International Journal for Modern Trends in Science and Technology, 9(04): 368-373, 2023

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0904054
Available online at: http://www.ijmtst.com/vol9issue04.html

The Effect of Wood Ash on the Workability, Water Absorption, Compressive Strength in Cement Mortar

Sheetal Verma[1] | Ajit Singh[2] | Rahul Gupta[3] | Dr.Sanjay Sundriyal[4]

[1] Lecturer[2] Assistant Professor [3] Assistant Professor [4] Assistant Professor
[1]Department of Civil Engineering,Pt .L.R .College of Technology, Faridabad, Haryana , India
[2]Department of Mechanical Engineering,Pt .L.R .College of Technology, Faridabad, Haryana , India
[3]Department of Mechanical Engineering,Pt .L.R .College of Technology, Faridabad, Haryana , India
[4]Department of Mechanical Engineering,Lingaya's, University, Faridabad, Haryana , India
Corresponding author – ajit7551@gmail.com

To Cite this Article
Sheetal Verma, Ajit Singh, Rahul Gupta and Dr.Sanjay Sundriyal. The Effect of Wood Ash on the Workability, Water Absorption, Compressive Strength in Cement Mortar. International Journal for Modern Trends in Science and Technology 2023, 9(04), pp. 368-373. https://doi.org/10.46501/IJMTST0904054

Article Info
Received: 22 March 2023; Accepted: 20 April 2023; Published: 21 April 2023.

ABSTRACT

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.

In the present study water absorption, compressive test are performed in simulated environment of cement mortar, 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 and the result shows Compressive strength of 40mm cubes at 0% replacement of WWA is 24.07 N/mm² at 7days of curing and 28.13 N/mm² at 28 days of curing while at 10% replacement of WWA, the compressive strength is 17.28 N/mm² 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 control mortar and also 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.

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

1. INTRODUCTION

This chapter contains the introduction, wood ash origin, wood ash applications, factors that affect quantity and quality of wood ash and objectives of wood ash in cement industry[1]. This chapter also deals with the problems that arise from combustion of wood, from cement industries and how we can handle wood ash economically as well as environment friendly. In the current trends of energy production, power plants which run from biomass have low operational cost and have continuous supply of renewablefuel[2].

The thermal combustion/incineration reduces the mass and the volume of the waste up to a large extent, thus providing an environmentally safe and economically efficient way to manage the solid waste. Solid wood waste is commonly preferred as fuels over other light/herbaceous and agricultural waste as their combustion produces comparatively less fly ash and other residual material[5].

Origin of WoodAsh

The combustion/incineration of wood biomass produces wood ash as a by-product. A major problem arising from the usage of forest/agricultural waste product as fuel is related to the ash produced in significant amount after the combustion of such wastes[3]. It is commonly observed that the hardwood produce more ash than softwood and the bark and leaves generally produce more ash as compared to the inner part of thetrees.

Applications of Wood ash

Ash by-products obtained from combustion of wood biomass are generally used in land filling for embankments, road/highway construction[8]. 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[17].

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[10].

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.

Udoeyo et al. (2006) found the behavior of concrete containing wood ash at varying replacement percentages (0%, 5%, 10%, 15%, 20%, 25%, 30%). It was found out by experiments that concrete mix with WWA as a replacing material, decreases the workability of concrete[6,7]. This was due to that wood ash particles are smaller than that of cement particles due to which, wood ash particles has more specific surface area. Hence these particles absorb more water and ultimately, workability decreased.

Smililarly,**Elinwa and Mehmood (2002)** found that when the cement is partially by wood waste ash obtained from open combustion/incineration of saw dust ash had the adverse effect on workability of grade 20 concrete. At constant w/c ratio of 0.565, when the percentage of replacement of cement is increased from 5% to 30% by weight of cement, slump value of concrete is decreased by 5-40mm with respect to controlmix.

However, **Horsakulthai et al. (2011)** studied the effect of finely ground ash obtained from combustion of wood, rice husk ash, sugarcane bagasse waste (BRWA) as partial replacement of cement on chloride permeability of concrete. They used replacement percentages as 0%, 10%, 20%, 30% and 40% of total cement content by weight. It was concluded that incorporation of wood ash enhanced the chloride permeability.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.

(a) (b)

Fig 1:Wood Waste Ash Obtained from Open Burning.

2. Experimental Setup

1. **Water absorption Test**

To perform this test, we made prisms of size **40mm*40mm*160mm** as per **BS EN 1015:1999 Part-18,** three for each replacement percentage (0, 5, 7.5, 10%). Take material in already given proportion as 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 28 days.

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

Testing:

The prisms were dried at a temperature of $60\pm5^{0}C$ till constant mass is attained. The constant mass is reached when the difference between two consecutive weighing is very very negligible. Drying was done at lower temperature instead of higher temperature so that organic matter in mortar, if present, should not be decomposed and so that structural water should not be destroyed.

After drying to constant mass, samples are coated with wax/epoxy on all four faces lengthwise as shown in fig 3.10 so that epavoration from sides does not take place.

Fig 3:Prisms with Epoxy Coating

Now, cut these samples into two halves (i.e., 80mm) and place the samples into tray as shown in fig 3.11 with cutting edge downwards in water. Put water upto 5 to 10mm depth into the tray to allow capillarity in samples.

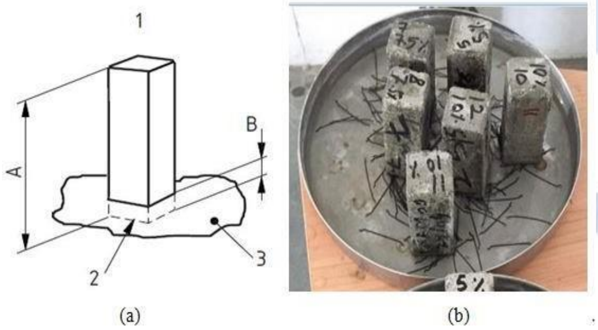

Fig 4: Immersion of Samples into Water Tray

Remove the samples after 10 minutes to get readings. Weigh individually the specimen and note down as M1. Now, take the readings after 90 minutes and note.

2. COMPRESSIVESTRENGTH:

Compressive strength is defined as the resistance of mortar breaking under compressive load. It is the capacity of mortar to withstand under compressive load which break the specimen or fracture occurs in specimen. Here, compressive load is applied by Universal Testing Machine or by Compression Testing Machine.

To perform compressive strength test, we used two broken pieces (two halves) of flexural strength test (as mentioned in **BS EN 1015-11:1999**). When load was applied on prisms in flexure test, these prisms broke into two halves. These two halves were used for compression test. Two bearing plates of steel of size **40mm*40mm*10mm** are used to apply load on brokenpieces.

Testing:

Test the samples at 7 days and 28 days after regular curing. **Universal Testing Machine (UTM)/ Compression Testing Machine (CTM)** of capacity 3000kN are used to test the compressive strength. Prisms, to be tested, were placed on UTM/CTM as shown in fig 5.

Bearing plates were applied, one above the prism and the other one below the prism, to uniformly distribute the load and to apply load on specified area (40mm*40mm). Fig.5 shows the different arrangements of placing the sample between

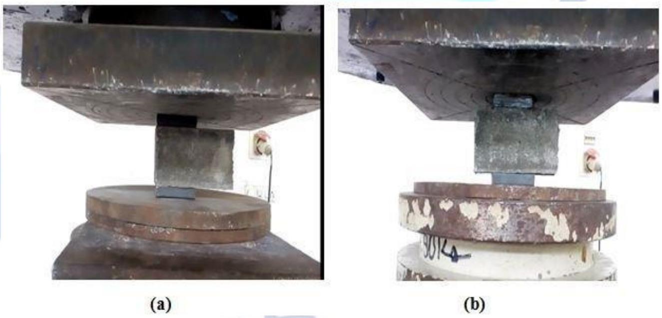

Fig 5: Different Arrangements of Bearing Plates on UTM

The loading rate should be uniform (without shock) at a rate of **10N/sec to 50N/sec** so that failure can occur within a period of 30 sec to 90sec.

Calculate the compressive strength as the maximum/peak load carried by the specimen divided by its cross-sectional area (area of bearing plates). Record the strength of each specimen individually.

3. CALCULATIONS

UTM/CTM gives us peak load (in kN) value. We have to find out compressive strength/compressive stress (in N/mm²). To get compressive strength of broken halves (obtained from flexural strength test), we use following formula:

Compressive Strength = Peak load/ area of bearing plates

where,

Area of bearing plates = 40mm*40mm = 1600mm²

To get compressive strength of cubes, we use following formula:

Compressive Strength = Peak load/ area of cube[13,19]

where,Area of cube = 50mm*50mm = 2500mm²

4. RESULTS 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.

1. Water AbsorptionCapacity

Water absorption capacity is measured by calculating water absorption coefficient and for all replacement levels, water absorption coefficient is depicted in table 1 and Variation in water absorption coefficient[11,13], when replacement level of wood ash in cement is increased, is shown in fig 6.

Table 1:Water Absorption Coefficient of Cement Mortar Containing WWA

WWA Content (%)	Water AbsorptionCoefficient, C_M [kg/(m²*min$^{0.5}$)]	Mean of C_M
0%	0.197	0.196
	0.184	
	0.209	
5%	0.172	0.164
	0.160	
	0.162	
7.5%	0.159	0.148
	0.145	
	0.140	
10%	0.147	0.140
	0.139	
	0.135	

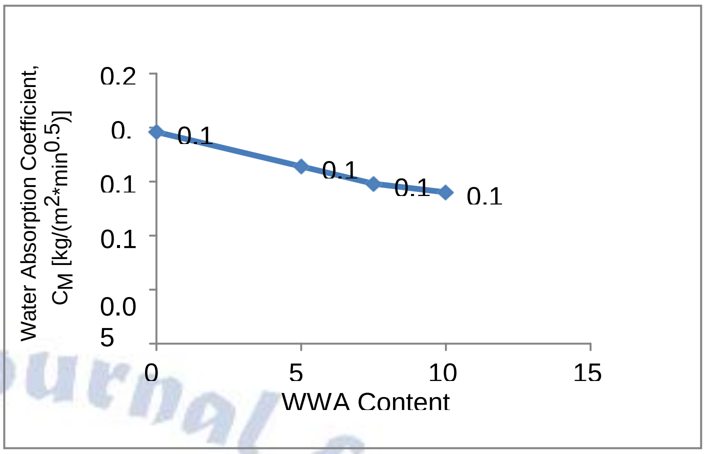

Fig 6:Variation in Water Absorption Coefficient with Different WWA% Levels

From figure 6, 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[14,15]. As we increase the percentage of wood ash, we get compacted matrix which reduce water absorption capacity of hardenedmortar.

2. Compression Test

The Variation in compressive strength of broken pieces obtained from flexural test, for 7 days and 28 of curing, is shown in table 2. UTM gives load value, we have to convert these load values in stress values by dividing load value from area of samples[1,12,18].

From Figure 7, shows how the strength values differ with each other at 7 days curing period and at 28 days curing period at different replacement level

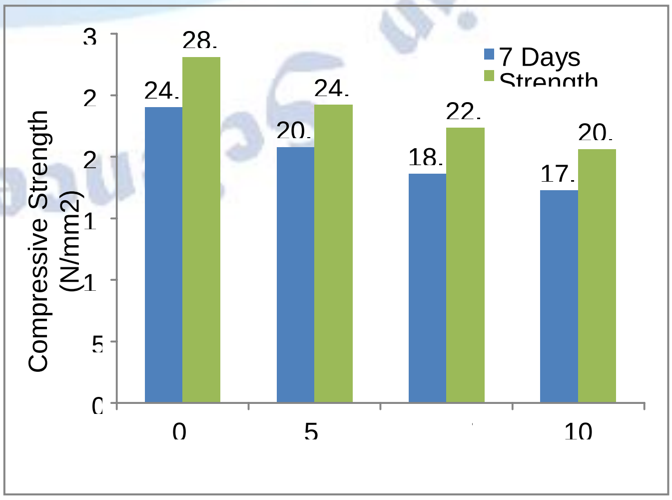

Fig 7: Variation in Compressive Strength with Variation in WWA Content at 7 Days and at 28 Days (Broken Halves)

the compressive strength of cubes of 50mm size with different replacement levels of wood ash in cement mortar illustrated in table 3.

Table 2:Compressive Strength of Mortar with WWA (Cubes)

WWA Content (%)	28 days strength (N/mm²)
0%	19.9
5%	18.1
7.5%	17.56
10%	16

Table 3: Compressive Strength of Mortar with WWA (Broken Halves)

WWA Content (%)	7 days strength (N/mm²)	28 days strength (N/mm²)
0%	24.07	28.13
5%	20.81	24.23
7.5%	18.63	22.37
10%	17.28	20.67

TheVariation in Compressive Strength of Cubes with Variation in WWA Content at 28 Days graph of decrease in compressive strength with increase in percentage of wood ash in mortar is shown in fig 8.

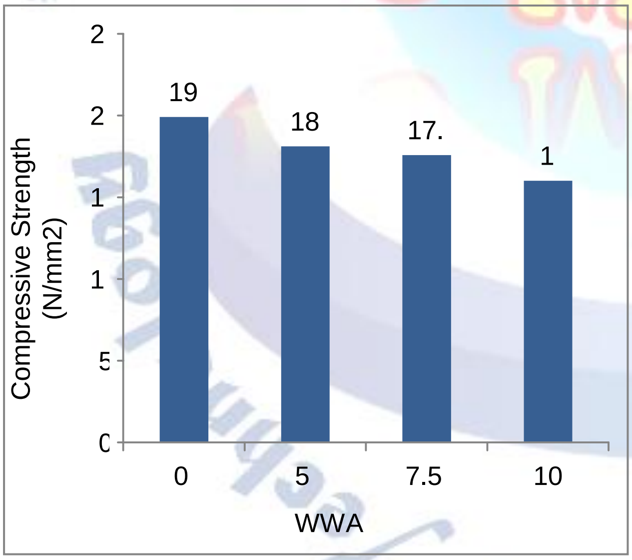

Fig 8:Variation in Compressive Strength of Cubes with Variation in WWA Content at 28 Days

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, from chemical composition of wood ash, silica is present in negligible amount which reduce the formation of C-S-H gel, hence reduction in compressivestrength[4,21,22].

5. CONCLUSIONS

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

1. Compressive strength of 40mm cubes at 0% replacement of WWA is 24.07 N/mm² at 7days of curing and 28.13 N/mm² at 28 days of curing while at 10% replacement of WWA, the compressive strength is 17.28 N/mm² 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.
2. 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/mm² and at 10% replacement, strength is 5.82N/mm².
3. If silica content is more, more is the formation of C-S-H gel and more is the strength. But, from chemical composition of wood ash, silica is present in negligible amount which reduce the formation of C-S-H gel, hence reduction in compressivestrength.
4. 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.
5. Workability decreases with increase in replacement percentage of woodash.

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