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Experimental Evaluation on Utilization of Waste Wood Ash by Partial Replacement in Cement Concrete

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ABSTRACT: Due to vast progression in the construction work, cement requirement has been escalated which is the main constituent in concrete. In current years there have been many studies carried out to find the alternative for cement. Many waste products and by- products have been utilized to minimise the use of cement as well as to lower the economy required in the constructions industries. Wood ash is develop as a by-product of combustion in wood-fired power plants, pulp and paper mills, steam power plants and other thermal power generating facilities. Many industries located in central India are producing wood ash. The use of Wood Ash (WA) in cement concrete mix will make it cost effective as well as a friendly disposal of the waste product.

The present research is aimed to study the effect of WA on the strength and durability characteristics of the concrete and compared to M 30 grade of conventional concrete (CC). This study carries out the compressive strength, splitting tensile strength tests on concrete after 7 and 28 days of curing. Durability tests of acid attack were carried out on the wood waste ash concrete.

KEYWORDS: Wood ash, concrete, strength, cement replacement.

I. INTRODUCTION

Waste substances and by-products are produced in abundant from various manufacturing processing units, municipal solid wastes and industries. For this reason, a good solid waste administration has turn out to be an important parameter to be considered as a protective measure to environment in the world. As the increasing knowledge about the surroundings, shortage of the land-fill area and because of it continually increase in cost, waste substances and the products usage has emerge as an appealing substitute to disposal. Excessive extraction of natural resources, very large quantity of factory made wastes and environmental desecration feel necessity for thinking new options for a renewable progress. In the current scenario of energy production, power plants which run from biomass have low operational cost and have continuous supply of endless fuel. It is considered that these energy resources will reduce the hazardous CO_2 emission in the environment when the consumption rate of the fuel is lower than the growth rate. And also, the usage of wastes produced from the biomass industries (sawdust, woodchips, wood bark, saw mill scraps and hard chips) as fuel offer a way for their safe, efficient and environment friendly disposal.

Agriculture wastes and other herbaceous waste on incineration produce comparably more fly ash and other residual material when compared to wood wastes. A major problem arising from the usage of forest and timber waste product as fuel is related to the ash produced in significant amount after the combustion of such wastes. It is commonly observed that the hardwood produces more ash when compared to softwood and the leaves and bark generally produce more ash as compared to the inner part of the trees.

Various research shows that rice husk ash and fly ash, are one of the major players which are proven to be effective mineral admixtures to cement at various percentages. Wood ash (WA) is also a similar kind of waste materials produced from wood burning industries which is mainly used as a fertilizer for soil. Significant quantities of wood ash are land filled by the industries that uses wood as a fuel partially or fully which can be a serious threat to the environment in many ways to life stock around. Chemical properties of wood ash shows that it has pozzolanic property and using it as a partial replacement to cement may be one of the great option in the current environment scenario.

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II. OBJECTIVE OF WORK

This experimental study sought to satisfy the aim of the research, through the following objectives.

- To conduct a feasible study on the utilization of wood waste ash (WA) in the production of structural grade concrete of M 30 grade.
- To conduct workability studies such as slump, compaction factor of wood waste ash on fresh properties of the concrete.
- To study the effect of addition or replacement of WA on the hardened properties of concrete such as compressive strength, splitting tensile strength at different curing periods.
- To study the effect of addition or replacement of WA on the durability properties of concrete.
- To come up with the optimum dosage of wood waste ash to be used in the structural grade concrete.

III. METHODOLOGY

3.1 Introduction

The main aim of this chapter is to provide a brief introduction to the materials and methods used in this study. The material properties like wood ash, cement, fine aggregate, coarse aggregate, water etc is presented in this chapter to identify their suitability.

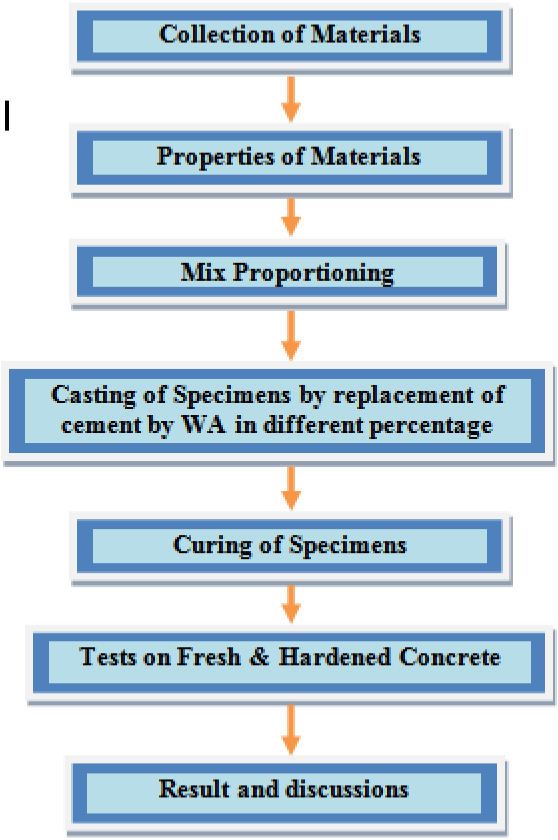

Fig 1 Methodology of study

3.2 Materials

The materials used in the experimental investigation include.

1. 43 grade OPC cement
2. Coarse aggregate
3. Fine aggregate
4. Wood Waste Ash
5. Water

3.2.1 Cement

Ordinary Portland cement of 43grade was used. The specific gravity of the cement was found 3.15. Ordinary Portland cement conforming IS: 8112-1989.

Cement: - OPC of 43 grade was used.

The Physical Properties of cement are shown in Table.

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Table 1 Physical properties of Cement

S. No.	Property	Values
1	Fineness of Cement	225 m^2/kg
2	Specific Gravity	3.15
3	Normal Consistency	33 %
4	Setting Time I. Initial Setting time II. Final setting time	 45 min 6 hours
5	Compressive Strength 3 days 7 days 28 days	 28 N/mm^2 39 N/mm^2 49 N/mm^2

Fig 2 Cement used on this study

3.2.2 Coarse Aggregates

Material which is held on BIS test sieve no.4.75mm is termed as a coarse aggregate. Coarse aggregate form the main matrix of the concrete. The broken stone is by and large utilized as a coarse aggregate. As per IS 383:1970 coarse aggregate, maximum size 20mm is suitable for concrete work. The aggregate were washed to remove the dust and earth and were dried to surface dry condition. After drying 10kg of aggregate was taken sieved through different number sieve and weight retained on each sieve was found along with percentage. The test of coarse aggregates was performed as per **IS 383:1970**.

Coarse aggregate was brought from local quarry located at Mahasamund area.

3.2.3 Fine aggregates

Fine aggregates are materials passing through as IS sieve which is less than 4.75mm. They are filler material between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The sand was initially sieved through 4.75mm to evacuate any particles more prominent than 4.75mm and after that was washed to evacuate the dust. After drying 2kg of sand was taken and it was sieved through different number sieve and weight retained on each sieve was recorded.

3.2.4 Wood waste ash

Wood waste ash (WA) was obtained from local industries of Raipur where the saw dust used as fuel for preparing their products, the output product of burnt saw dust treated as wood ash.

Hardwoods usually produce more ash than softwoods. The bark and leaves commonly produce more ash than the inner woody parts of the tree. On an average the burning of wood results ash in about 6%–10%. When ash is produced in industrial combustion systems, cleanliness of the fuel wood, the temperature of combustion, the collection location, and the process can also have profound effects on the nature of the ash material. Hence, wood ash composition can be highly variable depending on geographical location and industrial processes. It makes the ash testing extremely important. Physical and chemical properties are presented in Table.

Table 2 Physical Properties of Wood Waste Ash

Specific gravity	**2.57**
Fineness	**6.0 %**
Nature	**Pozzolanic**

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Table 3 Chemical Composition of Wood Waste Ash

Silicon dioxide (SiO_2) %	31.40
Aluminium oxide (Al_2O_3)%	17.30
Iron oxide (Fe_2O_3) %	9.70
Calcium oxide (CaO) %	3.60
Magnesium oxide (MgO) %	0.70
Potassium Oxide (K_2O) %	1.10
Loss of Ignition (1000℃)	30.60
Moisture content %	2.30
Alkalis %	0.80

Fig 2 Wood waste ash

3.2.5 Water

Potable water was used for mixing and curing of all concrete specimens.

Water used in the concrete work should have the following properties.

I. It should be free from injurious amounts of oils.

II. It should be free from injurious amounts of acids or alkalis or other such organic or inorganic impurities.

III. It should free from iron, vegetable matter, or any other harmful ingredients, which is likely to have adverse affect on concrete or reinforcement.

IV. It should be fit for drinking purpose.

3.3 Mix Proportioning

The M30 grade mix (1:1.26:2.90) has been prepared. During preparation control blend is planned as per Indian Standard Code rules. Water cement ratio is kept constant at 0.45 as prescribed by IS Code 456:2000. 438kg/m^3 of cement is used with 197L water. Fine aggregate 552.44 kg/m^3 and coarse aggregate 1273.28 kg/m^3 are used. For making blends containing WA cement has been replaced with WA in some percentage by weight. Table below shows various mixes proportioning for M30 grade concrete.

Table 4 Initial data for mix design for M30 grade concrete

Grade of concrete	**Cement material per m^3 of concrete (kg/m^3)**	**NCA**	**NFA**	**Water**
M30	438	1273.28	552.44	197

Table 5 Mix Designation

Sample	**Cement (kg/m^3)**	**WA (kg/m^3)**	**NCA (kg/m^3)**	**NFA (kg/m^3)**	**Water**	**% Replaced**
WA0	438	0	1273.28	552.44	197	0
WA1	416.1	21.9	1273.28	552.44	197	5
WA2	394.2	43.8	1273.28	552.44	197	10
WA3	372.3	65.7	1273.28	552.44	197	15
WA4	350.4	87.6	1273.28	552.44	197	20
WA5	328.5	109.5	1273.28	552.44	197	25

WA6	306.6	131.4	1273.28	552.44	197	30

IV. TESTS ON CONCRETE

4.1 Slump Test

Slump value is used to measure the ropy level of concrete mixture which has an effect with the workability of the concrete mixture process. If the value of the slump test is large then the concrete is liquid and easier to work with, otherwise if the value of the slump is small, the concrete is going to be more viscous and harder to work with. For all the mixes the slump is retained for a period of 15 minutes. The mix appeared to be very cohesive. To measure the workability of GPC, slump cone test was performed. The dimensions of cone are top portion is a truncated cone having a size of 200 mm diameter at the bottom and 100 mm diameter at the top with a height of 300 mm. As soon as concrete is prepared, it is placed in the cone in three layers with 25 times of tamping each layer. The cone is then lifted up gradually and the fall in height of the concrete is measured, indicating the slump of the mix.

4.2 Compaction Factor Test

This test was performed to get the workability of concrete. Concrete sample was placed gently in the upper hopper to its brim using the hand scoop and levelled. Trapdoor was opened at the bottom of the upper hopper so that concrete falls into the lower hopper. Trapdoor of the lower hopper was opened and concrete was allowed to fall into the cylinder below.

Excess of concrete was cut from the top level of cylinder using trowels and leveled. Weight of the cylinder with concrete was taken to the nearest 10 g. This weight is known as the weight of partially compacted concrete (**W1**).

The cylinder was empted and then refilled with the same concrete mix in layers. Weight of the cylinder with fully compacted was taken. This weight is known as the weight of fully compacted concrete (**W2**).

Weight of empty cylinder was found (**W**). Compaction factor was found using the relation

(W1−W) /(W2−W).

4.3 Bulk Density Test

Bulk density of concrete is that the mass of freshly mixed concrete required to fill the container of a unit volume. The Cylindrical measure jar was filled with freshly mixed concrete and compacted using tamping rod. The layers of 50 mm was placed and compacted with not less than 60 strokes. After consolidation of the concrete, the top surface was struck-off and finished smoothly with a flat cover plate using care.

All excess concrete was then cleaned from the outside and filled measure jar was weighed (W). Density of Concrete (W1) was calculated by dividing the weight of fully compacted concrete in the cylindrical measure by the capacity of measure in kg/m^3. Length of mould is 29cm and diameter is 16cm hence volume was calculated to be $0.006m^3$

4.4 Compressive Strength Test

The test specimens for compressive strength of cube are 150mmx 150mm x 150mm. The test specimens were cast in respective cast iron steel moulds. The mould specimens were applied with oil in all inner surfaces for easy removal of specimens during demoulding. Fresh concrete is filled in moulds in three equal layers. The mould is vibrated on a vibrating table to release the air trapped in the mix. The time of vibration was judged by the visual appearance of individual mixes to ensure full compaction. After casting, the specimens were demoulded after the lapse of 24 hours and placed in the normal atmospheric condition.

4.5 Split Tensile Strength Test

Splitting tensile strength is that the measure of tensile strength of the concrete which is determined by splitting the cylinder across its diameter. This is an indirect test method to determine the tensile strength of concrete of test specimen of cylinders. The load was applied using compression testing machine. Testing was carried out for tensile test on cylinder. Split tensile strength is determined on 7th day and 28th day.

4.6 Acid Resistance Test

The hardened specimen cubes of size 150 mm X 150 mm X 150 mm were cast. They were immersed separately in each 10% concentrated solutions of hydrochloric acid (HCL) and sulphuric acid (H_2SO_4) after 28 days water curing. The normal weights of cubes were initially taken (after 28 days water curing) and observed the deteriorating effect after 28 days by taking weights again. The weight loss due to acid immersion has been noted.

V. RESULT AND DISCUSSION

5.1 Slump Test

Table below shows slump value for each sample and line diagram of comparison of slump. Slump ranging from 25 to 75 mm is considered as having low workability.

Table 5.1 Slump values test of waste wood concrete

Sample	Slump Value(mm)
WA0	85
WA1	79
WA2	72
WA3	61
WA4	54
WA5	43
WA6	37

5.2 Compaction Factor Test

This test was performed to get the workability of concrete. Compaction factor value also decreased when percentage of wood ash was increased. Table and Figure below shows CF of various mixes and comparison of it.

Sample	Partially Compacted Concrete (W1)Kg	Compacted Concrete (W2)Kg	Empty Cylinder (W) Kg	CF
WA0	15.85	17.10	4.6	0.90
WA1	15.6	16.90	4.6	0.89
WA2	15.36	16.32	4.6	0.88
WA3	14.70	16.35	4.6	0.87
WA4	14.40	16.12	4.6	0.85
WA5	13.90	15.15	4.6	0.79
WA6	12.50	15.13	4.6	0.75

Table 5.2 Compaction factor test result of waste wood concrete

5.3 Bulk Density Test

Bulk density of concrete is the mass of freshly mixed concrete required to fill the container of a unit volume .Density of concrete is a measure of its unit weight. In this work, the density of the normal concrete is found to be 2345.17 kg/m^3 and the density of the wood ash concrete decreases gradually which may be due to the slightly lower specific gravity of the wood ash.

Table 5.3 Bulk Density Test Result of waste wood concrete

Sample	Density (kg/m^3)
WA0	2345.17
WA1	2324.14
WA2	2301.69
WA3	2290.14
WA4	2274.46
WA5	2261.21
WA6	2254.24

5.4 Compressive Strength Test

The compressive quality is the limit of a material or structure to withstand burdens having a tendency to lessen size. It is obtained by plotting force applied against deformation. Compressive strength at 7 days and after 28 days has been calculated. Figure below shows the compressive strength at 7 days and 28 days respectively.

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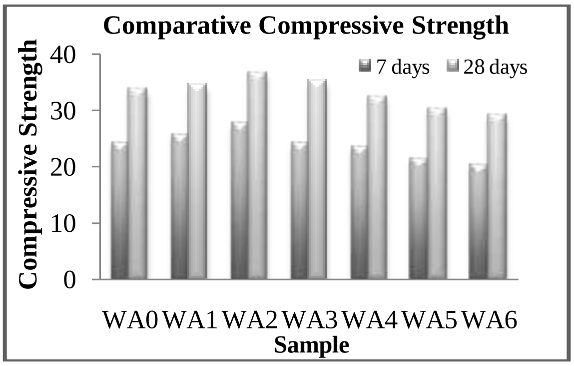

Fig 3 Comparative Compressive Test Result

5.5 Split Tensile Test

Tensile strength is an important property of concrete because concrete structures are very much vulnerable to tensile cracking and various kinds of loading. Tensile strength is very less as compared to compressive strength test of concrete. Figure below shows split tensile test results after 7 days and 28 days.

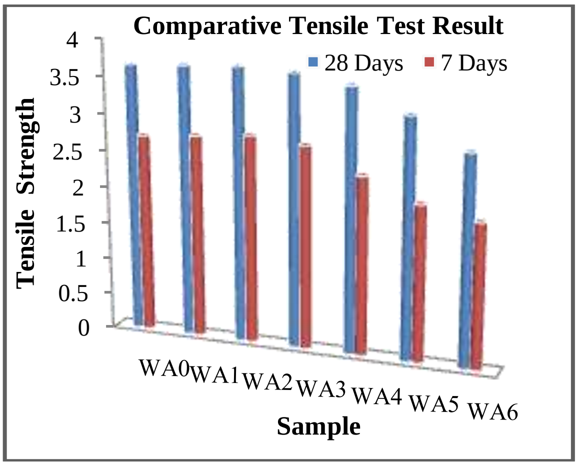

Fig 4 Comparative Tensile Test Result

5.6 Effect of acid on residual compressive strength

The influence of percentage of addition of WA and replacement of cement with WA in concrete on residual compressive strength due to acid attack for two different immersion periods in presented in Tables.

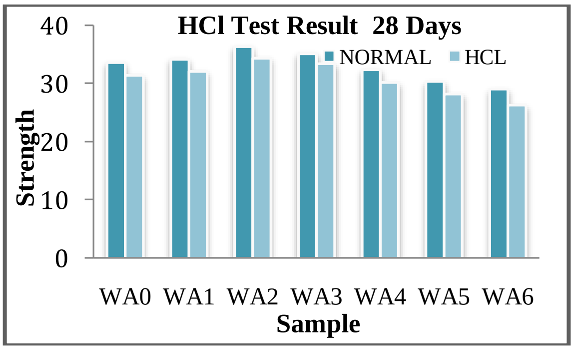

Figure 5 HCL Test Result

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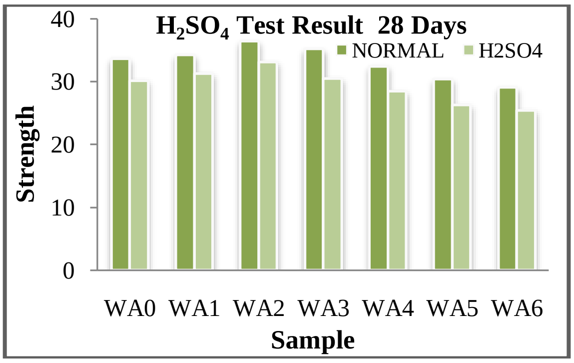

Fig 6 H_2SO_4 Test Result

VI. CONCLUSIONS

This work evaluated the possibility of replacing cement in concrete with wood waste ash at different levels (0%, 5%, 10%, 15%, 20%, 25% and 30%) produced in Raipur, Chhattisgarh, Concrete mix design of 30 MPa and water cement ratio of 0.45 was used. Based on the results from this study, the subsequent general conclusions can be made:

1. With increasing the percentage of WA addition in the concrete the workability of concrete decreases, indicated by decrease in slump & compaction factor. This can be mainly attributed to higher water demand of WA. However at 10% addition the slump value is 72 mm with a Compaction factor of 0.88, the mix is reasonably cohesive and workable.
2. In this work, the density of the normal concrete is found to be 2345.17 kg/m^3 and the density of the wood waste ash concrete is 2324.14 kg/m^3 at 5% replacement. The difference is due to the slightly lower specific gravity of the waste wood ash.
3. The maximum compressive strength of the concrete with waste wood ash at 28 days was 36.62 MPa which shows an improvement over the conventional concrete.
4. The maximum tensile strength of the concrete with waste wood ash at 28 days was 3.71 MPa for mix WA2.
5. The mechanical properties (compressive strength, tensile strength) of wood waste ash concrete have increased with 10% replacement of cement by wood waste ash. Further increase in cement replacement level with WA decreased the mechanical properties significantly.
6. From the acid attack tests, it is noted that the weight loss was marginal at 10% addition or replacement of cement with WA. Beyond 10%, the weight loss is significant for both WA addition and replacement.
7. From the results, it is concluded that 10% WA replacement with cement can be considered as optimum level for safe structural concrete from both strength and durability considerations. However consultation of expert must be taken.

REFERENCES

[1]. Abdullahi, M. Characteristics of Wood Ash/OPC Concrete" Leonardo Electronic Journal of Practices and Technologies, 8 (2006) 9-16.

[2]. Akeem Ayinde Raheem, Olumide A. Adenuga. Wood ash from bakery as partial replacement for cement in concrete. International Journal of Sustainable Construction Engineering & Technology 4(1) (2013) 75-81.

[3]. Alabadan, B. A., Njoku, C.F. and Yusuf, M.O. The Potentials of Groundnut Shell Ash as Concrete Admixture", Agricultural Engineering International: The CIGR Ejournal, (2006) 8.

[4]. Aribo S. Effect of Varying Corn Cob and Rice Husk Ashes on Properties of Moulding Sand. Journal of Minerals & Materials Characterization & Engineering. 10 (2011) 1449-1455.

[5]. Ban CC, Ramli M. The implementation of wood waste ash as a partial cement replacement material in the production of structural grade concrete and mortar: an overview. Resour Conserv Recycl., 55 (2011) 669–85.

[6]. Ban, C., Ramli, M., "Properties of high calcium wood ash and densified silica fume blended cement "International Journal of Physical Sciences, 6(28), (2011) 6596-06.

[7]. Campbell AG. Recycling and disposing of wood ash. TAPPI J., 73(9) (1990) 141–3.

[8]. Cheah, C. B. and Ramli, M. "The implementation of wood waste ash as a partial cement replacement material in the

production of structural grade concrete and mortar: an overview Review Article, Resources, Conservation and Recycling, 55 (1) (2011) 669-685.

[9]. Chowdhury .S, Maniar .A, Suganya.O.M. Strength Development in Concrete with Wood Ash Blended Cement and Use of Soft Computing Models to Predict Strength Parameters. Journal of advanced research, 2014. (doi:10.1016/j.jare.2014.08.006).

[10]. Chowdhury S, Mishra M, Suganya O. The incorporation of wood waste ash as a partial cement replacement material for making structural grade concrete: An overview. Ain Shams Engineering Journal. 2014

[11]. Eethar TD, Comparison Between the Effect of Silica Fume and Wood Ash Used for the Production of High Performance Mortar. AL-Mansour Journal. 12th Scientific Conference, (2013). pp43-49.

[12]. Elinwa, A.U. and S.P. Ejeh, "Effects of the incorporation of sawdust waste incineration fly ash in cement pastes and mortars", J. Asian Archit. Build. Eng., 3 (2004) 1-7.

[13]. Elinwa. A. U. and Mahmoodb, Y. A. "Ash from timber waste as cement replacement material, Cement and Concrete Composites, 24 (2) (2002) 219- 222.

[14]. Etiegni L, Campbell AG. Physical and chemical characteristics of wood ash. Bioresource Technol, 37(2) (1991) 173–8.

[15]. Etiegni, L. (1990). "Wood ash recycling and land disposal." Ph.D. thesis. Department of Forest Products, University of Idaho at Moscow, Idaho, USA.

[16]. Fehrs JE. Ash from the combustion of treated wood: characterization and manage-ment options. In: Presented at the National Bioash Utilization Conference; 1996. p. 20.

[17]. Food and Agricultural Organization (FAO) Records (2002). Retrieved from: http://apps.fao.org/ default.htm.

[18]. Hossain, K. M. A., "Chloride induced corrosion of reinforcement in volcanic ash and pumice based blended concrete", Cement & Concrete Composites, 27 (2005) 381-390.

[19]. Karuppiah M, Gupta G. Toxicity of metals in coal combustion ash leachate. J Hazard Mater, 56 (1997) 53–8.

[20]. McCollum, D., Gould, G., & Greene, D. (2009). Greenhouse Gas Emissions from Aviation and Marine Transportation: Mitigation Potential and Policies. PEW Research Center, Washington DC.

[21]. Mehta, P.K., "The chemistry and technology of cements made from ricehusk ash". Regional Centre for Technology Transfer, Bangalore, India, (1979) 113– 122.

[22]. Meyers NL, Kopecky MJ. Industrial wood ash as a soil amendment for crop produc-tion. TAPPI J., 81(4) (1998) 123–30.

[23]. Mishra, M.K., Ragland, K.W., and Baker, A.J. "Wood ash composition as a function of furnace temperature." Biomass Bioen., 4(2) (1993) 103–116.

[24]. 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, pp. 124, 2002

[25]. Naik TR. Environmental-friendly concrete with industrial and post-consumer by-products. Report No. CBU-2004-21, REP-570; 2004.

[26]. National Council for Air and Stream Improvement, Inc. (NCASI), "Alternative Management of Pulp and Paper Industry Solid Wastes," Technical Bulletin No. 655, NCASI, New York, N.Y., Nov. 1993, pp44.

[27]. Ogork EN, Uche OA. Effect Of Particle Size Of Groundnut Husk Ash (Gha) In Cement Paste And Mortar. International Journal on Recent and Innovation Trends in Computing and Communication. 2 (2014) 2764-2769.