RESEARCH ARTICLE

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A Preliminary Study on the Performance of Fly Ash Coating on M15 Block of Battery Waste Slag: Solidification/ Stabilization Process

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ABSTRACT

A Solidification/ Stabilization performance of lead containing battery waste slag with cement matrix was studied. The samples of an industrial battery waste slag were used in experimental work. Heavy Metal Characterization of battery waste slag by Atomic Absorption Spectrometry (AAS) revealed that battery waste slag contains a certain percentage of lead and Chromium. Dissolving of the slag components causes migration of ions into water that can induce a significant pollution of environment. The influence of concrete block composition was the evaluated for fly ash coated and without fly ash coated block. For Mandatory requirement also available leaching test [NEN- 7341] to evaluate the leaching behavior of coated and without coated concrete block. The result revealed that Unconfined Compressive Strength were observed in the range of 6.51- 25.66 mpa without coated concrete block and coated block with 2.9 mpa - 17.67 mpa.

INTRODUCTION

Lead is one of the essential and most widely used metals in the industrial world. Globally the lead production in world up to 70 % which is used in battery industry and scrap automotive batteries are a major source of lead Knežević, Korać, Kamberović, & Ristić, 2010; Štulović *et al*., 2013).

The battery industry represents one important and growing sector where the use of non-toxic and non-hazardous substitute materials has not rapidly developed. As regulations increase and concern for the environment and human health becomes more prevalent, the fate of toxic and hazardous materials in the environment should be more carefully considered (Pan, Zhang, & Liu, 2015).

Lead-acid storage batteries are widely used on a mass-scale in all parts of the world. Lead-acid batteries contain sulphuric acid and large amounts of lead. The acid is extremely corrosive and is also a good carrier for soluble lead and lead particulate (Zafar, 2016).

More than eighty thousand tons of lead-acid batteries are destroyed with every year as a hazardous waste. Solidification/Stabilization has been considered as an alternative solution to the disposal of slag containing heavy metals. Solidification is a process, in which wastes are mixed with various binding materials to obtain a new product with improved physical properties and compressive strengths of waste, in which the subsequent is reduced (Filibeli, Buyukkamaci, & Senol, 2000). Portland cement is the most is the most commonly used binder for this process. High pH of this binder is effective in immobilizing many toxic metals, by precipitation and sorption reaction (Malviya & Chaudhary, 2006).

The aim of this work was to determine the compressive strength and amount of lead leached from solidified battery waste slag using Cement and Fly ash as the binders through solidification/stabilization process.

MATERIALS AND METHODS

Waste and Binder

A composite grabe sample obtained fromautomotive battery industry. Ordinary Portland cement (OPC) (53 grade) and Aggregate (fine + coarse aggregate) used as binder. Fly ash used as a coating of concrete block to immobilized the metal ions. Heavy metal content of slag, Ordinary Portland cement (OPC) & Fly ash was also determined and is presented in Table 1.

Preparation of Solidified/Stabilized Sample and Curing

The products were prepared through mixing different ratios of sludge with OPC, sand, aggregate and water. The mixture was compacted, vibrated, and molded in a cubical mold of dimensions 5x5x5 (in inch). The concrete samples were prepared according M15 grade of concrete. The cubes were unmolded after 24h and samples were cured for 7 days. Sample's mixing and cube preparation have done according IS 9013:1978 (IS:, 1978). Samples were cured for 7 days by dipping in water for 7 days and were subjected tounconfined compressive strength testing and available leaching test.

Combination of Cement + Lead slag + Aggregate (Fine Aggregate Sand + Coarse Aggregate).

Unconfined Compressive Strength (UCS)

The mechanical strength was evaluated by compressive strength carried out according to ASTM D 1633-84 & IS9013:1978 (Environmental, 1990; IS:, 1978). on three samples of each composition, using a Standard Universal Testing Machine. Cube of dimension 5x5x5inch cured for a period of 7 days were tested for strength on Universal Testing Machine(Enky Machines).The cubes were unmolded after 24 hours

IS456:2000 grade proportions M15 was used for making concrete mould. The percentage of waste is varied in the mould taking it from 0 % to 80 % as given below in Table 2.

Table 1: Heavy Metal content lead slag, cement and Fly ash

	Lead (mg/kg)	*Chromium (mg/kg)*
Lead Slag	3100	413
Cement	183	95
Fly Ash	248	41

LEACH TEST

Available Leaching

NEN 7345 is used to determine the leaching mechanism of heavy metals from solidified/stabilized product. During available leaching the solid was pulverized and mixed with leachate. The suspension was then tumbled for 3 hours at pH 4 and 18 hours at pH 7 and separation of the extract solution from solid was achieved by filtration. Leachates were analyzed through atomic absorption spectrophotometer. The leaching data was normalized with dry waste concentration and pH of the solutions was maintained by the acid (HNO_3)/alkali (NaOH) addition.

RESULT AND DISCUSSION

The effect of Unconfined Compressive Strength and leaching rate of without coated and fly ash coated mould was studied for 7 days curing.

Table 3 revealed compressive strengths of the mixtures differ according to the proportions of the additives. Among the without coated, the highest strength was

Table 2: Different Combination Of Concrete Block Sample of Without coated(WC) and with Coated(C)

Sample no.	*Waste %*	*Waste quantity (g)*	*Cement (g)*	*Sand + aggregate (g) [1:1]*
1	0	0	214.5	86
2	20	43	171.5	86
3	40	86	129	86
4	50	107.5	107.5	86
5	60	129	86	86
6	80	117.5	43	86

Table 3: Unconfined Compressive Strength (UCS) and Available Leaching at 7 days curing

Without Coated (WC)						*Coated (C)*				
				Available Leaching					*Available Leaching*	
S. No.	*Sample coding*	*UCS in (MPa)*	*Water consume (ml)*	*Pb (mg/kg)*	*Cr (mg/kg)*	*UCS in (MPa)*	*Sample coding*	*Water consume (ml)*	*Pb (mg/kg)*	*Cr (mg/kg)*
1	WC1	25.66	45	83	BDL	17.67	C1	45	109	BDL
2	WC2	26.93	50	186	BDL	13.39	C2	50	207	BDL
3	WC3	20.51	58	310	BDL	12.16	C3	58	372	BDL
4	WC4	18.22	65	392	BDL	11.37	C4	65	455	BDL
5	WC5	17.9	75	415	BDL	10.3	C5	75	579	BDL
6	WC6	6.51	90	682	BDL	2.9	C6	90	806	BDL

BDL* Below Detectable Level

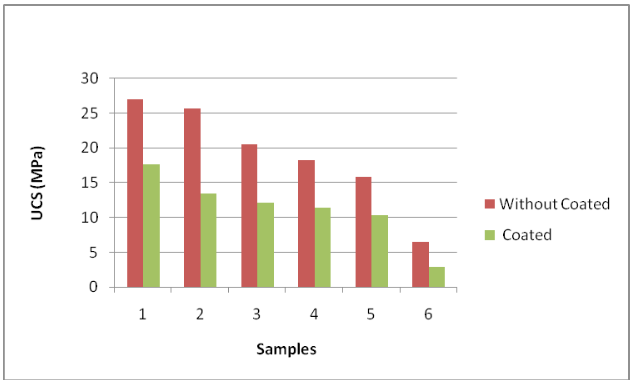

Figure 1: Unconfined compressive strength (UCS) of without coated (WC) and coated(C) samples at 7 days curing

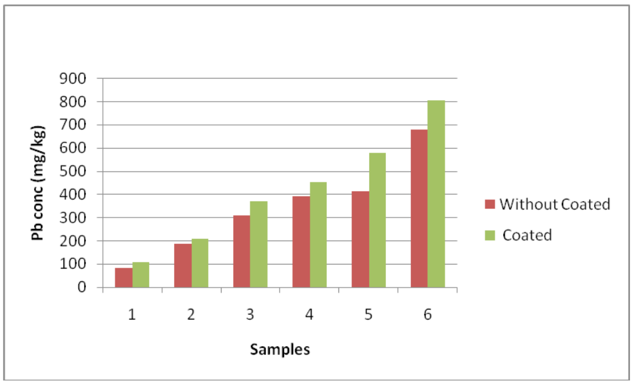

Figure 2: Leaching of Pb in without coated (WC) and coated(C) samples at 7 days curing

obtained sample WC1 mixture (25.66 MPa), while the lowest was obtained in the sample WC6 (6.51 Mpa). In the coated sample the highest strength was obtained C1 mixture (17.67MPa) and the lowest was obtained in the sample C6 (2.9Mpa). Strength of Without Coated (WC) sample is higher than Coated (C) sample (Figure 1). It is seen that the compressive strengths depended on the changes in the percentages of slag and cement in the mixture. It was observed that when the ratio of slag was increased, the compressive strength was decreased. Figure 1 shows solidified specimen WC6, C5, C6, to have low compressive strengths because of the low ratio of cement to slag. When the ratio of cement was raised and the ratio of slag was reduced, the compressive strength was increased. This can be seen from sample WC1, to WC5, and C1 to C4. This clearly shows that the water content of the material has a direct effect on the compressive strength and that increase in the water content of the mixture, decreases the compressive strength Table 3.

Leaching of Pb in coated samples is more than without coated (WC) samples. Among the without coated sample highest leaching of Lead was obtained in WC6 mixture (682mg/kg), while the lowest was obtained in the sample WC1 (83 mg/kg). In the coated sample the highest leaching was obtained C6 mixture (806 mg/kg), the lowest was obtained in the sample C1 (109 mg/kg) Table 3 & Figure 2. Chromium for all the samples was below detectable level (BDL) Table3. It is seen that the leaching depended on the changes in the percentages of slag and cement in the mixture. Samples WC1 to WC5, C1due to high percentage and low percentage of waste, it reveals in the low leaching of lead.

CONCLUSION

Solidification/Stabilization of Battery waste lead slag seems to be an effective method of reducing their environmental impact.

Whereas without coated sample from WC1 to WC5 shows Unconfined Compressive Strength greater than 15 MPa (as per IS-456 of 2000). Sample WC1 and WC2 show 1.5 times value as compare to others. While only C1 of coated sample revealed slightly higher strength as compare to above standard value. The rate of leaching was followed an increasing pattern from without coated sample WC1 to WC6. Similarly, the same behavior was followed in coated sample C1 to C6. It is finally concluded that without coated sample may be used as ordinary concrete block.

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