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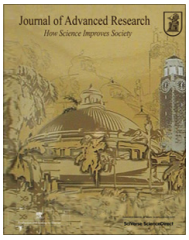

ORIGINAL ARTICLE

Strength development in concrete with wood ash blended cement and use of soft computing models to predict strength parameters

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ABSTRACT

In this study, Wood Ash (WA) prepared from the uncontrolled burning of the saw dust is evaluated for its suitability as partial cement replacement in conventional concrete. The saw dust has been acquired from a wood polishing unit. The physical, chemical and mineralogical characteristics of WA is presented and analyzed. The strength parameters (compressive strength, split tensile strength and flexural strength) of concrete with blended WA cement are evaluated and studied. Two different water-to-binder ratio (0.4 and 0.45) and five different replacement percentages of WA (5%, 10%, 15%, 18% and 20%) including control specimens for both water-to-cement ratio is considered. Results of compressive strength, split tensile strength and flexural strength showed that the strength properties of concrete mixture decreased marginally with increase in wood ash contents, but strength increased with later age. The XRD test results and chemical analysis of WA showed that it contains amorphous silica and thus can be used as cement replacing material. Through the analysis of results obtained in this study, it was concluded that WA could be blended with cement without adversely affecting the strength properties of concrete. Also using a new statistical theory of the Support Vector Machine (SVM), strength parameters were predicted by developing a suitable model and as a result, the application of soft computing in structural engineering has been successfully presented in this research paper.

Introduction

In the recent years, growing consciousness about global environment and increasing energy security has led to increasing demand for renewable energy resources and to diversify current methods of energy production. Among these resources, biomass (forestry and agricultural wastes) is a promising source of renewable energy. In the current trends of energy production, power plants which run from biomass have low operational cost and have continuous supply of renewable fuel. It is considered that these energy resources will be the CO_2 neutral energy resource when the consumption rate of the fuel is lower than the growth rate [1]. Also, the usage of wastes generated from the biomass industries (sawdust, woodchips, wood bark, saw mill scraps and hard chips) as fuel offer a way for their safe and efficient disposal. The thermal combustion

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greatly reduces the mass and the volume of the waste thus providing an environmentally safe and economically efficient way to manage the solid waste [2]. Usually, timber product manufacturing units develops small scale boiler units which employ wood waste generated in the unit itself as main fuel to produce heat energy for their various processes like drying the finished products. Wood wastes are commonly preferred as fuels over other herbaceous and agricultural wastes as their incineration produces comparably less fly ash and other residual material.

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 produce more ash than softwood and the bark and leaves generally produce more ash as compared to the inner part of the trees. On an average burning of wood produces 6–10% of ash by the weight of wood burnt and its composition can be highly variable depending on geographical location and industrial processes [3]. The most prevailing method for disposal of the ash is land filling which accounts for 70% of the ash generated, rest being either used as soil supplement (20%) or other miscellaneous jobs (10%) [4,5]. The characteristics of the ash depend upon biomass characteristics (herbaceous material, wood or bark), combustion technology (fixed bed or fluidized bed) and the location where ash is collected [6–8]. As wood ash primarily consists of fine particulate matter which can easily get air borne by winds, it is a potential hazard as it may cause respiratory health problems to the dwellers near the dump site or can cause groundwater contamination by leaching toxic elements in the water. As the disposal cost of the ashes are rising and volume of ash is increasing, a sustainable ash management which integrate the ash within the natural cycles needs to be employed [6].

Extensive research is being conducted on industrial by-products and other agricultural material ash like wood ash or rice husk ash which can be used as cement replacement in concrete. Due to current boom in construction industry, cement demand has escalated which is the main constituent in concrete. Also, the cement industry is one of the primary sources which release large amounts of major consumer of natural resources like aggregate and has high power and energy demand for its operation. So utilization of such by product and agricultural wastes ashes solves a twofold problem of their disposal as well providing a viable alternative for cement substitutes in concrete [9–12]. Researchers have conducted tests which showed promising results that wood ash can be suitably used to replace cement partially in concrete production [5,16,17]. Hence, incorporating the usage of wood ash as replacement for cement in blended cement is beneficial for the environmental point of view as well as producing low cost construction entity thus leading to a sustainable relationship.

The basic aim of this study was to investigate the effect of wood ash obtained from uncontrolled burning of Sawdust on the strength development of concrete (Compressive strength, Flexural strength and Split Tensile strength) for two different water–cement ratio and to develop a regression model using Support Vector Machines (SVM) to predict the unknown strength parameters.

Experimental

Materials

Cement

Ordinary Portland cement (Type 1) conforming to IS 8112:1995 was used [14]. The physical and chemical property of cement is in Table 1.

Aggregates

Normal weight graded natural sand having a maximum particle size of 4.75 mm and specific gravity 2.6 was used as fine aggregate. Properties of sand are reported in Table 2 and its size distribution is according to requirements of ASTM C33/C33M-08 [15]. The coarse aggregate used was crushed gravel with mean size of 10 mm and having bulk specific gravity 2.6.

Wood Ash (WA)

Saw dust from the Wood polishing unit in the state of Tamilnadu, India was selected to evaluate its suitability as ash for OPC replacement. The Wood Ash (WA) was obtained from open field burning with average temperature being 700 °C. The material was dried and carefully homogenized. An adequate wood ash particle size was obtained by mixing wood ash and coarse aggregate together for a fixed amount of time. This mixing was done to facilitate easy pozzolanic reaction and

Table 1 The chemical analysis and physical properties of the cement.

	Particular	Value
Chemical properties		
1	SiO_2 (%)	20.25
2	Al_2O_3 (%)	5.04
3	Fe_2O_3 (%)	3.16
4	CaO (%)	63.61
5	MgO (%)	4.56
6	Na_2O (%)	0.08
7	K_2O (%)	0.5
8	Loss on ignition	3.12
Physical properties		
1	Specific gravity	3.1
2	Mean size	23 μm

Table 2 Grading and properties of fine aggregate.

Sieve size (mm)	Percentage passing	Limits of specifications ASTM C33/C33M-08
9.5	100	100
4.75	98	95–100
2.36	92	80–100
1.18	84	50–85
0.60	57	25–60
0.30	23	5–30
0.15	3	0–10
Property	Result	
Bulk specific gravity	2.62	
Absorption (%)	0.70	