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Experimental Work on Effect of Wood Waste Material (Wood Ash) on the Porosity,Thermal Cycling and Workability in Mortar

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ABSTRACT

The production of cement needs a massive amount of raw material, and at the same time releases carbon dioxide into the atmosphere. Researchers showed that for every 600 kg of cement, approximately 400 kg of CO_2 is released into the atmosphere. The increasing demand of cement, as the population is increasing day by day, environmental pollution is also increasing and exploitation of natural resources for raw material is also increasing.. Researchers have conducted tests which showed effective results that wood ash can be suitably used to replace cement partially in concrete production. Hence, usage of wood ash as replacement for cement is beneficial for the environmental point of view as well as producing low cost construction entity thus leading to a sustainable relationship. In the present study porosity test, workability test and thermal cycling are performed. The results shows porosity of mortar decreases with increase in percentage of wood ash. The reason behind this is that the particles of wood waste ash are smaller than particles of cement which also acts like a filler material in hardened state and also shows, As we increase the temperature upto 150⁰C, dehydration of C-S-H gel is started which results in the decrease of strength properties of mortar as well as concrete. During hydration process, C_3S and C_2S react with water to form calcium silicate hydrate (C-S-H) gel. C-S-H gel is important for good binding properties in mortar/concrete. If silica content is more, more is the formation of C-S-H gel and more is the strength

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KEYWORDS: Wood waste ash, Water Absorption Coefficient of Cement Mortar ;UTM Machine; mortar with wood waste ash.

1. INTRODUCTION

Wood ash produced from the combustion of wood waste biomass is widely used as raw material for cement production and also as filling material in the construction of road base in place of soil. Due to lack of space availability and strict environmental rule and regulations issued by environmental bodies, land filling of wood ash is becoming restrictive[1,11]. Moreover, the use of wood ash as soil supplementary material is becoming limited due to significant heavy metal content in wood ash which may cause serious ground water pollution with uncontrolled applications on agricultural land[19,22]. As wood ash primarily consists of fine particle matter which can easily dissolve in environment by winds, it is dangerous/hazardous as it may cause respiratory health problems to the workers, householders near the dump/ working site or can cause groundwater contamination by leaching toxic elements in the water. There are restrictions on land filling of wood ash and the use of wood ash as a soil supplementary material. In this regard, many attempts and research has been carried out to reuse of wood ash especially as a constituent in construction material to dispose the ashmaterial[17,23].

Vishwakarma V. et al. (2015) studied the porosity results of concrete made by OPC with replacement of rice husk ash (RHA) and fly ash (FA) and some admixture (1.2% by weight of cement). They made cylinders of size 50mm*100mm and two types of mix, one with fly ash and the other with rice husk ash. The ratio of OPC/FA was 4:1 and the ratio of OPC/SF was 3.91:1. They observed that the porosity of RHAC was less than FAC as shown in fig.1due to the presence of nanosilica which enhance the formation of more hydration products which fills the voids of concrete and hence decrease the porosity.

Fig. 1:Variation in Porosity of FAC and RHAC

Smililarly,**Naik et al. (2002)** studied the behavior of compressive strength of concrete containing wood waste ash as partial replacement for curing age upto 365 days. Wood ash replacement levels were 5%, 8% and 12%. From the compressive strength results, it is concluded that

1) control mixture (only OPC as binder) gained a strength level of 34 MPa at curing of 28 days and 44 MPa at curing of 365days.

2) concrete containing wood ash as replacing material gained a strength level of range from 33MPa at 28 days and 42 to 46 MPa at 365 days ofcuring.

3)the replacement of wood ash upto 12% had a significant contribution to strength development of concrete mix produced. There was continuous gain in strength of wood ash concrete mix upon long time curing durations. This was an indication of pozzolanic reaction between cement and wood wasteash.

However, **Rajamma et al. (2009)** showed the effect on compressive strength of cement mortar mixes when cement is replaced by wood ash at different replacement levels (0%, 10%, 20%, 30%). It was observed that when we increase the replacement level of wood waste ash, compressive strength of mortar decrease at 28 days in comparison to neat mortar (control mixture).

In the present study, The report presents an overview of the work carried out with cement mortar in which cement is partially replaced by wood waste ash on several aspects such as the physical, chemical, strength and durability properties of mortar with wood waste ash. This report shows the effect of wood ash on the workability, porosity, water absorption, compressive strength, flexural strength, thermal cycling, salt crystallization and rapid chloride permeability test etc.

2. EXPERIMENTAL SETUP

1. THERMAL CYCLING:

This test is performed to analyze the impact of heat/sunlight on mortar. By this test, we analyze the performance of mortar when exposed to weathering induced by wet, followed by dry cycle brought by environmental exposure. This test is also done to check the performance of mortar when exposed to fire.

A mortar must withstand disintegration by thermal expansion. Therefore, it is necessary to conduct durability testing that will give an indication of mortar resilience under thermal cyclingmechanism.

Preparation: To perform this test, we made cubes of size **50mm*50mm*50mm** as per **RILEM 1980,** three of each replacement percentage (0, 5, 7.5, 10%). As shown in fig.2 shows the mould of 50mmcube.

Fig 2:Moulds of Cubes of Size 50mm*50mm*50mm

Take material in already given proportion (the cement and sand ratio is 1:3 and water/cement ratio is 0.50) and mixed it by hand or by epicyclicmixture.

Fig. 3:Cubes Casted for Thermal Cycling Test

Prepare three specimens for each replacement percentage for testing at an age of 28 days. As shown in Fig.3 shows the casted cubes of 50mm size for thermal cycling.

Testing:

After curing of 28 days, we immersed mortar specimens into water at a constant temperature 20±0.5^{0}C for a period of 16 hours. The specimens were removed from water and placed in a pre-heated oven at a temperature of **105^{0}C** to dry for 6 hours as shown in figure.

After drying in oven, samples are allowed to cool at room temperature for 2 hours. Fig.4 shows the cubes placed in oven and cubes in polybag to protect cubes from moisture when cooling at room temperature

(a) (b)

Fig.4:(a) Hot Air Oven and (b) Cubes Protected from Humid Atmosphere

When samples are allowed to cool at room temperature, samples were protected from atmosphere so that humidity cannot alter the weight of samples. When samples cooled down, their individual weight was measured accurately with an accuracy of ±0.5 grams. After each cycle, condition of the samples was recorded and results were taken in the form of weight loss (expressed as a percentage of initial dry weight of sample).The samples were subjected to **20 such cycles**.

Repeat the same procedure after every cycle and record the weight loss of the sample. Table shows the chemical composition of mortar containing 10% WWA after 20 cycles of thermal cycling process, obtained from SEM (scanning electron microscopy)[2,5,9].Table 1 shows the chemical composition of mortar obtained from SEM (scanning electron microscope) at 10% replacement of wood waste ash after 20 cycles of thermal cycling. Fig. 5 shows the energy dispersive X-Ray analysis of cement mortar containing wood
ash at 10% replacement level treated by thermal
ash at 10% replacement level treated by thermal
cycling.

Table 1:Chemical Composition of Mortar containing 10% WWA Treated with Thermal Cycling

S. No.	Composition	Percentage by weight
1.	CaO	29.18
2.	SiO_2	8.64
3.	Al_2O_3	2.61
4.	Fe_2O_3	1.40
5.	Oxides	50.86
6.	Na_2O	3.20
7.	K_2O (feldspar)	0.46
8.	CaCO3	3.48
9.	Total	100

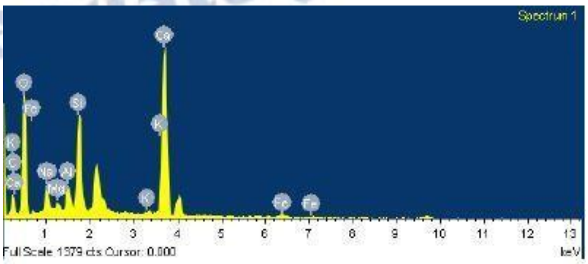

Fig. 5: EDX Analysis of Mortar containing 10% WWA Treated by Thermal Cycling

Now, 6 shows the images of scanning electron microscope analysis of mortar containing 10% WWA which is thermally treated.

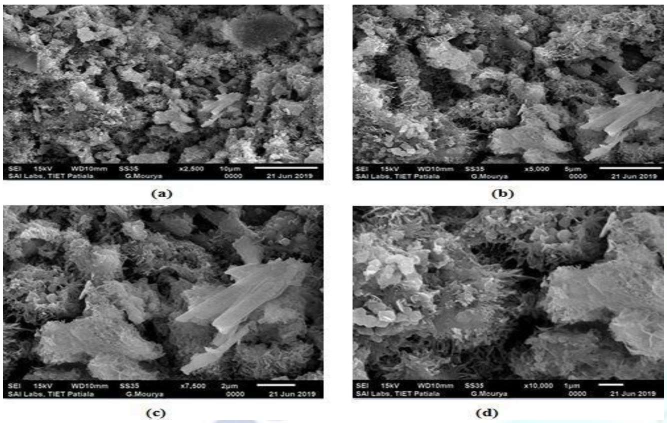

Fig. 6:SEM Images of Thermally Treated Mortar containing 10% WWA (a) 2500 times enlarged, (b) 5000 times enlarged, (c) 7500 times enlarged, (d) 10000 times Enlarged

2. POROSITY:

It may be defined as the ratio of volume of voids present in any mortar specimen to the total volume of that specimen expressed as a percentage. In other words, it is a ratio of accessible void volume to water, to the specimen's bulk volume.It is afundamental property of stone/concrete/mortar which influence the properties of durablity. Pores present in hardenedmortar are shown in Fig.7.

Fig.7:Voids Present in Mortar Sample

Preparation:

To carry out the porosity test, we have to make prisms of size **40mm*40mm*160mm** as per **RILEM 1980** three for each substitute (replacement) percentage (0, 5, 7.5, 10%). Take material in already given amount as the cement and sand ratio is 1:3 and water/cement ratio is 0.50 and mix it by hand or by epicyclic combination. Prepare three specimens for each substitute percentage for testing at an age of 28days.

Testing:

The prisms were dried at a heating temperature of 60 ± 5^0C till constant mass is obtained. The constant mass is achieved when the difference between two consecutive weighing is very very minor. Drying was done at a low temperature rather than higher temperature so that organic matter in mortar, if present, should not be spoil and so that structural water should not be demolish.

After evaporating to constant mass (M1), samples were put set into evacuation vessel for 24 hours so as to remove the air present in voids of the sample. Fig.8 shows evacuation vessel or called as vacuum desiccator.

Now, samples were kept into water for further 24 hours at atmospheric pressure. Then, these samples are weighed separately in water (M2). This is called hydrostatic weighing as shown in fig. 8. Now, extract the samples out of water and rubbed with a cotton cloth to wipe additional water drops and saturated weight was taken of samples (M3)[22].

Fig.8: Evacuation Vessel

Fig.9: Hydrostatic Weighing

3. CALCULATIONS

Porosity, accessible to water, is expressed as a percentage and is calculated by the following formula[17,15]:

Porosity (%) = ((M3-M1)/(M3-M2))*100

where,

M1 = constant mass of sample, in grams

M2 = hydrostatic weighing (weighing in water), in grams

M3 = weight of saturated sample in grams

4. RESULTS AND DISCUSSION

This chapter contains the outcomes of our experimental work. In this section, we study the findings, outcome and results of researchers on physical properties of mortar/concrete such as workability (slump), porosity test, Thermal cycling test.

1. THERMAL CYCLINGTEST

All data for thermal cycling as shown in table 2, Results are taken in the form of weight loss after every cycle expressed as a percentage of initial dry weight of specimens and results are also taken in the form of residual compressive strength of specimen as compared to those specimens which are not exposed to thermal cycling.

Table shows the residual compressive stress in samples which are exposed to thermal cycling[6,10]. Comparison in compressive strength values before and after thermal cycling is shown in fig. 10.

Table 2: Residual Compressive Strength in Samples exposed to Thermal Cycling

WWA Content, %	Residual Compressive Strength (N/mm²)		Reduction (in comparison to normal sample)
	Normal Samples	Exposed to Thermal Cycling	
0%	19.9	18.80	5.53%
5%	18.1	17.34	4.19%
7.5%	17.56	17.29	1.54%
10%	16	15.78	1.38%

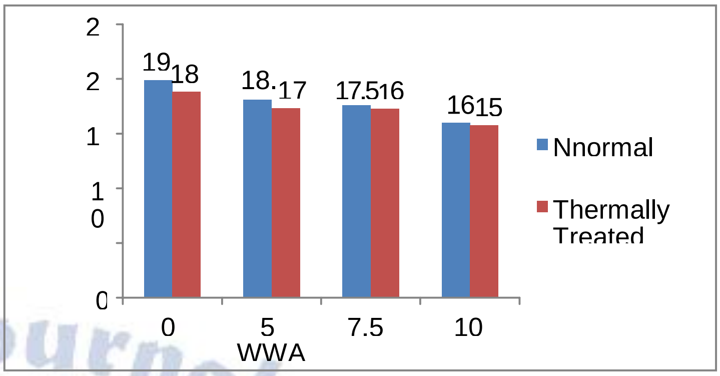

Fig. 10 : Compressive Strength values before and after Thermal Cycling

Loss in weight of samples (expressed as a percentage with respect to initial dry weight) after 20 thermal cycles is shown in table 3.

Table 3: Reduction in Weight after Thermal Cycles

WWA Content %	Dry Weight (in gm)		Percentage Reduction in Weight
	Initial	After 20 Cycles	
0%	290.67	281.33	3.21%
5%	294.67	287	2.603%
7.5%	298	292.67	1.8%
10%	304.33	299.67	1.53%

As we increase the temperature upto 150⁰C, dehydration of C-S-H gel is started which results in the decrease of strength properties of mortar as well as concrete. During hydration process, C_3S and C_2S react with water to form calcium silicate hydrate (C-S-H) gel. C-S-H gel is important for good binding properties in mortar/concrete[12,19].

If silica content is more, more is the formation of C-S-H gel and more is the strength. But, in case of wood ash, silica is present in negligible amount which reduce the formation of C-S-H gel. And as we increase the temperature, water present in the pores of mortar starts evaporating, cause shrinkage cracks in samples.

After every cycle, we allow to cool down the samples at room temperature, due to sudden change in temperature, expansion cracks occur in the samples[16].

Due to these alternating cycles, scaling of specimen occurs which cause loss in weight.

2.POROSITYTEST

Table 4: Porosity at Different WWA Content

Table 4 shows, The difference in porosity on changing the content of wood ash in mortar. It is understandable from the table given above that, if we increase the level of replacement of wood ash then porosity decreases correspondingly[11].

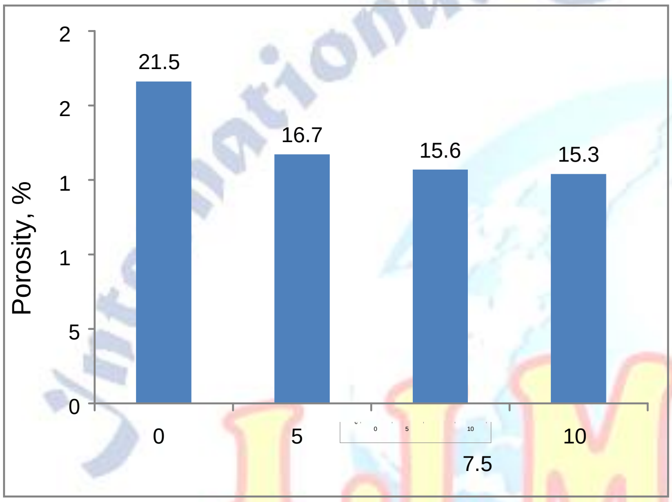

Fig. 11: Variation in Porosity with Variation in WWA Content

As we can conclude from fig. 11 and examined results, porosity of mortar reduces with increase in percentage of wood ash. The justification at the back of this is that the particles of wood waste ash are smaller than particles of cement which also behave the same as a filler stuff in accustomed state. As these particles are smaller than cement particles, they fill up the void space between cement as well as particles. As we increase the percentage of wood ash, we obtain compressed matrix, hence deduction in porosity[4,5].

3. WORKABILITY

To acquire workability, we make a note of spread base diameter of mortar and more the spread mortar increased is the workability. As the percentage of wood ash in mortar is increased, hence the workability is reduced because particles of wood ash are finer than cement particles[7,8]. Therefore, specific surface area of wood ash particles is more than cement particles as wood ash suck up more water than cement. To acquire desired workability for wood ash mortar, we have to add more water in comparison to cement mortar.

5. CONCLUSIONS:-

On the basis of results and discussion following conclusions are drawn:

1. Workability decreases with increase in replacement percentage of woodash.
2. Porosity also decreases with increase in replacement percentage of wood ash. Porosity at 0% replacement level is 21.6% and at 10% replacement level is 17.28%. There is a reduction of 4.32% in porosity at 10% replacement as compared to 0%replacement.[1,2]
3. Bulk density increases from 1993.73 kg/m^3 at 0% wood ash to 2019.23 kg/m^3 at 10% wood ash level. This increase is due to decrease inporosity.
4. As porosity decreases, water absorption capacity also decreases because they are directly related to each other. Water absorption coefficient at 0% wood ash is 0.196 $kg/(m^{2}*min^{0.5})$, at 5% wood ash is 0.164 $kg/(m^{2}*min^{0.5})$, at 7.5% wood ash is 0.148 $kg/(m^{2}*min^{0.5})$ and at 10% wood ash is 0.140$kg/(m^{2}*min^{0.5})$.[11]
5. As we increase the temperature upto $150^{0}C$, dehydration of C-S-H gel is started which results in the decrease of strength properties of mortar as well as concrete. During hydration process, C_3S and C_2S react with water to form calcium silicate hydrate (C-S-H) gel. C-S-H gel is important for good binding properties in mortar/concrete.
6. If silica content is more, more is the formation of C-S-H gel and more is the strength. But, in case of wood ash, silica is present in negligible amount which reduce the formation of C-S-H gel

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] Abdullahi M. Characteristics of wood ash/OPC concrete. Leonardo Electronic Journal of Practices and Technologies2006;8:9–16.

[2] Mobili, A. Belli, C. Giosuè, T. Bellezze, F. Tittarelli, Metakaolin and fly ash alkali- activated mortars compared with cementitious mortars at the same strength class, Cem. Concr. Res. 88(2016).

[3] Ellinwa AU, Ejeh SP, Akapabio IO. Using metakaolin to improve sawdust ash concrete.ConcrInt 2005.
[4] Ellinwa AU, Ejeh SP. Effects of incorporation of saw dust incineration fly ash in cement pastes and mortars. J Asian Architect Build Eng2004;3(1):1–7.
[5] Ellinwa AU, Mahmood YA. Ash from timber waste as cement replacement. Cement Concr Compos2002;24:219–22.
[6] Greene TW. Wood ash disposal and recycling source book. Prepared for the coalition of Northeast Governors by OMNI environmental sources. Beaverton, Oregon;1988.
[7] Horaskulthai V, Phiuvanna S, Kaenbud W. Investigation on the corrosion resistance of bagasse rice husk wood ash blended cement concrete by impressed voltage. Construct Build Mater2011;25(1):54–60.
[8] Indian Standard Ordinary Portland Cement, 43 grade – Specification, Bureau of Indian Standards, ManakBhawan, 9 Bahadur Shah Zafarmarg, NewDelhi.
[9] Naik TR, Kraus RN, Siddique R. CLSM containing mixtures of coal ash and a new pozzolanic material. ACI Materials Journal2003;100(3):208–15.
[10] Naik TR, Kraus RN, Siddique R. Demonstration of manufacturing technology for concrete and CLSM utilizing wood ash from Wisconsin. Report no. CBU-2002-30. Report for year 1 activities submitted to the Wisconsin Department of Natural Resources, Madison, WI, for Project # 01-06 UWM Center for By-Products Utilization, Department of Civil Engineering and Mechanics, University of Wisconsin-Milwaukee, Milwaukee; 2002.p.124.
[11] RajammaRejini, Ball Richard J, Tarelho Luis AC, Allen Geoff C, Labrincha Joao A, Ferreira Victor M. Characteristics and use of biomass fly ash in cement based materials. J HazardMater2009;172(2009):1049–60.
[12] SiddiqueRafat. Utilization of wood ash in concrete manufacturing.ResourConservRecycl 2012;67:27–33.
[13] Udoeyo FF, Dashibil PU. Sawdust ash as concrete material. J Mater CivEng 2002;14(2):173–6.
[14] Udoeyo FF, Inyang H, Young DT, Oparadu EE. Potential of wood waste ash as an additive in concrete. Journal of Materials in Civil Engineering2006;18(4):605–11.
[15] Vassilev SV, Baxter L, Anderson LK, Vassileva CG. An overview of the chemical composition of biomass. Fuel2010;89:913–33.
[16] Wang S, Miller A, Llamazos E, Fonseca F, Baxter L. Biomass fly ash in concrete: mixture proportioning and mechanical properties. Fuel2008;87:365–71.
[17] W. Yao, H. Liu, Y. Xu, K. Xia, J. Zhu, Thermal degradation of dynamic compressive strength for two mortars, Constr. Build. Mater.136 (2017) 139–152.
[18] Ajit, I.A khan,M Z Khan, et.al , The effect of low Reynolds number on coefficient of S-type pitot tube with the variation in port to port distance, Materials today proceedings 45P9(2021) pp.7810--7815. [13] Ajit, Iqbal Ahmed Khan(2020).
[19] Experimental work on the low Reynolds number behaviour of 2-hole offset probes.International Journal of Engineering and Advanced Technology(IJEAT).449-454
[20] Ajit , I A Khan(2022) The Experimental analysis on effect of low Reynolds number on probe coefficient having different-2 intertube spacing of S-type probe. ", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 4, page no.a604-a610, April-2022
[21] Ajit, M.z Khan, et.al ,The impact of low Reynolds number on coefficient of probe at different-different angle of S-type pitottube,Materials today proceedings 46P15(2021) pp.6867-6870.
[22] Rahul Gupta , Ajit Singh '' To Study and Analysis on Performance of Regenerative Breaking System'' International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.10, Issue 3, page no.d518-d523, MarchS-2023.
[23] Ajit Singh, Rahul Gupta et.al. "Investigation the Effect on Coefficient of filled and unfilled port to port dimension with plaster of paris of 2-Holes offset probe"International Journal for Research in Applied Science and Engineering Technology(IJRASET),ISSN:2321-9653,Volume 11,Issue 3,March 2023,page no.-2144-2151.