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Investigation and Optimization on Use of Wood Ash as partial Cement Replacement in Cement Mortar

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Abstract: Management of solid waste is the major concern globally due to increasing quantities of waste materials and by-products from industries. Lack of space availability for land filling and because of its increasing cost, utilization and recycling of industrial by- products and waste materials has the only option as it is economical and eco friendly. There are several types of such materials, which can be recycled or reused in construction. The utilization of such materials in construction not only makes it economical, but also helps in reducing disposal problems. One such material is wood ash (WA). Wood ash (WA) is the residue generated due to combustion or incineration of wood and wood products (chips, saw dust, bark, etc.).The XRD (X-RAY DIFFRACTION) test results, SEM (scanning electron microscope) analysis and chemical analysis of WA showed that it contains amorphous silica and thus can be used as cement replacing material.

Many researches had been carried out to incorporate wood waste ash as a cement replacement material in the production of greener construction material (concrete/mortar) and also as a sustainable means of disposal for wood waste ash. Results of these researches indicated that wood waste ash can be effectively used as a cement replacement material for the production of structural concrete/mortar of acceptable strength and durability parameters.

This 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.vi |

Keywords: wood waste ash, , SEM (scanning electron microscope); XRD (X-RAY DIFFRACTION); mortar with wood waste ash

I. INTRODUCTION

The Accumulation of industrial/domestic waste, mainly in developing countries, has resulted in a great environmental concern. In the last few years, growing awareness about global environment and increasing energy security has led to increasing demand for renewable energy resources and to explore some new methods of energy production. Since, due to increase in population, demand of building materials is also increasing that causes a shortage of building material, the civil engineers/researchers have to convert industrial and domestic wastes to useful building material substitute. Ash by-products obtained from combustion of wood biomass are generally used in land filling for embankments, road/highway construction. It can be used as soil supplementing material to reduce the alkalinity of soil in agricultural lands. And it can also be used as raw material in the manufacturing of cement in cement industries. As par current situation, approximately 70% of wood ash produced is managed by land filling, 20% of total wood ash produced is used as a soil supplement material for agricultural activity and the remaining 10% is implemented for other/miscellaneous applications as metal recovery and pollution control.

Siddique R. (2012) gave a data that, on an average, 6 to 10% (by weight of wood) ash is produced by the burning of wood and its composition may differ according to wood type, geographical location and industrial process. While Godwin (2013) proved that rice husk ash can be used to make structural concrete by replacing cement by rise husk ash at suitable replacement levels. Smililarly, Greene (1998) observed that 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.

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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. 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 ash material.


(a) (b)

Fig 1: Wood Waste Ash Obtained from Open Burning.

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.

II. EXPERIMENTAL SETUP

To perform this test, we made prisms of size 40mm*40mm*160mm as per BS EN 1015:1999 Part-11 three for each replacement percentage (0, 5, 7.5, 10%). Mould of prisms is shown in fig 2. 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 epicyclic mixture. Prepare three specimens for each replacement percentage for testing at an age of 7 days and at 28 days.

Fig 2.Moulds for Prisms of Size 40mm*40mm*160mm.

A. Testing

After curing of 28 days, samples were put into pre-heated oven at a temperature of **105⁰C** to dry for a period of 16 hours and after this, these samples were allowed to cool at room temperature for 5 hours. Temperature should not be greater than **105⁰C** because high temperature destroy the structural water.

the cubes placed in oven and cubes in polybag to protect cubes from moisture when cooling at room temperature. 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 before soaking samples into salt solution.

Now, the samples were immersed in 14% solution of sodium sulphate decahydrate (Na2SO4.10H2O) for a period of 4 hours as shown in fig 3

Fig 3:Immersion of Samples in 14% Solution of Sodium Sulphate Decahydrate

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.

B. Preparation of Solution

In actual, we had a container of 500 grams of sodium sulphate anhydrous (Na2SO4) instead of sodium sulphatedecahydrate as shown in figure 3.26. So, we had to convert sodium sulphate anhydrous into sodium sulphatedecahydrate.

As we know, 1000 grams of Na2SO4.10H2O is equivalent to 441 grams of Na2SO4. And 14% solution means 14% of Na2SO4.10H2O and 86% of water in that solution. So, after calculating, we required 6.965 kg of water and 500 grams of Na2SO4 to prepare a 14% solution of Na2SO4.10H2O. As shown in figure 4 the images of scanning electron microscope analysis of mortar containing 10% WWA which is treated by salt solution. the energy dispersive X-Ray analysis of cement mortar containing wood ash at 10% replacement level treated by salt solution.

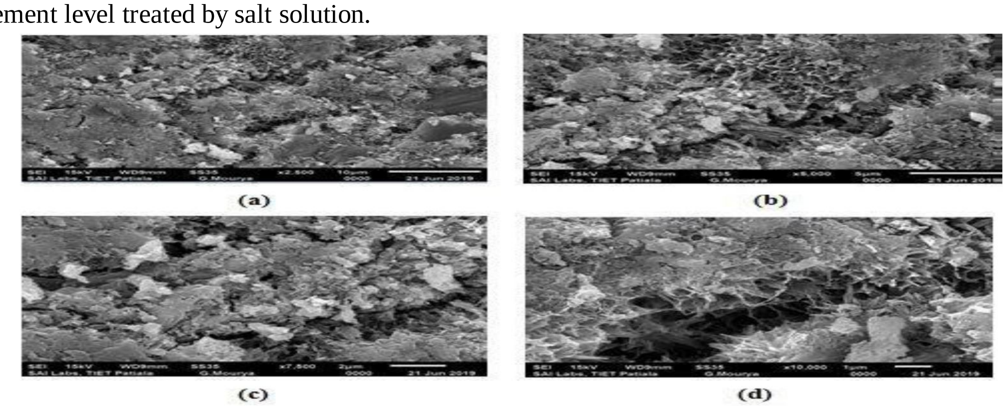

Fig 4 :SEM Images of Mortar containing 10% WWA Treated by Sodium Sulphate (a) 2500 times enlarged, (b) 5000 times enlarged, (c) 7500 times enlarged, (d) 10000 times enlarge

III. RESULT AND DISCUSSION

This chapter contains the outcomes of our experimental work. In this chapter, results of all the experiments are mentioned with their explanations and reasons behind the outcomes. This chapter gives the details of variation in results, graphical and tabulated representation of results.

A. Workability

Workability of mortar is directly related to flow table value or simply flow value. To get workability, we note down the spread base diameter of mortar and more the spread mortar more is the workability. As we increase the percentage of wood ash in mortar, workability decrease because particles of wood ash are finer than cement particles. Therefore, specific surface area of wood ash particles is more than cement particles due to which wood ash absorb more water than cement. To get desired workability for wood ash mortar, we have to add more water in comparison to cement mortar.

B. Porosity Test

Table 1 shows the variation in porosity on varying the content of wood ash in mortar. It is clear from the table that, on increasing replacement level of wood ash, porosity decreases accordingly. Table 1:Porosity at Different WWA Content

WWA Content	Dry Weight (gm),M1	Submerged Weight (gm), M2	Saturated Weight (gm), M3	Porosity (%)
0%	529.33	321.17	586.67	21.6%
5%	535	312.33	579.67	16.71%
7.5%	547	317.67	586.67	15.69%
10%	560	325.33	602.67	17.28%

Table 1 :- shows the percentage decrease in porosity with increase in wood ash content

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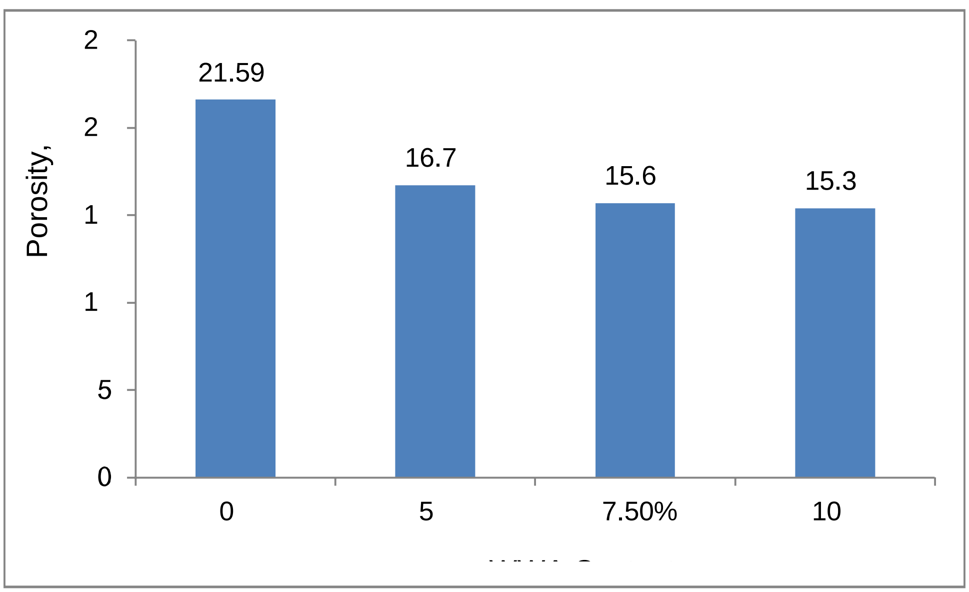

Fig 5:Variation in Porosity with Variation in WWA Content

As we can see from graph and tabulated results, 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. As these particles are smaller than cement particles, they fill the void space between cement and sand particles. As we increase the percentage of wood ash, we get compacted matrix, hence reduction in porosity.

C. Bulk Density Test

Bulk density is the weight of hardened mortar in one cubic meter of volume. Table 2 depicts the variation in bulk density on varying wood ash content in cement mortar. It is clear from table 2 that as we increase percentage of wood ash, bulk density increase. Fig 6 shows the trend that how bulk density is increasing on increasing in percentage of wood ash in cement mortar.

WWA Content	Dry Weight (gm),M1	Submerged Weight (gm), M2	Saturated Weight (gm), M3	Bulk Density (kg/m^3)
0%	529.33	321.17	586.67	1993.73
5%	535	312.33	579.67	2001.25
7.5%	547	317.67	586.67	2011.03
10%	560	325.33	602.67	2019.23

Table 2:Bulk Density at Different WWA Content

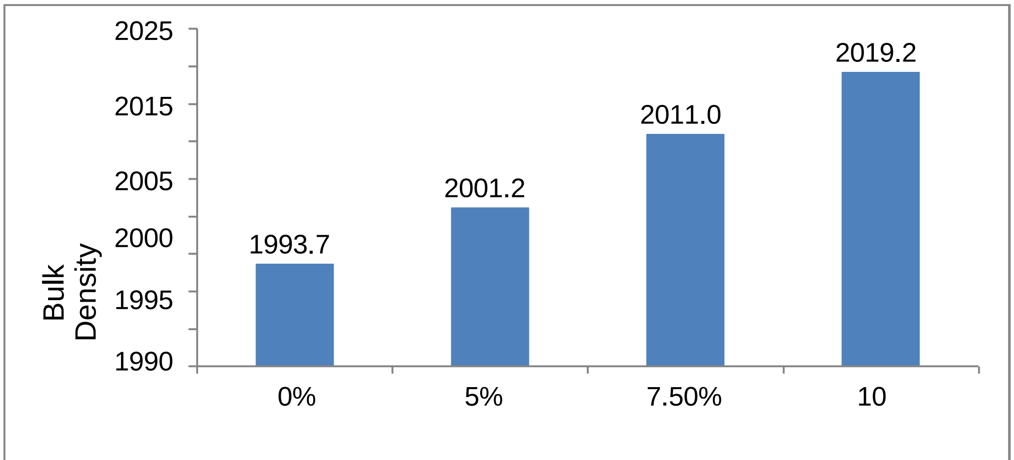

Fig 6:Variation in Bulk Density with Variation in WWA Content

Bulk density is inversely proportional to porosity. When porosity decreases, bulk density increases. As we can see from graph and tabulated results, bulk density of mortar increases with increase in percentage of wood ash. The reason behind this is that the particles of wood waste ash are finer than particles of cement which also acts like a filler material in hardened state. As these particles are smaller than cement particles, they fill the void space between cement and sand particles. As we increase the percentage of wood ash, we get compacted matrix of higher density. Variation in water absorption coefficient, when replacement level of wood ash in cement is increased, is shown in fig 7

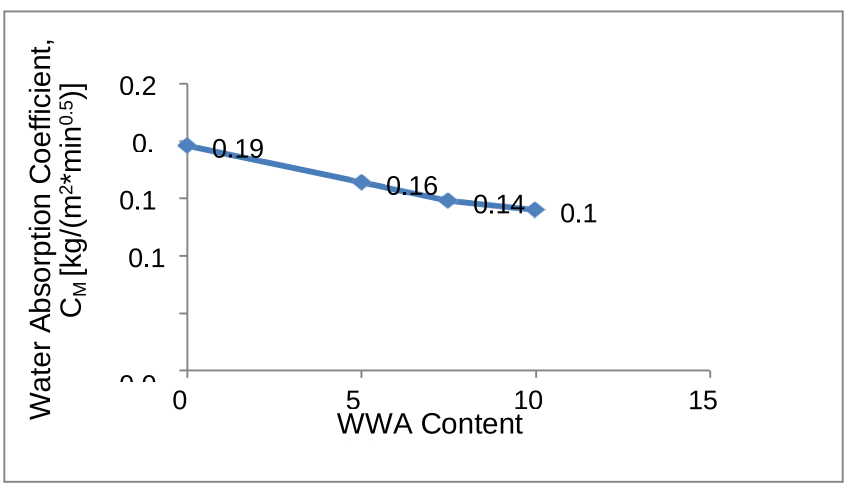

Fig 7:Variation in Water Absorption Coefficient with Different WWA% Levels

Water absorption capacity is inversely proportional to porosity and directly proportional to bulk density. Water absorption capacity of mortar decreases with increase in percentage of wood ash. The reason behind this is that the particles of wood waste ash are finer than particles of cement which also acts like a filler material in hardened state. As these particles are smaller than cement particles, they fill the void space between cement and sand particles. As we increase the percentage of wood ash, we get compacted matrix which reduce water absorption capacity of hardenedmortar

D. Flexural Test

Flexural strength of mortar with different replacements of wood ash at 7 days and at 28 days are shown in table 3.

WWA Content (%)	7 days strength (N/mm^2)	28 days strength (N/mm^2)
0%	6.6	7.097
5%	6.26	6.61
7.5%	6.07	6.2
10%	5.09	5.82

Difference in values of flexural strength at 7 days and 28 days of testing with different wood ash content in mortar is shown in fig 8.

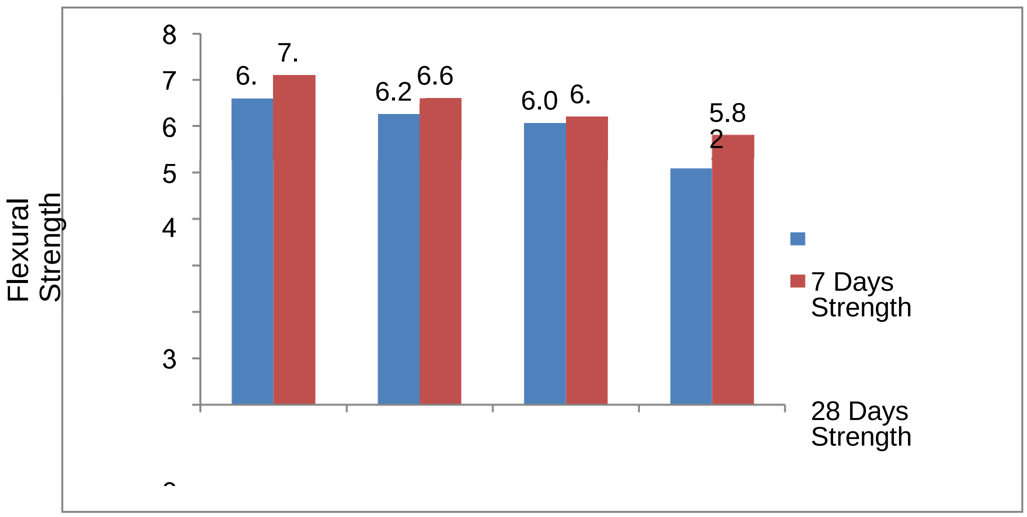

Fig 8:Variation in Flexural Strength with Variation in WWA at 7 and 28 Days

Fig 9 shows the load versus deflection graph at different wood ash content. Load readings are taken from UTM and deflection readings are taken from dial gauge.

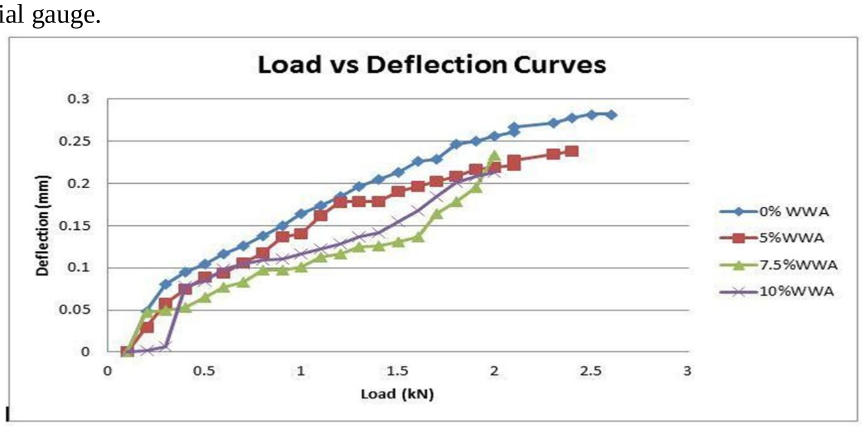

Fig 9:Load versus Deflection Curves with Different WWA Content

Main components of cement are C_3S, C_2S, C_3A and C_4AF. 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. But, in case of wood ash, silica is present in negligible amount which reduce the formation of C-S-H gel, hence reduction in flexuralstrength.

E. RCPT Test

Results of rapid chloride permeability test in the form of charge passed in coulombs after 6 hours is shown in table 4.

Cylindrical Slices	Charge Passed (coulombs)	Chloride Ion Penetrability
0% WWA	7297	High
5% WWA	7137	High
7.5% WWA	6886	High
10% WWA	6386	High

Table 4:Results of RCPT

As we can see from table 4 and that chloride ion permeability is high in all the cases but as we increase the percentage of wood ash, chloride ion permeability decreases. Fig 10 shows the trend line of decreasing chloride ion permeability on increasing percentage of wood ash in cement mortar.

As discussed earlier, on increasing replacement of cement by wood ash, porosity decreases because particles of wood ash are finer than particles of cement. And permeability is directly proportional to porosity. If porosity decreases, permeability decreases. So, passage of charge is also less.

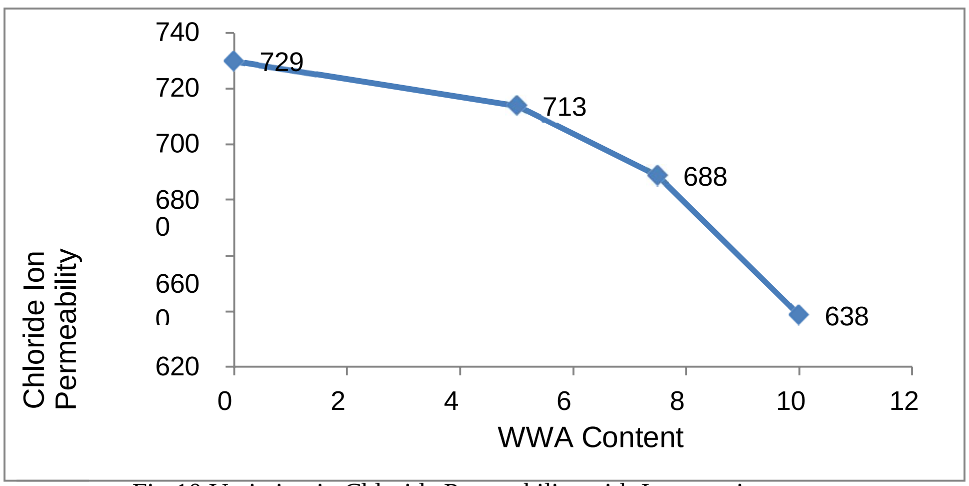

Fig 10:Variation in Chloride Permeability with Increase in wwa.

IV. CONCLUSIONS

In the research work, experiments are done to check the performance and behavior of wood waste ash in cement mortar by varying replacement percentages. This attempt is done to check that either we can partially replace the cement by wood waste ash or not so that we can make construction economical and ecofriendly because lot of carbon dioxide is released in atmosphere in production of cement. So, for this purpose, we performed some experiments such as workability test, compression and flexure test, RCPT, thermal cycling and salt crystallization etc. From the outcomes of these tests, we conclude that

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.
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 0.140kg/(m^2*$min^{0.5}$).
5) Compressive strength of 40mm cubes at 0% replacement of WWA is 24.07 N/mm^2 at 7days of curing and 28.13 N/mm^2 at 28 days of curing while at 10% replacement of WWA, the compressive strength is 17.28 N/mm^2 at 7 days of curing and 20.67 at 28 days of curing. It is clear from results that at replacement of 10%, compressive strength decreased by 26.52% in comparison to controlmortar.
6) Flexural strength results show that there is a significant decrease in flexural strength at upto 10% replacement level of wood ash. At 0% replacement of cement by WWA, the flexural strength is 7.1 N/mm^2 and at 10% replacement, strength is 5.82N/mm^2.
7) On treating with thermal cycling and salt attack, there is a decrease in weight of samples as well as well as decrease in compressive strength as compare to untreated samples.

REFERENCES

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