iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VII **Month of publication:** July 2023

DOI: https://doi.org/10.22214/ijraset.2023.54869

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

Effect of Wood Ash on salt Crystallization and Rapid Chloride Permeability Test (RPCT) in Mortar

Shivangi[1], Varun Kumar Sikka[2], Ajit Singh[3], Rahul Gupta[4]
[1]M. Tech Student, [2]Assistant Professor, Rattan Institute of Technology and Management, Palwal, Haryana , India
[3, 4]Assistant Professor, Pt .L.R .College of Technology, Faridabad, Haryana, India

Abstract: 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. 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 salt crystallization, rapid chloride permeability test are performed. The results shows As wood ash contains more amount of calcium oxides which are soluble in water and leached out and further react with sodium sulphate. That is why, on increasing the percentage of wood ash, loss in weight as well as loss in compressive strength and chloride ion permeability is high in all the cases but as we increase the percentage of wood ash, chloride ion permeability decreases.
Keywords: wood waste ash, , Water Absorption Coefficient of Cement Mortar ; UTM Machine; mortar with wood waste ash

I. INTRODUCTION

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[1]. 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[2,3]. Researchers have conducted tests which showed effective results that wood ash can be suitably used to replace cement partially in concrete production [18,17]. 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[20,18]. The main objective of this report is to find out optimum amount of wood ash in cement mortar And effect of wood ash on mortar strength and durability properties [4, 5]. Nehdi and Hayek (2008) studied the effect of sulphate attack on normal Portland cement (NPC) and sulphate-resistant Portland cement (SRPC) mortars. Mortars were prepared by replacing cement as partial replacement by 25% fly ash (FA), 8% silica fume (SF) and 8% diatomaceous earth (DE)[6,7]. Cement and sand ratio was taken as 1:2 and 5cm cubes were made. Curing was done for 28 days. The performance of mortar is monitored for 24 weeks. The performance was noted in the form of weight loss in the sample day by day after immersion in 5% solution of Na_2SO_4 and in the solution of 5% $MgSO_4$ and in the form of reduction of compressive strength in comparison to mixture which was not immersed in the sulphate solution[8]. Loss in compressive strength is shown in fig

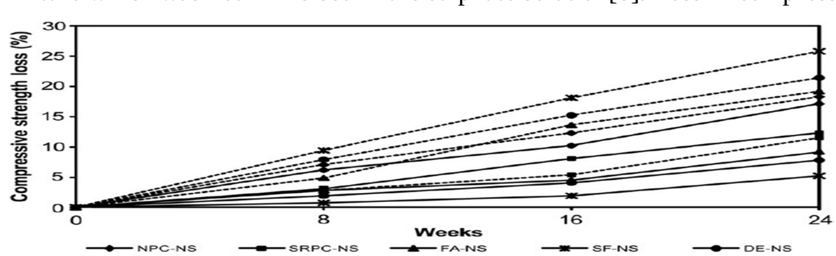


Fig 1: Loss of Compressive Strength by Salt Attack, Nehdi and Hayek (2008)

Higher reduction in compressive strength in NPC mortar was noted followed by SRPS and FA after 24 weeks. It is clear from the fig that strength is lower in blended mortars as compared to neat mortar [9]. This is because of reduction in the quantity of calcium hydroxide (CH) and tri calcium aluminate (C_3A). CH is the most vulnerable substance which is affected by Na_2SO_4 to a most.

Haynes et al. (2008) studied the effect of 10% Na_2SO_4 with temperature and humidity cycles on concrete mix made with Portland cement. They concluded that concrete scaling occurs at the surfaces when sample is immersed in solution of sulphate and it is significant when repeative cycles are applied[2,5].

Similarly, 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[9,11]. 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.

However, Wang et al. (2008) studied the chloride permeability on concrete mixture with partial replacement of wood/coal ash, wood fly ash. Level of cement replacement kept constant at 25%. Various types of ash was used like ash from combustion of wood, fly ash of class C type and class F type and coal ash is also blended with these[21]. They performed the rapid chloride permeability test after 56 days of curing. Test was performed in accordance with ASTM C 1202-1991. Based on their experimental work, they concluded that level of 25% replacement level did not result in considerable effect on chloride permeability property of concrete. they also concluded that there was a decrease in chloride permeability when cement is replaced by different wood ashes as compared to pure OPC mixture [15].

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 due to the presence of nanosilica which enhance the formation of more hydration products which fills the voids of concrete and hence decrease the porosity[23].

Ellinwa and Ejeh (2004) studied the effect of wood waste ash on compressive strength of mortar with different replacement percentages between 5% and 30%, at a rate of 5% increment in wood ash at each step. They observed that the mortar with 10% replacement level exhibits more compressive strength at all ages of curing upto 60 days. At 60 days of curing, mortar with partial replacement of wood ash at 10% has the equivalent strength as that of control mix[14].

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, salt crystallization and rapid chloride permeability test etc. The results shows As wood ash contains more amount of calcium oxides which are soluble in water and leached out and further react with sodium sulphate. That is why, on increasing the percentage of wood ash, loss in weight as well as loss in compressive strength and chloride ion permeability is high in all the cases but as we increase the percentage of wood ash, chloride ion permeability decreases.

II. EXPERIMENTAL SETUP

A. Salt Crystallization

Salt crystallization test is used to determine the resistance of mortar against salt attack. A mortar must withstand disintegration by salt attack. Therefore, it is necessary to conduct durability testing that will give an indication of mortar resilience under salt crystallization mechanism.

1) 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%). From Fig 2, shows the mould of 50mm cube. 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 28 days[6].

2) Testing

After curing of 28 days, samples were put into pre-heated oven at a temperature of 105^0C 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 105^0C because high temperature destroy the structural water.

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

Fig 3(a, b) shows, 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[8]. Now, the samples were immersed in 14% solution of sodium sulphate decahydrate ($Na_2SO_4.10H_2O$) for a period of 4 hours as shown in fig 4, 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). Thesamples were subjected to 20 such cycles. Repeat the same procedure after every cycle and record the weight loss of the sample.

(a) (b)

Fig 3: (a) Hot Air Oven and (b) Cubes Protected from Humid Atmosphere

Fig 4:Immersion of Samples in 14% Solution of Sodium Sulphate Decahydrate

3) Preparation of Solution

In actual, we had a container of 500 grams of sodium sulphate anhydrous (Na_2SO_4) instead of sodium sulphate decahydrate as shown in figure 5. So, we had to convert sodium sulphate anhydrous into sodium sulphate deca hydrate. As we know, 1000 grams of $Na_2SO_4.10H_2O$ is equivalent to 441 grams of Na_2SO_4. And 14% solution means 14% of $Na_2SO_4.10H_2O$ and 86% of water in that solution. So, after calculating, we required 6.965 kg of water and 500 grams of Na_2SO_4 to prepare a 14% solution of $Na_2SO_4.10H_2O$[13,16]. Now Table 1 shows, the chemical composition of mortar containing 10% WWA after 20 cycles of salt crystallization process obtained from SEM (scanning electron microscopy).

Fig 5:500 grams of sodium sulphate anhydrous (Na_2SO_4)

Table 1:Chemical Composition of Mortar containing 10% WWA Treated with Sodium Sulphate

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.	$CaCO_3$	3.48
9.	Total	100

Fig 6 shows, the images of scanning electron microscope analysis of mortar containing 10% WWA which is treated by salt solution. Fig 3.28 shows the energy dispersive X-Ray analysis of cement mortar containing wood ash at 10% replacement level treated by salt solution. Figure 7 shows, the physical appearance of samples treated with salt at different replacements by wood waste ash[8,15].

Fig 7: Physical Appearance of Mortar Treated with Sodium Sulphate solution

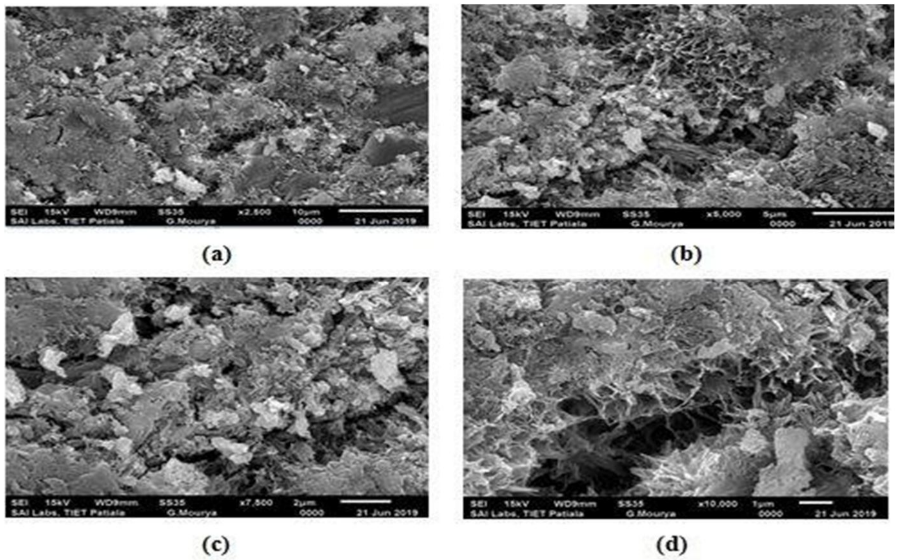


Fig 6: SEM Images of Mortar containing 10% WWA Treated by Sodium Sulphate (a) 2500 times enlarged, (b) 5000 times enlarged, (c) 7500 times enlarged, (d) 10000 times enlarge

B. Rapid Chloride Permiability Test

This test determines the electrical conductance of mortar to provide a rapid indication of its resistance to penetration of chloride ions. Less the ion penetration, less is the permeability, less is the electrical conductance. This test consists of monitoring the amount of electrical current passed through 50mm thick and 100mm in diameter slices of cylinders during a 6h period and a potential difference of 60V is maintained across the ends of specimen, one of which is immersed in sodium hydroxide solution and other is immersed in sodium chloride solution.

1) Preparation

To perform this test, we made cylinders of 100mm diameter and 200mm in length as per **ASTM C 1202** for each replacement percentage (0%, 5%, 7.5%, 10%) and cured for 28 days. Cut these cylinders into slices of 100mm diameter and 50mm height. Moulds of cylinder are shown in fig 8 and fig 9 shows the cut slices of cylinder for use in RCPT test.

Fig 8: Moulds of Cylinder of 100mm dia. and 200mm height

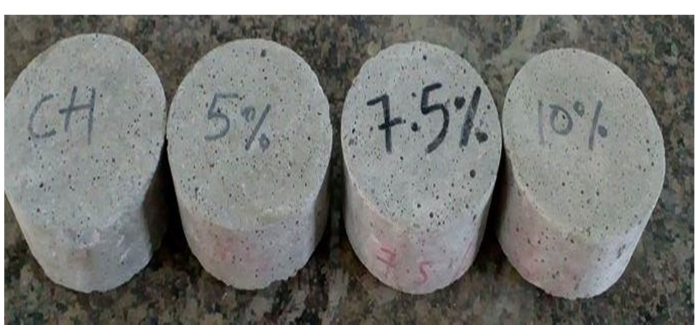


Fig 9: Cylindrical Slices (100mm diameter and 50mm height)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

Place these slices in vacuum desiccator for 3 hours as shown in fig 10, to evacuate air from very tiny voids.
Now, soak these slices in water for 18±2 h. Remove specimen from water and wipe out excess water from surface and place the specimens in PROOVE' it cell after applying sealent and rubber gaskets. Fill the PROOVE' it cell with solutions as mentioned earlier. Make electrical connections and read out data from monitor attached to setup.

(a) (b)

Fig 10 :(a) Vacuum Desiccator, (b) Cylinders in Vacuum Desiccator

2) Testing

The PROOVE' it equipment shown in fig 11, is designed to perform rapid chloride permeability of mortar ability to resist chlorides ion penetration according to ASTM C1202-97 or AASHTO T 277-831. The PROOVE' it software is installed in IBM- compatible PC and test runs after adding required parameters. The specimen is positioned in PROOVE' it cell which has small reservoirs for containing solution at each face. One reservoir contains sodium chloride (3.0% NaCl) solution and the other contains solution of sodium hydroxide (0.3% NaOH)[7,13,21]. Reservoir containing NaCl is connected to negative terminal and reservoir containing NaOH is connected to positive terminal of PROOVE' it Microprocessor power supply unit as shown in fig 12.

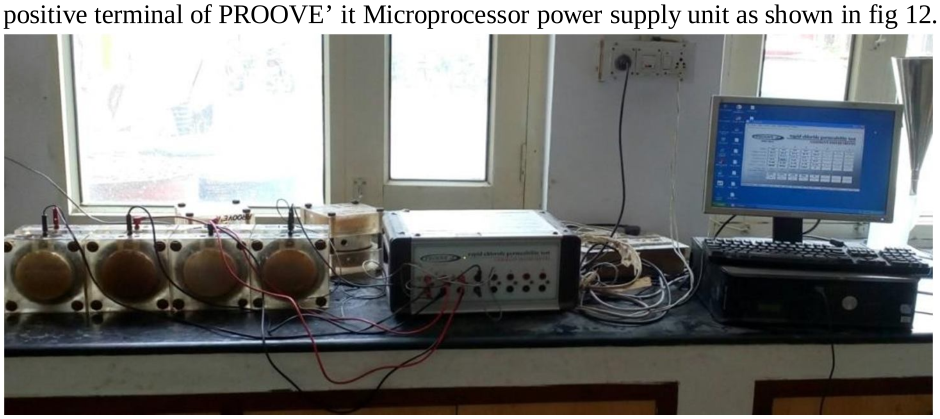


Fig 11: Complete setup of Rapid Chloride Permeability

(a) (b)

Fig 12: (a) PROOVE' it Microprocessor Power Supply Unit and (b) PROOVE' it Cell

Factors that affect chloride ion permeability include W/C ratio, type and quantity of cement and replacing material in mortar mixture, specimen age etc. Total charge passed, in coulombs, is related to resistance of specimen to chloride ion penetration. Indication of ion penetrability based on outcomes is provided in table 2.

Table 2: Chloride Ion Penetrability

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

III. 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 salt crystallization and rapid chloride permeability test.

A. Salt Crystallization

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 salt attack or salt crystallization. Table 3 shows, the residual compressive stress in samples which are exposed to salt attack [2,9]. Reduction in compressive strength of samples (treated with sodium sulphate solution), in comparison of samples which are not treated by solution, is shown in fig 13.

Table 3 : Residual Compressive Strength in Samples exposed to Salt Attack

WWA Content, %	Compressive Strength (N/mm^2)		Reduction (in comparison to normal sample)
	Normal Samples	Exposed to Salt Attack	
0%	19.9	18.2	8.54%
5%	18.1	16.5	8.90%
7.5%	17.56	15.89	9.51%
10%	16	14.33	10.44%

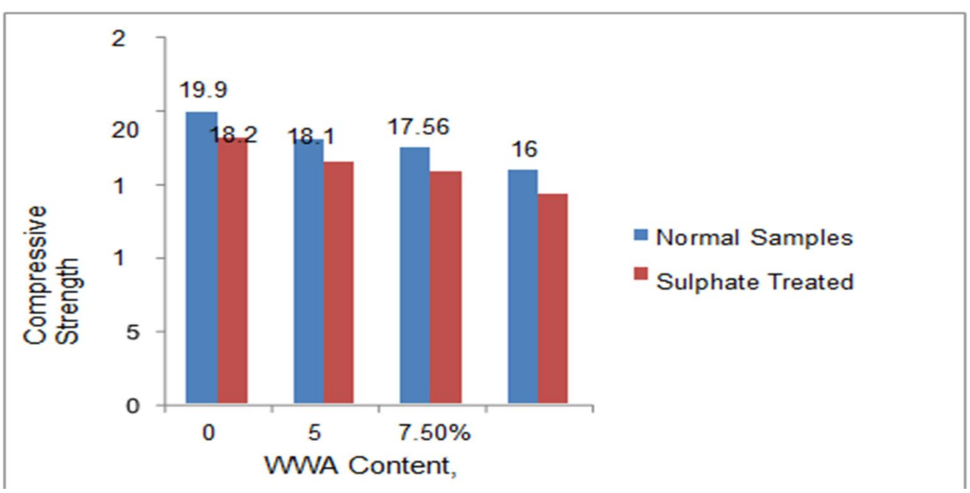


Fig 13: Variation in Compressive Strength of normal samples and Sulphate Treated Samples

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

Loss in weight of samples (expressed as a percentage with respect to initial dry weight) after 20 salt crystallization cycles is shown in table 4.

Table 4: Reduction in Weight after Salt Crystallization Cycles

WWA Content, %	Dry Weight (in gm.)		Percentage Reduction in Weight
	Initial	After 20 Cycles	
0%	292.67	287.33	1.83%
5%	295.33	287.67	2.59%
7.5%	297.67	289	2.91%
10%	302.33	291.67	3.63%

During hydration process, C_3S and C_2S react with water to form calcium silicate hydrate (C-S-H) gel along with calcium hydroxide [$Ca(OH_2)$]. This calcium hydroxide reacts with sodium sulphate to form calcium sulphate which further react with C_3A and cause deterioration of mortar/concrete. As wood ash contains more amount of calcium oxides which are soluble in water and leached out and further react with sodium sulphate. That is why, on increasing the percentage of wood ash, loss in weight as well as loss in compressive strength.

As we increase the temperature upto 150^0C, dehydration of C-S-H gel is started which results in the decrease of strength properties of mortar as well as concrete. 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. Due to these alternating cycles, scaling of specimen occurs which cause loss in weight.

B. RCPT Test

Results of rapid chloride permeability test in the form of charge passed in coulombs after 6 hours is shown in table 5 and Outcome given by software of RCPT is depicted in fig 14.

Table 5: Results of RCPT

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

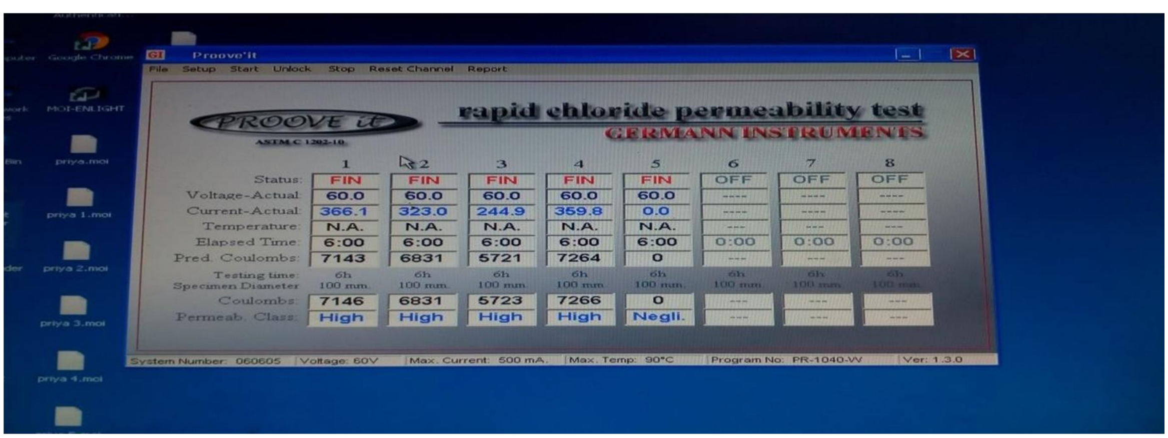


Fig 13: Results of RCPT

As we can see from table and figure that chloride ion permeability is high in all the cases but as we increase the percentage of wood ash, chloride ion permeability decreases. From Fig 15 shows, the trend line of decreasing chloride ion permeability on increasing percentage of wood ash in cement mortar[4].

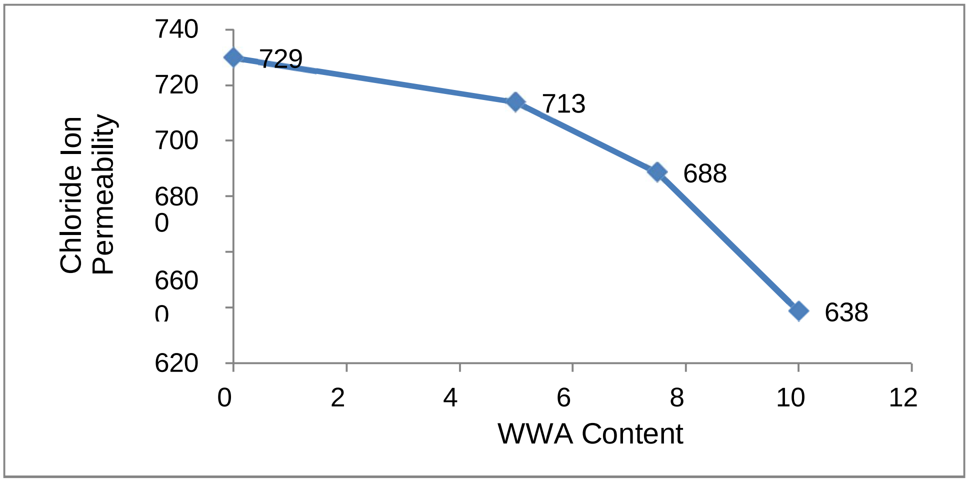


Fig 15: Variation in Chloride Permeability with Increase in WWA Content

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.

IV. CONCLUSIONS

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

1) Workability decreases with increase in replacement percentage of wood ash.
2) 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.
3) From the test results, it is clear that chloride ion permeability is high for all replacement percentages. But it is also concluded that chloride permeability decrease with increase in percentage of wood ash. Chloride ion permeability at 5% replacement is 1.37% of control mix and at 7.5% replacement, it is 5.63% of control mix while at 10% replacement level, it is about 13.86% of control mix.
4) As wood ash contains more amount of calcium oxides which are soluble in water and leached out and further react with sodium sulphate. That is why, on increasing the percentage of wood ash, loss in weight as well as loss in compressive strength.
5) chloride ion permeability is high in all the cases but as we increase the percentage of wood ash, chloride ion permeability decreases.
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

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

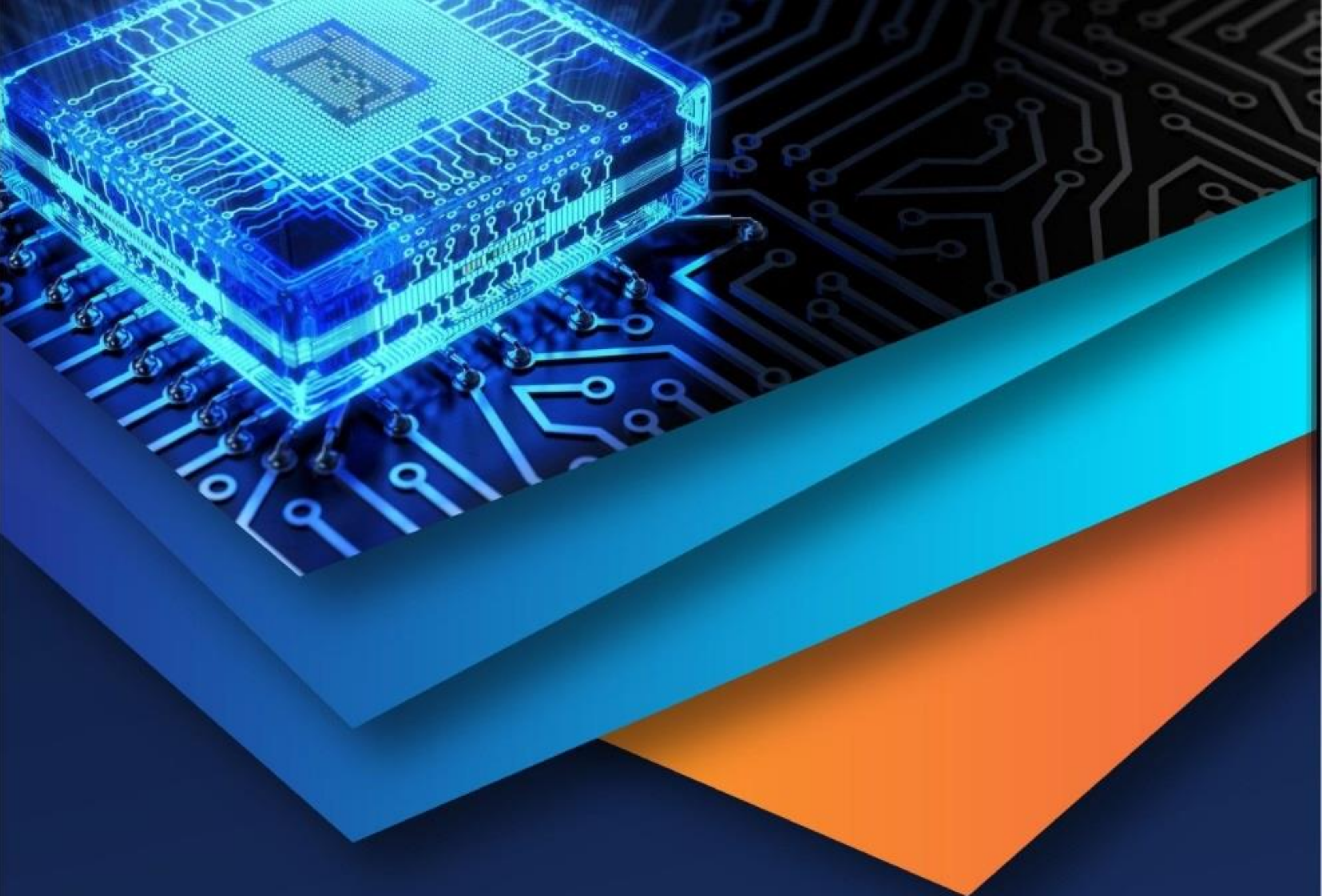
[20] Ajit , I A Khan(2022) The Experimental analysis on effect of low Reynolds number on probe coefficient having different-2 intertube spacing of S-type probe. ", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 4, page no.a604-a610, 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 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

[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.

.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)