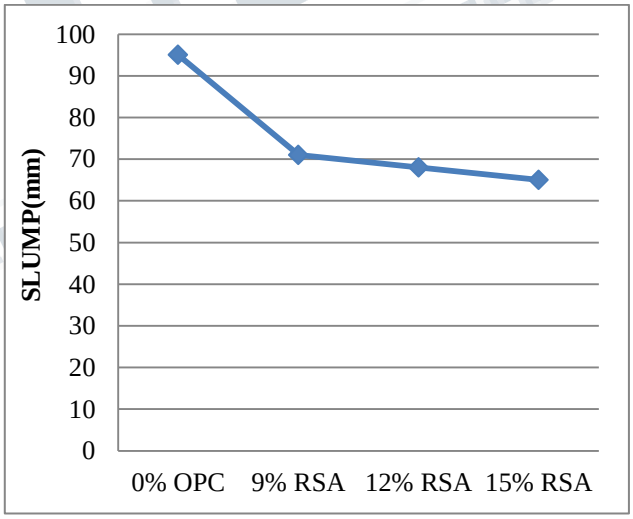

FIG 3.1.2: Effect of replacement of fine aggregates with Rice Straw Ash on workability of concrete

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

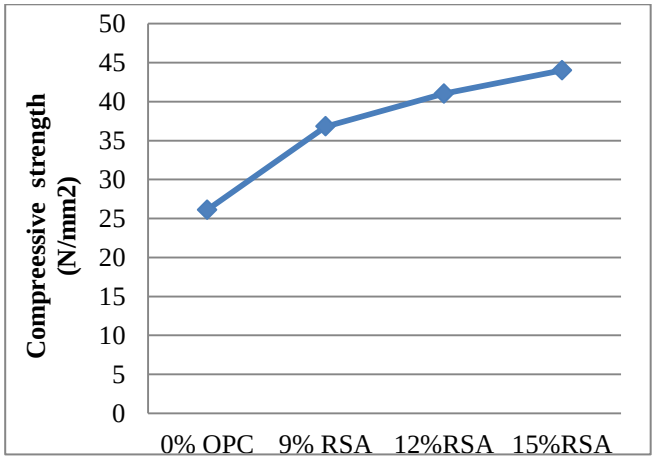

FIG 3.2.1: Variation of compressive strength of concrete containing Rice Straw Ash as a replacement of cement

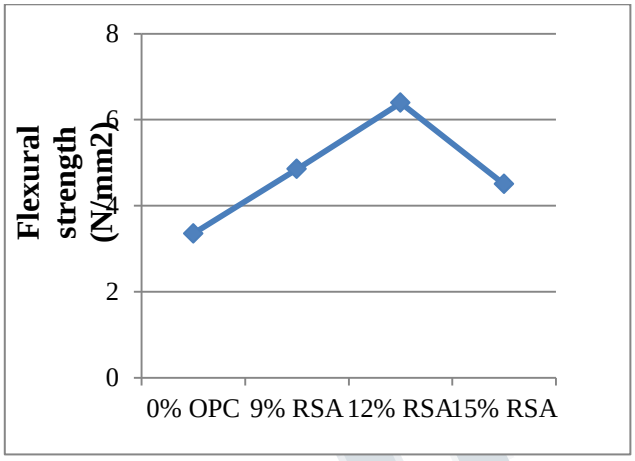

FIG 3.3.2: Variation of flexural strength of concrete containing Rice Straw Ash as replacement of fine aggregates

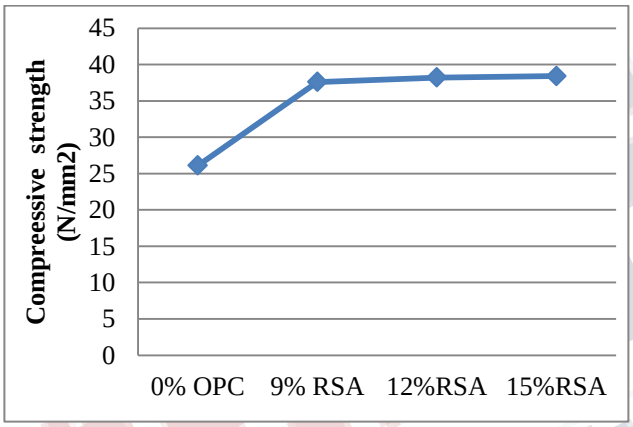

FIG 3.2.2 : Variation of compressive strength of concrete containing Rice Straw Ash as replacement of fine aggregates

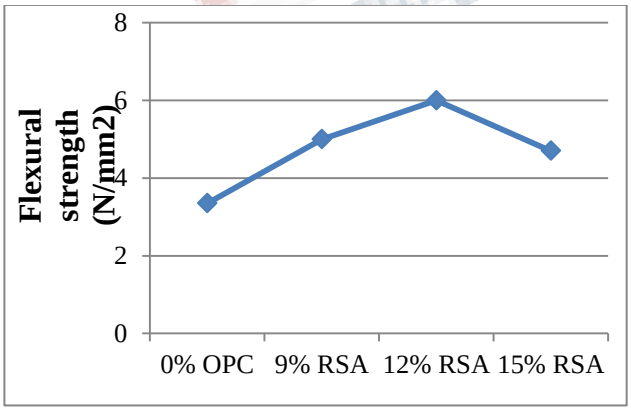

FIG 3.3.1 : Variation of flexural strength of concrete containing Rice Straw Ash as replacement of cement.

3.4 ABRASION RESISTANCE : The Variation of abrasion resistance of concrete containing Rice Straw Ash as a replacement of cement and fine aggregates at 28 days are given in fig 3.4.1 and 3.4.2 respectively. It has been observed from the graphs that the abrasion resistance of concrete increases with increase in replacement of cement and fine aggregates with Rice Straw Ash. The volume loss of abrasive sample decreases with increases in percentage of Rice Straw Ash , thus due to fineness of ash all the voids of the pavement block are filled and as a results the resistance against abrasion increased. Also the adhesive forces between the particles is stronger thus resulting in increases in abrasion of pavement block. Increased compressive strength of concrete due to the incorporation of Rice Straw Ash also results in increase in abrasion resistance of concrete block.

3.5 CARBONATION DEPTH : The Variation of carbonation depth of concrete containing Rice Straw Ash as a replacement of cement and fine aggregates at 28 days are given in fig 3.5.1 and 3.5.2 respectively. It can be observed that due to the incorporation of Rice Straw Ash at a replacement level of 9% , 12% and 15% as a replacement of cement and fine aggregates the overall carbonation of concrete admixed with Rice Straw Ash is less than control concrete. The carbonation depth of concrete containing Rice straw Ash is less due to the fineness of ash the voids get filled and CO_2 penetration becomes less ,thus resulting in reduced depth.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 3, March 2021

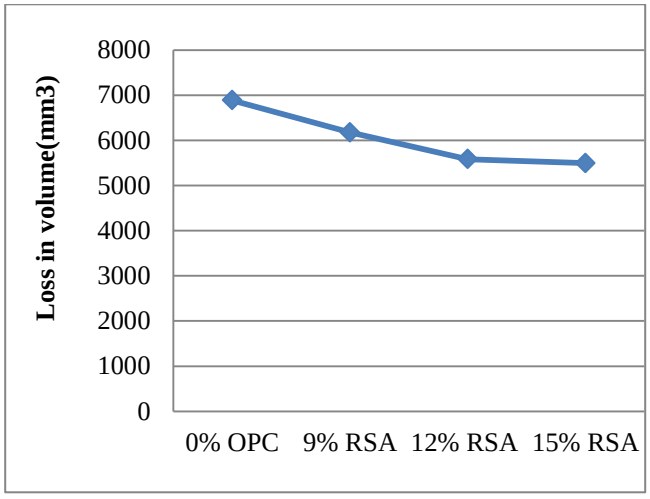

FIG 3.4.1: Variation of abrasion resistance of concrete containing Rice Straw Ash as replacement of cement

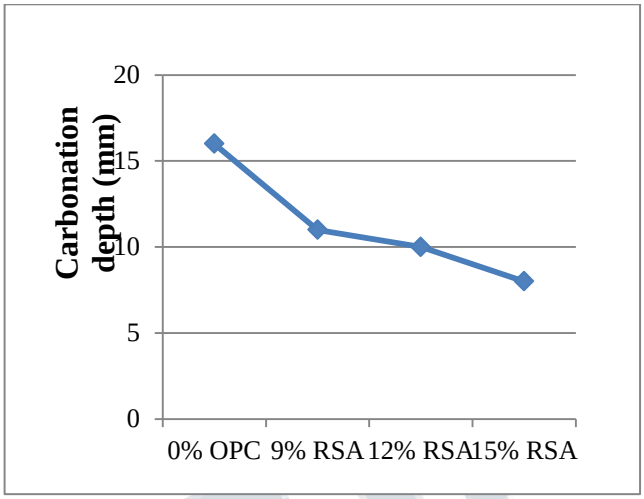

FIG 3.5.1: Variation of carbonation depth of concrete containing Rice Straw Ash as replacement of cement.

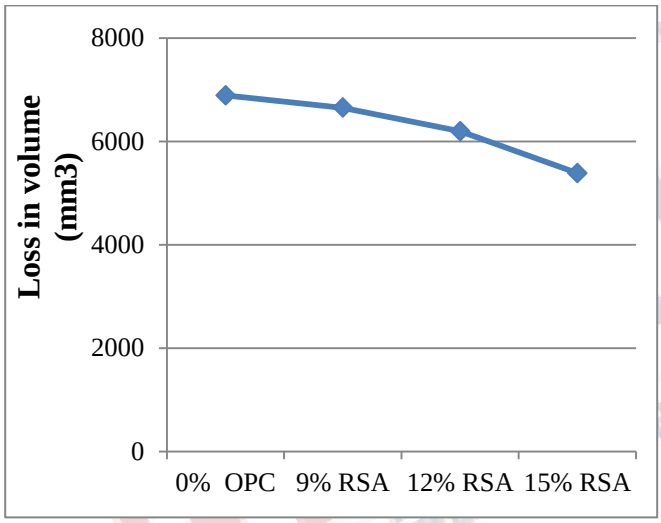

FIG 3.4.2: Variation of abrasion resistance of concrete containing Rice Straw Ash as replacement of fine aggregates

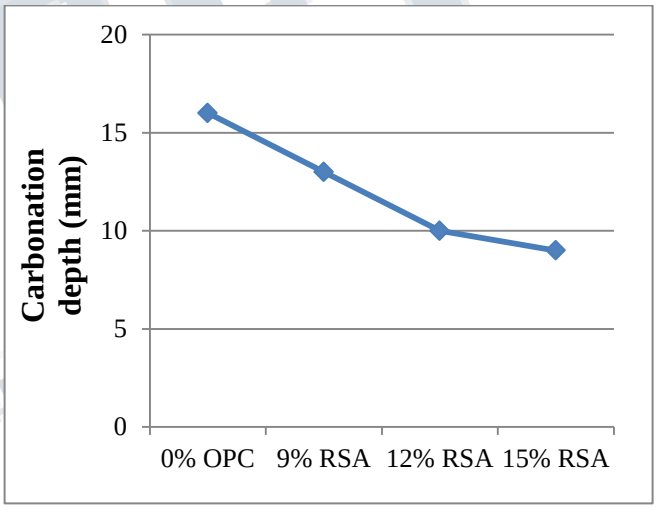

FIG 3.5.2: Variation of carbonation depth of concrete containing Rice Straw Ash as replacement of fine aggregates

FIG 3.4.3: a) Specimen without abrasion test
b) Specimen after abrasion test

Fig 3.5.3: Sample After Carbonation Test

IV. CONCLUSION

1) Concrete's workability shows inverse relationship with the inclusion of Rice Straw Ash . Control concrete has higher value of slump than the other mixes admixed with Rice Straw Ash as an alternative of fine aggregates and cement. .

2) "Compressive strength" of mix admixed with Rice Straw Ash as an alternative of cement and sand was higher than that of control concrete .This means that compressive strength of concrete shows positive results with the addition of Rice Straw Ash

3) "Flexural strength" of concrete admixed with Rice Straw Ash shows great variation. The flexural strength of concrete containing Rice Straw Ash as an alternative of sand and cement first increases to optimum value and then shows decline in it . At 12% cement and fine aggregate replacement level flexural strength was maximum .

4) "Abrasion resistance" of concrete admixed with Rice Straw Ash in some proportion as an alternative of sand and cement was more than that of normal specimen .

5) The carbonation depth of control concrete was higher than concrete admixed with " Rice Straw Ash" as partial replacement of cement and sand at a replacement level 9% 12% and 15%.

6) Finally it was concluded that concrete containing Rice Straw Ash as a partial replacement of cement gives more pronounced results as compared to concrete containing Rice Straw Ash as a partial replacement of fine aggregates.

V. ACKNOWLEDGEMENT

I express my sincere thanks to Department of Civil Engineering ,Guru Nanak Dev Engineering College , Ludhiana for the encouragement and guidance .

REFERENCES

[1] Abdelbary , A . and Mohamed , A,. (2018). Investigating Abrasion Resistance of Interlocking Blocks incorporating Steel slag aggregates , ACI Materials Journal , 115(1).

[2] Dabai , M., Muhammad , C., Bagudo , B. and Musa , A.,(2010) . Study on the effect of rice husk ash as cement admixture . Nigerian Journal Of basic and applied science, 17(2). https://doi.org/10.4314/njbas.V17i2.49917.

[3] EI –Sayed , M. and EI-Samni , T., (2006) . Physical and chemical properties of Rice Straw Ash and its effect on the cement paste produced from different cement types . Journal of King Saud University – Engineering Science , 19(11) , pp.21-29

[4] EI- Sayed , T.A., ERFAN, A.M.and Naby,E.L.(2017) .Influence of rice ,wheat straw ash and rice husk ash on properties of concrete mixes. JOKULL journal

[5] EI-Sayed , T.A., Erfan , A. and EI-Naby ,R., (2019) . Recycled rice and wheat straw ash as a replacement of cement. Journal of Engineering Research and Reports , 1-9. https://doi.org//10.9734/jlrr/2019/V5i2/692/.

[6] Garas , G., Bakhoum, E. and Allan , M ., (2015). Rice Straw –cementitious bricks analytical study on mechanical properties and sustainability measures .Journal of Engineering and applied sciences , 1-11.

[7] Kumar , A. and Velayutham , N., (2019). Experimental research on rice husk ash as a replacement to cement in construction industry . International Journal of research technology and engineering , 8(2S8), 1197-1200. https://doi.org/10.35940/ijrte.b1.37.0882s819

[8] Mahmuda , A., Tijaronge , M. and Amiruddin , A .,(2020). The potential utilization of rice straw ash as cement replacement in mortar material ,IOP Confrence Series ; Earth and Environmental Science , 419 , p.012037.

[9] Miller , S., Cunningham , P. and Harvey , J., (2019) . Rice Based Ash In concrete : A Review Of Past Work And Potential Environment Sustainability . Resource conservation and Recycling , 146, pp416-430. https://doi.org/10.1016/j.resconrec.2019.03.041.

[10] Munshi , S., Dey ,G. and Prasad Sharma , R.(2013) .Use of Rice Straw Ash as a pozzolanic material in cement mortar . International Journal of Engineering And Technology , 603-606. https://doiorg/10.7763/ijet.2013.

[11] Munshi , S. and Sharma , R.,(2016) . Experimental investigation on strength and water permeability of mortar incorporate with Rice Straw Ash. Advances in material science and technology , pp.1-7.

[12] Munshi,S. and Sharma , R ., (2018). Investigation on the pozzolanic properties of rice straw ash prepared at different temperatures . Material Express ,8(2) , pp.157-164.

[13] Munshi , S. and Sharma , R.,(2019) . Utilization of rice straw ash as a mineral admixture in construction work. Materials today: proceeding ,11,pp,637-644.

[14] Naveed , S, and Sharma , T., (2020) . Utilization of rice straw ash in mortar mixes . International Research Journal of Engineering and Technology ,7,1156-1160.

[15] Pandey , A. and Kumar , B.,(2016). Analysis of rice straw ash for partial replacement of opc in pavement

quality concrete . International Journal of advances in mechanical and civil engineering , 3,1-4 .

[16] Pandey , A . and Kumar , B ., (2020) , Investigation on the effects of acidic environment and accelerated carbonation concrete admixed with rice straw ash and microsilica , Journal of building Engineering ,29, p. 101125.

[17] Rosello , J., L., Santamarina , M., Akasaki , J . , Monzo , J , and Paya, J., (2017) , Rice Straw ash : A potential pozzolanic supplementary material for cementing systems , Industrial Crops and products , 103 , pp.39-50.

[18] BIS 456 ; 2016 , Plain and Reinforced Concrete , Bureau of Indian Standards , New Delhi.

[19] BIS 10262 : 2019 , Concrete mix proportioning – Guidelines , Bureau of Indian Standards , New Delhi.

[20] BIS 2386 (Part 1) : 1988 , Method of test for aggregates : Part 1; Particle size and shape , Bureau of Indian Standards , New Delhi .

[21] BIS 2386 (Part 3) : 1963 , Method of test for aggregates of concrete – Specific Gravity, Density , Voids, Absorption and Bulking , Bureau of Indian Standards , New Delhi.

[22] BIS 383; 1970 , Specifications for coarse and fine aggregates for natural source , Bureau of Indian Standards , New Delhi.

[23] BIS 4031 (Part 1); 1966 , Methods of physical tests for hydraulic cement : Part 1 ; Determination of fineness by dry sieving , Bureau of Indian Standards , New Delhi.

[24] BIS 4031 (Part 4); 1988 , Methods of physical tests for hydraulic cement : Part 4 ; Determination of consistency of standard cement paste , Bureau of Indian Standards , New Delhi.