Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 9; April-June, 2015 pp. 756-757

http://www.krishisanskriti.org/jbaer.html

# Analysis of Coal Waste and Waste Glass Recycling to Cast Paving Blocks

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**Abstract—***In this paper a parametric study for manufacture paving block from coal waste and waste glass is presented. Waste created by a typical coal plant includes more than 125,000 tons of ash and 193,000 tons of sludge from the smokestack scrubber each year which pose a severe disposal problem for any nation. Similarly glass is a large component of household and industrial waste usually in form of bottles, broken glassware, light bulbs and other items. A paver is stone, tile or brick-like piece of concrete commonly used as exterior flooring, roads, driveways, walkways and other outdoor platforms. The methodology considered in this paper includes sampling of a coal mining waste and glass waste, gravity separation of the fraction, comminution of the material and particle size analysis; technological characterization of the material and the production of concrete paving blocks. The results showed that the coal waste and glass waste considered in this work can be used to replace conventional sand as a fine aggregate for concrete paving blocks*

## 1. INTRODUCTION

Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing [1]. Glass is an ideal material for recycling. The use of recycled glass in new container helps save of energy. It helps in brick and ceramic manufacture, and it conserves raw materials, reduces energy consumption, and the volume of waste sent to landfill [2]. Coal ash pollution contains high levels of toxic heavy metals such as arsenic, lead, selenium, and other cancer causing agents. The public health hazards and environmental threats to nearby communities from unsafe coal ash dumping have been known for many years, including increased risk of cancer, learning disabilities, neurological disorders, birth defects, reproductive failure, asthma, and other illnesses. Paver blocks made of different materials have been in use since thousands of years. Concrete block paving offers outstanding strength and durability and is resistant to most chemicals. Block paving is suitable for a range of applications from ultra-heavy duty areas, such as industrial units, container stacking yards and airport pavements, to lightly trafficked residential areas and hard landscaping projects. Waste glasses are used as aggregates for concrete [3-4]. However, the applications are limited due to the damaging expansion in the concrete caused by ASR between high-alkali pore water in cement paste and reactive silica in the waste glasses. The chemical reaction between the alkali in Portland cement and the silica in aggregates forms silica gel that not only causes crack upon expansion, but also weakens the concrete and shortens its life [5]. Ground waste glass was used as aggregate for mortars and no reaction was detected with fine particle size, thus indicating the feasibility of the waste glass reuse as fine aggregate in mortars and concrete. In addition, waste glass seemed to positively contribute to the mortar micro-structural properties resulting in an evident improvement of its mechanical performance [6]. Recently, some studies are carried out to suppress the ASR expansion in concrete and find method to recycle waste glasses [7-8]. The concrete containing 20% waste glass reduced the expansion ratio by 40% [9]. Shayan and Xu [10] reported fine glass powder for incorporation into concrete up to 30% as a pozzolanic material suppressed the ASR. Coal ash can be converted to a binding material by activating with alkaline solution [11]. Geopolymer made of waste materials like fly ash have smaller carbon footprint compared to OPC [12]. According to Davidovits Geopolymer technology was used by Egyptians to build pyramids [13].

## 2. METHODOLOGY

1. Samples were collected from four drill holes in the waste deposit, from rourkela coal reserve and coal waste from steel plant.
2. The white windows glass as waste is collected from windows glass market as broken pieces.
3. The sample was screened to separate the “coarse” fraction (-50.8mm + 2.0mm), “fine” fraction (-2.0mm +0.5mm) and the “ultra-fine” fraction (-0.5 mm),.
4. The coarse and fine fractions were submitted to a laboratory dense medium tests.
5. A total of seven series of mixtures are prepared in the laboratory trials according to the requirements of BS 6717 [14] and TS 2824 EN 1338 [15].

6. In the mixing process of samples, waste glass, coal waste and cement contents are placed in a concrete mixer and mixed for 1 min as dry. Details of mix is given in table 1.

**Table 1: Mix Propotion Details**

| MIXTURE NO. | WATER(kg/mm3) | CEMENT(kg/mm3) | WASTE GLASS(kg/mm3) | COAL WASTE(kg/mm3) |
|---|---|---|---|---|
| 1 | 121 | 350 | 0 | 1100 |
| 2 | 121 | 350 | 110 | 990 |
| 3 | 121 | 350 | 220 | 880 |
| 4 | 121 | 350 | 330 | 770 |
| 5 | 121 | 350 | 110 | 990 |
| 6 | 121 | 350 | 220 | 880 |
| 7 | 121 | 350 | 330 | 770 |

7. Then, water is poured into concrete mixer for another 3 min. Afterward, the fresh mixes are fed into the steel moulds with internal dimensions of 105×75×225 $mm^3$.
8. The steel moulds are filled over with material and the initial depth of materials covering the mould is approximately 85 mm.
9. A pressure force of 17 MPa is applied for 1 min to compact the materials in the mould
10. The formed paving blocks are then removed from the moulds and cured under thewater according to the rule [15] for 28 days
11. After 28 days of curing, the paving block samples are tested for water absorption. After obtaining the saturated weight content, they are placed into an oven at 105 °C and dried to a constant mass for 28 hours, and then taken out from the oven and weighted at the room.

## 3. RESULT AND DISCUSSION

Table 2 and 3 show the averaged mechanical and physical test results obtained from the tests, respectively. The test results showed that the unit weight and absorption values are approximately similar in the all paving block samples.

**Table 2: Mechanical Properties**

| MIX NO. | COMP. STRENGTH (Mpa) | FLEXURE STRENGTH (Mpa) |
|---|---|---|
| 1 | 31.5±1.5 | 3.41±0.23 |
| 2 | 30.9±1.0 | 5.09±0.12 |
| 3 | 28.8±1.7 | 3.77±0.18 |
| 4 | 39.7±4.5 | 3.89±0.68 |
| 5 | 34.7±3.2 | 6.48±0.60 |
| 6 | 23.5±2.5 | 4.17±0.72 |
| 7 | 25.2±2.5 | 3.93±0.4 |

**Table 3: Physical Properties**

| MIX NO. | VOLUME LOSS ON WEAR (cm3/50 cm2) | UNIT WEIGHT(g/cm3) | ABSORPTION % |
|---|---|---|---|
| 1 | 11.95±1.42 | 2.18±0.01 | 6±0 |
| 2 | 10.82±2.75 | 2.19±0.03 | 7±0 |
| 3 | 14.11±1.02 | 2.17±0.03 | 6±1 |
| 4 | 11.48±1.05 | 2.20±0.02 | 7±0 |
| 5 | 10.18±0.44 | 2.16±0.02 | 6±1 |
| 6 | 10.93±3.68 | 2.16±0.06 | 6±1 |
| 7 | 10.93±0.94 | 2.18±00.2 | 7±1 |

## 4. CONCLUSION

It was possible to process coal waste and waste glass to obtain a recycled fine aggregate (RFA) that can be used in civil construction. Concrete blocks for paving produced with 25% and 50% of RFA in substitution of sand presented satisfactory results in terms of mechanical strength. The use of coal waste as a fine aggregate and glass as fusing component to bind the mix for concrete block paving manufacture presents technical viability and environmental benefits. It would be valuable to investigate the durability properties of these paving blocks in the future work.

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