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EFFECTIVE DISPOSAL OF CHROMIUM LADEN WASTE USING REGULAR CONCRETE BLOCK

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Abstract. *With the advent of industrialisation waste generation has also increased drastically. In India 0.4 million tonnes of hazardous waste is produced annually. This waste is disposed off either by incineration or by dumping in a landfill. In landfill leachate is produced which is highly toxic and leaches out minerals from the waste. This leachate comprises of heavy metals such as chromium, lead, arsenic, etc. when this leachate percolates through landfill then it contaminates ground water and soil. Therefore present study aims at stabilisation and effective disposal of chromium laden solid waste in regular concrete blocks of different matrices(cement, lime, flyash & gypsum). Seven mixes of concrete and solid waste were made. Solid waste replaced concrete partly from 0 to 40%. Variation in compressive strength and leachability of chromium was observed in the mixes. The Mix-2 containing 20% waste, 100% cement as cementitious binder showed the best result. The compressive strength(after 28 days) of Mix-2 is 13.32 N/mm^2 and the chromium leached from the Mix-2 after permeability test is 0.2176 mg/l.*

Keywords: Chromium, hazardous waste, landfill, leachate, stabilisation, concrete.

1 Introduction

India's 2500 tanneries produce 2400 million cubic metres of waste water and 0.4 million tonnes of hazardous waste[1]. Improper disposal of effluents from these tanneries results in degradation of environmental quality[2]. Disposal of hazardous waste in india is done either by incineration or by dumping in a industrial landfill[3]. Hazardous Waste(HW) when dumped in landfill produces leachate which is highly toxic. Leachate is a viscous fluid that passes through a landfill and leaches out dissolved and suspended matter from it[4]. Industrial landfills may render critical environmental impacts if leachate and gas emissions are not regulated. Leachate produced in industrial landfill comprises huge amounts of inorganic pollutants[5]. Leachate also comprises of heavy metals and hazardous organic chemicals such as chromium, arsenic, lead, etc.[6]. This leachate when percolated with precipation and surface runoff can potentially contaminate ground water and soil[7]. Chromium as a contaminant in water poses severe adverse effects on plants and animals. Chromium(Vl) is highly carcinogenic and may also cause mutations[8].

This paper presents the stabilisation of chromium laden solid waste by solidifying it in the regular concrete block of M-10 grade of different cementious matrices(cement, fly ash, lime and gypsum). Seven mixes of different mix ratios of cementitious binders and waste as shown in Table 1 were made. Water to the cement plus waste ratio was kept constant for all the mixes i.e. 0.87. Variation in the compressive strength of concrete and leachability of chromium from matrices was observed.

Table 1. Composition of different mixes of concrete of M10 Grade(in weight %)

S. No.	*MIX*	*Cement (in %)*	*FlyAsh (in %)*	*Lime (in %)*	*Gypsum (in %)*	*Sand (in %)*	*Aggregate (10 mm) (in %)*	*Aggregate (20 mm) (in %)*	*Waste (in %)*
1	Mix 0	100	-	-	-	100	50	50	-
2	Mix 1	100	-	-	-	100	50	50	10
3	Mix 2	100	-	-	-	100	50	50	20
4	Mix 3	80	-	20	-	100	50	50	20
5	Mix 4	80	20	-	-	100	50	50	30
6	Mix 5	70	10	10	10	100	50	50	30
7	Mix 7	90	-	-	10	100	50	50	40

2 Experimental Procedure

2.1 Materials and Methodology

Tannery sludge obtained from common effluent treatment plant, jajmau, Kanpur was used. Locally available PPc cement and sand were used alongwith lime, fly ash and gypsum as cementitious binders. Fly Ash was obtained from Panki Thermal Power Plant, Panki, Kanpur.

T60 Spectrophotometer was used for determination of chromium content. 540 nm wavelength with light path of 1cm was used in the procedure.

2.2 Determination of Chromium Content in Tannery Sludge

Preparation of sample was done as per IS code 3025 (part-1)[9]. Then concentration of chromium was determined by following the procedure mentioned in IS code 3025 (part-52)[10]. The tannery sludge was checked for chromium content in spectrophotometer of 540nm wavelength with light path of 1 cm. The sample had 5.2833 mg/l of hexavalent chromium with absorbance value of 1.563.

2.3 Preparation of Concrete Cubes

Concrete cubes of size 150mm of M10 grade were prepared by following the procedure as per IS code 516[11]. The water/cement ratio was taken as 0.68 for the standard mix(Mix 0). The water to the cement plus waste ratio for the cubes in which waste was partly replaced was 0.87(for mixes Mix 1 to Mix 6). The cubes were made for checking the compressive strength of concrete after 7 days and 28 days. The procedure followed for checking the compressive strength of concrete was as prescribed in IS code 516[11]. The average value of three samples was taken for the compressive strength of concrete.

The solid sludge was partly added to the concrete mixes(Mix 1 to Mix 6) by replacing sand in the mixtures from Mix 1 to Mix 3 and by replacing coarse aggregate in the mixtures from Mix 4 to Mix 6. Total 6 cubes for each mix was prepared to be tested for compressive strength after 7 days and 28 days. The compression testing machine of capacity 200 tonnes was used in the process.

2.4 Preparation of Concrete Cylinders

Concrete cylinders of size 150mm diameter and 150 mm height were prepared for testing the permeability of concrete mixes. The procedure followed for the permeability test of concrete was adhered to IS code 3085[12]. The permeabilty test on concrete was done after 28 days on cylinders. The pressure head of water was kept 10kg/cm^2 in the permeability apparatus. Total 3 cylinders were made for each mix and the average value of the three samples is taken for permeability of concrete mix. The leachate produced after permeability test was collected. The leachate produced was further checked for chromium content as per IS code 3025(part-52)[10].

3 Results and Discussion

The effect of waste on the compressive strength of mixes of concrete and permeability of concrete was investigated. The results are discussed in the following sections.

3.1 *Compressive Strength*. The results of compressive strength of concrete cubes of mixes(from Mix 0 to Mix 6) are shown in fig. 3. It can be seen that early strength gain of concrete blocks was less than 65% of the total strength in 28 days. The 7 days compressive strength of the concrete blocks ranged between 4 to 10 MPa. The 28 days compressive strength of the concrete blocks ranged between 7 to 17 MPa for M10 grade of concrete. The 7 and 28 days compressive strength of Mix 0(standard mix) was 10.40 MPa and 17.34 MPa respectively. The 7 days strength gain of the mixes was reported to be 60%. With the increase of waste % in the concrete the strength of concrete decreased. **Table 2** shows the decrease % of strength with increase % of waste in the mixes. The Mix 5 showed the optimised result of compressive strength which has 6.12 MPa and 10.46 MPa as 7 day and 28 day compressive strength respectively.

3.2 *Permeability of Concrete*. The results of permeability of concrete cylinders of mixes(from Mix 0 to Mix 6) are shown in fig. 4. It can be seen that permeability of concrete increases with increase of waste % in the concrete. **Table 3** shows the increase % of permeability with increase % of waste in concrete. The Mix 5 showed the optimised results of permeability with just 26.74% increase.

3.3 *Chromium content*. The results of the hexavalent chromium determination in the leachate collected after permeability test of the mixes(from Mix 0 to Mix 6) are shown in fig. 5. It can be seen that chromium content in the leachate increased with the increase in waste %. The hexavalent chromium in the leachate produced was reduced in the amount as it was present in the sludge.

Table 2. *Decrease % of compressive strength of 28 days with increase in waste %*

Mix 0	*Mix 1*	*Mix 2*	*Mix 3*	*Mix 4*	*Mix 5*	*Mix 6*
Standard mix	9.34	23.18	46.30	52.54	39.68	56.98

Table 3. *Increase % in permeability with increase in waste %*

Mix 0	*Mix 1*	*Mix 2*	*Mix 3*	*Mix 4*	*Mix 5*	*Mix 6*
Standard mix	2.67	4.80	7.40	19.25	26.74	29.95

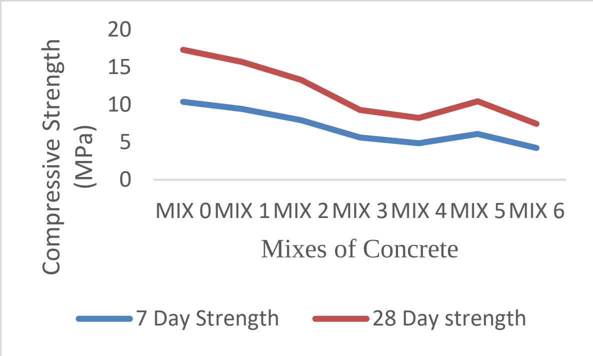

Fig. 3. Compressive Strength of Concrete Cubes After 7 Days And 28 Days.

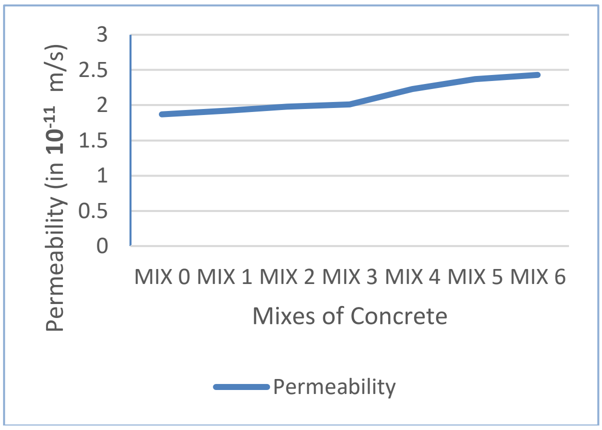

Fig. 4. Permeability of Concrete Cylinders After 28 Days.

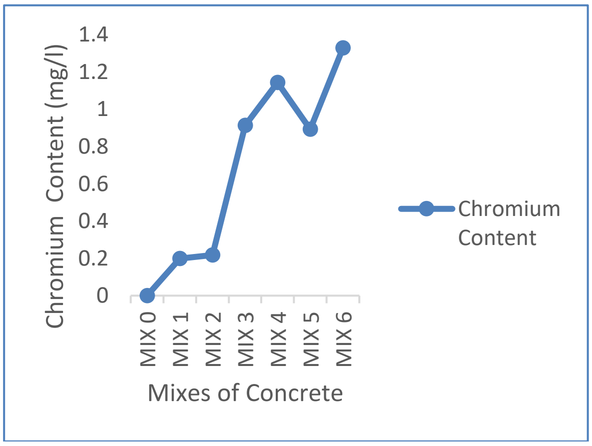

Fig. 5. Chromium Content in Leachate Produced.

4 Conclusions

The following conclusions can be drawn based on the experimental study.

1. The solid sludge solidified and became immobile in all the cementitious matrices.
2. The compressive strength of concrete decreased with increase in percentage of waste in concrete. The waste replacement from 20% to 30% was found to be suitable and economical. The strength values for all the mixes were greater than the minimum value prescribed in EPA guidelines[13]
3. The permeability of concrete increased with the increase in percentage of waste. The permeability value was optimum upto 20% waste replacement.
4. The part replacement of cement with fly ash,lime and gypsum increased the strength of concrete. The part replacement of cement will result in recycling of fly ash(waste product of thermal power plants). The CO_2 emissions will also reduce.
5. The hexavalent chromium in the leachate was reduced upto 83% for waste replacement upto 30%. The value of hexavalent chromium content are much below than the values prescribed in CPCB[3].
6. The cement matrix of cement, lime, fly ash and gypsum with waste upto 30% was most optimised matrix.

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