GREEN BUILDINGS- Review of Effectiveness in Using Waste materials as Building Materials

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ABSTRACT

A slogan everybody utters is GO Green. With more and more emphasizes on the environment and resources, the concept of green buildings has been widely accepted. Building materials are vectors of architectures, only if green building materials and related technical means are used, can we construct green buildings to achieve the purpose of energy conservation and environmental protection. It is need of the hour to use more Waste materials which are eco-friendly and a lead for better tomorrow. This paper introduces a review for effectiveness of waste materials namely Waste Glass Powder, Waste Paper Sludge Ash, Rice Husk Ash and Saw Dust Ash to be used as green building materials in making Construction industry sustainable and eco-friendly.

Keywords: Waste Glass, Waste Paper Sludge, Rice Husk Ash, Saw dust Ash, compressive strength, lightweight.

I INTRODUCTION

Building and construction activities worldwide consume 3 billion tons of raw materials each year and represent 40 percent of total global use [1]. In addition, integrating green building materials into construction projects can help reduce the environmental impacts associated with the extraction, transportation, processing, fabrication, installation, reuse, recycling, and disposal of construction industry source materials.

In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best approaches. An enormous quantity of waste glass is generated all around the world. In India, 0.7% of total urban waste generated comprises of glass [2]. UK produces over three million tons of waste glass annually [3] Waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete [4]. When waste glasses are reused in making concrete products, the production cost of concrete will go down [5]. This move will serve two purposes; first, it will be environment friendly; second, it will utilize waste in place of precious and relatively costlier natural resources.

Another waste material brought into focus in this research is waste paper sludge ash, a byproduct of paper recycling industry. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low- quality paper fibers are separated out to become waste sludge. Paper mill sludge can be used as an alternative material applied as partial replacement of fine aggregates in manufacturing fresh concrete intended to be used for low cost housing projects [6]. About 300 kg of sludge is produced for each ton of recycled paper. This is a relatively large volume of sludge produced each day that makes making landfill uneconomical as paper mill sludge is bulky. In 1995, the U.S. pulp and paper industry generated about 5.3 million metric tons of mill wastewater-treatment residuals (on oven-dry basis), which is equivalent to about 15 million metric tons of dewatered (moist) residuals. About half of this was disposed in landfills/lagoons, a quarter was burned, one-eighth was applied on farmland/forest, one sixteenth was reused/recycled in mills, and the rest, one sixteenth, was used in other ways [7]. Pulp and paper mill residual solids (also called sludge) are composed mainly of cellulose fibers, moisture, and papermaking fillers (mostly kaolinitic clay and/or calcium carbonate) [8]. The material is viscous, sticky and hard to dry and can vary in viscosity and lumpiness. It has an energy content that makes it a useful candidate as an alternative fuel for the manufacture of Portland cement. Paper sludge is currently in use as an alternative fuel. It is classified as Class 2 (liquid alternative fuels) in the Cembureau classification of alternative fuels. After incinerating paper sludge at approximately 800 0C, the resultant fly ash may contain reactive silica and alumina (in the form of metakaolin) as well as lime (CaO) which contributes chemically to the Portland cement ingredients. As wastepaper sludge ash contains higher percentage of silicon dioxide SiO2, it may provide extra strength to concrete.

Milling of rice generates a byproduct know as husk. The rice grain is protected by husk as its skin. During milling of paddy about 78 % of weight is received as rice, broken rice and bran. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk has about 75 % organic volatile matter and the remaining 25 % of the weight of this husk is converted into ash during the burning process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica. Hence, RHA can act as a good super-pozzolana. For every ton of cement produced, approximately one ton of carbon dioxide is released into atmosphere. The cement industry produces about 5% of global man-made CO_2 emissions. Also cement production leads to disturbance to the landscape, dust and noise and disruption to local biodiversity from quarrying limestone which is raw material for cement production. Moreover rice husk ash is regarded as a waste and has disposal problem because of the fact that it consumes a vast area for dumping. There are numerous ways for disposing it by making commercial use of this rice husk ash. Hence, if waste rice husk ash provides an opportunity to be used as partial replacement of cement in concrete, it will help in reducing the CO_2 emissions, soil pollution and amount of dust into the atmosphere. Moreover its usage in concrete will reduce the cost. About 20 million tons of RHA is produced annually. Rice husk ash which was used in this research finer than cement having very small particle size of 30 microns, so much so that it fills the interstices in between the cement in the aggregate. From previous researches it has been found that Rice Husk Ash minimizes alkali-aggregate reaction, reduces expansion, polishes pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure .The rice husk ash cement on hydration produces practically no Calcium Hydroxide and hence is superior to Portland cement.

Saw dust is a waste material from the timber industry. It is produced as timber is sawn into planks at saw mills located in virtually all major towns in the country. This process is a daily activity causing heaps of saw dust to be generated after each day. The need to convert this waste product into a useful by-product is the focus of the study. Some industrial wastes have been studied for use as supplementar y cementing materials such as Fly ash (Siddique, 2004; Wang and Baxter, 2007; Wang et al., 2008), Silica fume (Lee et al., 2005; Turker et al., 1997), Pulverized fuel ash (Balendran and Martin-Buades, 2000), Volcanic ash (Hossain,2005), Rice husk ash (Waswa-Sabuni et al. 2002) and Corn cob ash (CCA) (Adesanya and Raheem, 2009a; 2009b; 2010; Raheem and Adesanya, 2011; Raheem et al. 2010). Elinwa and Ejeh (2004) considered the effect of the incorporation of waste incineration fly ash (SWIFA) in cement pastes and mortar. Cheah and Ramli (2011) investigated the implementation of wood waste ash as a partial cement replacement material in the production of structural grade concrete and mortar. Elinwa et al. (2008) assessed the fresh concrete properties of self compacting concrete containing saw dust ash. Elinwa and Mahmood (2002) considered ash from timber waste as cement replacement material. The present study considered both fresh and hardened properties of normal concrete in which saw dust ash is incorporated at the point of mix.

II EXPERIMENTATION REVIEW

1. Waste Glass Powder as Partial replacement of Fine Aggregates [9]

Waste Glass Powder was ground and sieved through 1.18 mm IS sieve. Fine aggregates were replaced by waste glass as 10%, 20%, 30% and 40% by weight in M25 concrete mix. Concrete specimens were tested for Compressive Strength, Tensile Strength (Table 1) and light weight character (Table 2).

Table 1 – Compressive strength and splitting tensile strength test results

Waste Glass in %	Cube compressive Strength (N/mm^2)		Cylinder splitting tensile strength (N/mm^2)	
	7 days	28 days	7 days	28 days
0	21.48	28.07	2.12	2.55
10	24.29	33.69	2.08	2.48
20	24.73	35.11	2.02	2.30
30	22.37	30.82	1.80	2.16
40	18.07	25.69	1.63	1.91

Table 2 – Light weight test results for cube specimens of size 150mm x 150mm x 150mm.

Waste glass Content	Average dry weight of cubes (g)	Dry density (KN/m^3)	Percentage change in weight with respect to reference M25 cubes
0%	8382	24.83	0%
10%	8343	24.72	- 0.456%
20%	8235	24.40	- 1.753%
30%	8130	24.10	- 3.006%
40%	7952	23.56	- 5.130%

2. Partial Replacement of cement and fine aggregates by waste paper sludge ash and waste glass respectively [10]

In this experiment, fine aggregates were replaced by waste glass powder and cement by waste paper sludge ash simultaneously for M25 concrete mix with varying percentages (Table 3) and were tested for Compressive Strength, Tensile Strength (Table 3) and light weight character (Table 4).

Table 3 – Compressive strength and splitting tensile strength test results of concrete waste glass and waste paper sludge ash in combination.

Waste Paper sludge ash in %	Waste Glass %	Cube compressive Strength (N/mm^2)			Cylinder splitting tensile strength (N/mm^2)		
		7 days	28 days	60 days	7 days	28 days	60 days
0	0	21.48	28.07	29.78	2.12	2.55	2.74
5	10	22.82	33.78	35.83	2.08	2.51	2.64
10	10	22.15	32.73	34.72	2.01	2.39	2.50
5	20	26.07	36.14	38.34	1.91	2.26	2.39
10	20	23.77	33.62	35.61	1.80	2.15	2.28
5	30	23.33	32.00	33.93	1.84	2.26	2.36
10	30	20.67	26.90	28.54	1.91	2.33	2.48

Table 4 – Light weight test results for concrete cube specimens with waste glass and waste paper sludge ash in combination.

Paper Sludge Ash %	Waste Glass %	Avg. Dry weight of cube (gm)	Avg. dry density of cube (KN/m^3)	Percentage change in weight as compared to reference (%)
0	0	8382	24.83	0%
5%	10%	8318	24.65	- 0.763%
10%	10%	8255	24.46	- 1.515%
5%	20%	8180	24.24	- 2.490%
10%	20%	8080	23.94	- 3.600%
5%	30%	8025	23.78	- 4.260%
10%	30%	7995	23.69	- 4.610%

3. Rice Husk Ash as Partial replacement of Cement [11]

In this experiment, cement was replaced by Rice Husk Ash for M25 concrete mix with varying percentages (Table 5) and were tested for Compressive Strength, Tensile Strength at 7 days and 28 days (Table 5) and light weight character (Table 6).

Table-5 Compressive strength test results

Waste RHA %	Avg. load @ 7days (KN)	Avg. Load @ 28 days(KN)	Avg. Compressive Strength @7 days(N/mm^2)	Avg. Compressive Strength @28 days(N/mm^2)
0%	498	678	22.13	30.13
5%	530	690	23.55	30.67
10%	580	700	**25.78**	**31.11**
15%	490	670	21.78	29.78

Table 6 – Light weight test results for cube specimens of size 150mm x 150mm x 150mm

Waste RHA %	Avg. Dry weight of cube (gm)	Avg. dry density of cube (KN/m^3)	Percentage change in weight as compared to reference (%)
0%	8390	24.86	0%
5%	8350	24.74	- 0.483%
10%	8225	24.37	- 1.971%
15%	8110	24.03	- 3.339%

4. Saw Dust Ash as partial replacement of Cement [12]

In this experiment, the authors have replaced cement by saw dust ash for M25 concrete mix with varying percentages (Table 7) and were tested for Compressive Strength, Tensile Strength (Table 7) and light weight character (Table 8).

Table-7 Compressive strength test results

Saw Dust Ash %	Avg. load @ 7days (KN)	Avg. Load @ 28 days(KN)	Avg. Compressive Strength @7 days(N/mm^2)	Avg. Compressive Strength @28 days(N/mm^2)
0%	530	620	23.55	27.55
5%	564	730	25.06	32.44
10%	550	680	**24.44**	**30.22**
15%	450	500	20.00	22.22
20%	375	420	16.66	18.66

Table 8 – Light weight test results for concrete cube specimens with Saw Dust ash in combination.

Saw Dust Ash %	Avg. Dry weight of cube (gm)	Avg. dry density of cube (KN/m^3)	Percentage change in weight as compared to reference (%)
0	8260	24.47	0%
5%	8352	24.75	- 0.358%
10%	8225	24.37	- 1.870%
15%	8115	24.04	- 3.185%
20%	7998	23.70	- 4.580%

III RESULTS AND CONCLUSION

i. Waste Glass Powder as Partial replacement of Fine Aggregates

1. 20% replacement of fine aggregates by waste glass showed 15% increase in compressive strength at 7 days and 25% increase in compressive strength at 28 days.
2. Fine aggregates can be replaced by waste glass up to 30% by weight showing 9.8% increase in compressive strength at 28 days.
3. Splitting tensile strength decreases with increase in waste glass content.
4. With increase in waste glass content, average weight decreases by 5% for mixture with 40% waste glass content thus making waste glass concrete light weight.
5. Use of waste glass in concrete can prove to be economical as it is non useful waste and free of cost.
6. Use of waste glass in concrete will eradicate the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.
7. Use of waste glass in concrete will preserve natural resources particularly river sand and thus make concrete construction industry sustainable.

ii. Partial Replacement of cement and fine aggregates by waste paper sludge ash and waste glass respectively

1. 20% replacement of fine aggregates by waste glass showed 15% increase in compressive strength at 7 days and 25% increase in compressive strength at 28 and 60 days.
2. Fine aggregates can be replaced by waste glass up to 30% by weight showing 9.8% increase in compressive strength at 28 and 60 days.
3. Cement in concrete can be replaced by waste paper sludge ash up to 5% by weight showing 15% increase in compressive strength and 5% increase in splitting tensile strength at 28 and 60 days.

4. Simultaneous utilization of waste glass and waste paper sludge ash showed 28.7% maximum increase in compressive strength for 20% waste glass and 5% waste paper sludge ash combination.
5. Use of waste glass and waste paper sludge ash in concrete can prove to be economical as it is non useful waste and free of cost.
6. Use of waste glass and waste paper sludge ash in concrete will eradicate the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.

iii. Rice Husk Ash as Partial replacement of Cement

1. 10% replacement of cement by waste rice husk ash showed 16% increase in compressive strength at 7 days and 3.25% increase in compressive strength at 28 days.
2. The optimum value for cement replacement is 10%.
3. With increase in waste rice husk ash content, average weight decreases by 3.34% for mixture with 15% waste rice husk ash content thus making waste rice husk ash concrete light weight.
4. Use of waste rice husk ash in concrete can prove to be economical as it is free of cost.
5. Use of waste rice husk ash will eradicate its disposal problem and reduce carbon emissions (CO_2) thus proves to be environment friendly thus paving way for greener concrete.

iv. Saw Dust Ash as partial replacement of Cement

1. SDA is a suitable material for use as a pozzolan, since it satisfied the requirement for such a material by having a combined (Sio2+Al2O3+Fe2O3) of more than 70%.
2. The compressive strength generally increases with curing period and decreases with increased amount of SDA. Only 10% substitution is allowed at maximum and 5% substitution is adequate to enjoy maximum benefit of strength gain.
3. Use of saw dust ash in concrete can prove to be economical as it is non useful waste and free of cost.
4. Use of saw dust ash in concrete will eradicate the disposal problem of saw dust and prove to be environment friendly thus paving way for green concrete.
5. Use of saw dust ash in concrete will preserve resources particularly cement and thus make concrete construction industry sustainable.

We can effectively use these waste materials as partial replacement of fine aggregates and cement in concrete thus preserving the environment from pollution, saving nonrenewable resources from depleting, eradicating demand for dumping site for these waste materials, reducing CO_2 emissions and above all making the concrete industry SUSTAINABLE and GREEN.

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