A Case Study on Effect of Lead Effluent from Batteries on Soil Properties.

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***Abstract*— Recent method of construction requires not only basic study of the foundation materials, but also a well developed knowledge of the reasons responsible to the modifications in the course of the life of the structures resisted by it. The major source of surface and subsurface contamination are land disposal of industrial, mining, agricultural wastes and accidental spillage of chemicals during the course of industrial operations. . The unintended modification of soil properties due to interactions with contaminants can lead to various geotechnical problems. Lead–acid batteries also know as storage batteries are used primarily in automobiles, trains and other motor vehicles. As the name implies, lead acid batteries contain predominantly lead and sulphuric acid. In the present investigation, Battery effluent obtained from an industry situated near the pilgrim town of Tirupati has been added as contaminated to the Local soil collected from the CRS area near Tirupati. Soil properties has changed like Atterberg limits increases, Swell index increases, Unit weight of soil decreases, Unconfined Compressive Strength decreases, CBR value decreases with increase in Lead content. cohesion of soil decreases and Angle of internal friction increases with increase in Lead**

Index terms— Effect of battery effluents, Atterberg limits, swell index, pH, CBR, UCS, Shear parameters.

I.INTRODUCTION

The Bulk wastes from industrial, commercial, mining, agricultural and domestic activities cause soil and ground water contamination. The leachate can move down under gravity and contaminate the ground water resources. The polluted water will attack foundation structures such as footings, caissons, piles, and sheet piles. If the polluted water is used for mixing concrete, it will affect the workability and durability of the concrete. In embankment construction, the moisture-unit weight relationship of soil also will be affected. Hence, providing engineering solutions to minimize surface and subsurface contamination has become the dominant concern of governmental regulatory agencies and of geotechnical engineers. The lead battery contains of 17 percent metallic lead, 50 percent of lead oxide/sulfate, 24 percent of electrolyte, 5 percent of plastics and 4 percent of inert residuals. A mixture of 10% percent lead monoxide and 30% metallic lead, are used to manufacture lead acid batteries. Lead monoxide is the most key component of lead, based on volume. Waste battery paste has been analyzed by standard methods (APHA 1997). The composition consists of lead monoxide: 27.77%, lead sulfate: 63.08%, free lead: 7.44%, total lead: 75.42% (LOA technical notes, 1992).

TABLE I.
PROPERTIES OF LEAD

Atomic Number	82
Atomic Weight	207.21
Density , g/cc	11.34g/cc
Tensile Strength , Ultimate	18MPa
Modules of Elasticity	14GPa
Poisson's Ratio	0.42
Melting Point 0c	327 Deg
Boiling Point 0c	175 Deg

A. properties considered in this investigation:
1. Plasticity Characteristics
   (i)Liquid Limit
   (ii)Plastic Limit
   (iii)Plasticity Index
2. Hydrogen ion concentration (pH)
3. Swelling Characteristics
   (i)Differential Free Swell Index (DFSI)
   (ii)Swelling Pressure
4. Compaction Characteristics
   (i)Maximum Dry Unit Weight (MDU)
   (i)Optimum Pore Fluid Content (OPC)
5. California Bearing Ratio (CBR) Values
6. Strength characteristics
   (a)Unconfined Compression Strength
      (i)Effect of curing period
      (ii) Effect of pore fluid content
   (b)Triaxial Compression Strengt

II. LITERATURE REVIEW

Karen D bradhamand Elizabeth a Dayton (2006) have investigated Effect of soil properties on lead bioavailability and toxicity. **F. Gil Stores and C. Traser–cepeda (2004)** established different approaches to evaluating soil quality using biochemical properties. **W. J. Bond (1998)** have studied Effluent irrigation—an environmental challenge for soil science. **Zhen-Guo Shen, Xiang-Dong Li et.al (2001)** have investigated Lead Phytoextraction from Contaminated Soil with High Biomass Plant Species. **Dr.jevan singh and Ajay.s. kalamdhad (2011)** have investigated the effect of Heavy metals on soil, Human, health and Aquatic life..

III. MATERIALS USED

SOIL: The crystalized and powdered material passing through I.S.4.75 mm sieve is taken for the examination. The soil is classified as 'SC' as per I.S. Classification (IS 1498:1978) indicating that it is clayey sand. The properties of the soil are given in below Table. It is highly expansive in nature as the (DFSI) Differential Free Swell Index is about percent.

TABLE II.
PROPERTIES OF THE UNCONTAMINATED SOIL

SI.No.	Property	Value
1.	Grain size distribution	
	(a)Gravel (%)	2
	(b)Sand (%)	67
	(c)Silt and Clay (%)	31
2.	Atterberg Limits	
	(a) Liquid Limit (%)	77
	(b)Plastic Limit (%)	30
	(c) Plasticity Index (%)	47
3.	Differential free swelling Index (%)	254.54
4.	Swelling pressure (kN/m^2)	246
5.	Specific gravity	2.76
6.	pH value	8.45
7.	Compaction characteristics	
	(a) Maximum dry unit weight (kN/m^3)	18.49
	(b)Optimum moisture content (%)	12.8
8.	California Bearing Ratio Value (%)	
	(a) at 2.5 mm penetration	10.236
	(b) at 5.0mm penetration	8.990
9.	Unconfined Compression Strength (kN/m^2)	217
10.	Triaxial Compression Test Results	
	(a)Angle of Internal Friction (degrees)	3.4
	(b)Cohesion (kN/m^2)	66.3

BATTERY EFFLUENT

Battery effluent is a colorless liquid and soluble in water

TABLE III.
CHEMICAL COMPOSITION OF BATTERY EFFLUENT

SI.No.	Parameter	Value
1.	Color	White
2.	pH	8.45
3.	Sulphates	250 mg/l
4.	Chlorides	30 mg/l
5.	Lead Monoxide	27.77%
6.	Lead Sulfate	63.08%
7.	Free Lead	7.44%
8.	Total Lead	75.42%
9.	BOD	110 mg/l
10.	COD	320 mg/l

TABLE IV.
PLASTICITY CHARACTERISTICS OF CONTAMINATED SOIL

Battery Effluent (%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)
0	30	77	47
20	30.5	79	48.5
40	31	80.5	49.5
60	31.5	82	50.5
80	32	83	51
100	32.5	84	51.5

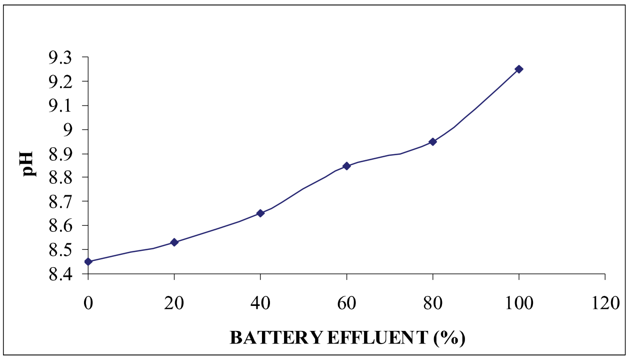

Figure 1. Varitation of pH with percentage of battery effluent

The pH value of uncontaminated soil is 8.45.From the above fig. it is observed that, the pH value of contaminated soil increases with per cent increase in Battery effluent.

TABLE V.
DIFFERENTIAL FREE SWELL INDEX OF CONTAMINATED SOIL

Battery Effluent (%)	DFSI(%)	Percent increase in DFSI
0	254.54	-----
20	255.45	0.36
40	256.36	0.71
60	259.1	1.79
80	261.82	2.86
100	272.73	7.15

The variation of Differential Free Swell Index with per cent Battery effluent is shown in Table V. It is observed that the Differential Free Swell Index rices a little with per cent rise in Battery effluent. The per cent increase in the Differential Free Swell Index is about 7% at 100% of Battery effluent

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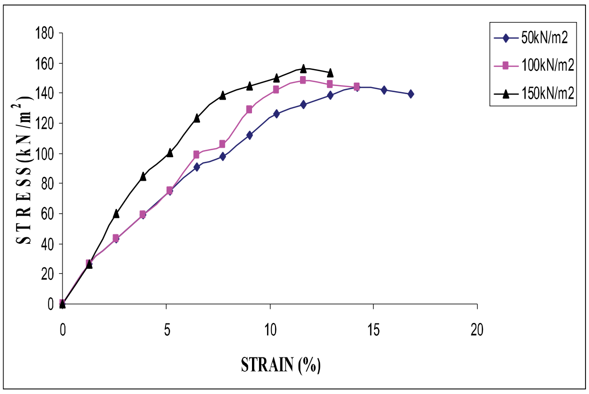

Figure 2. Deviator stress versus strain for soil contaminated with 0% battery effluent

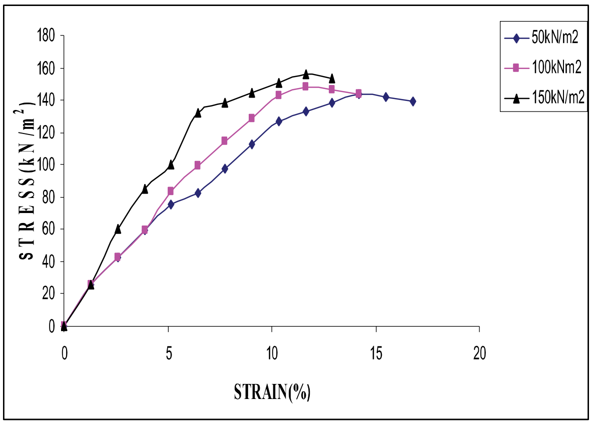

Figure 3. Deviator stress versus strain for soil contaminated with 20% battery effluent

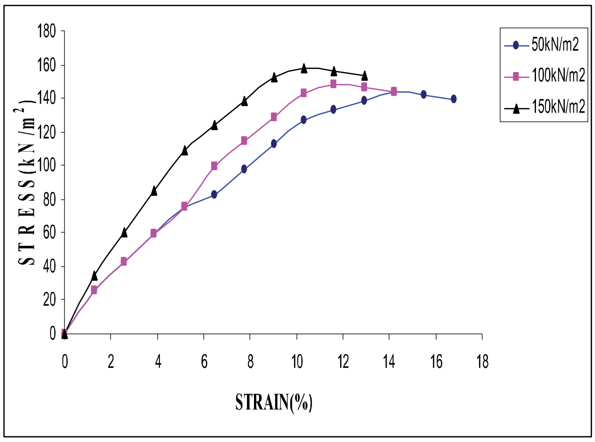

Figure 4. Deviator stress versus strain for soil contaminated with 40% battery effluent

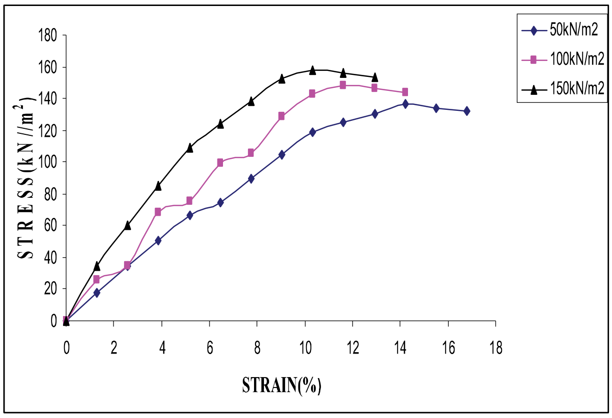

Figure 5. Deviator stress versus strain for soil contaminated with 60% battery effluent

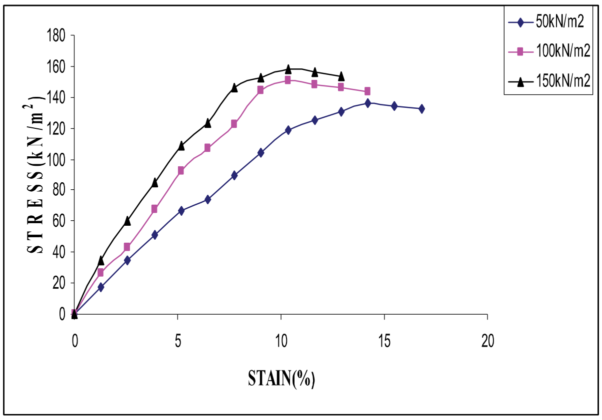

Figure 6. Deviator stress versus strain for soil contaminated with 80% battery effluent

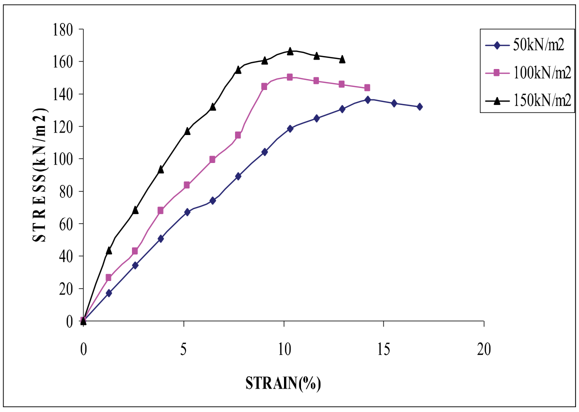

Figure 7. Deviator stress versus strain for soil Contaminated with 100% battery effluent

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TABLE VI. ANGLE OF INTERNAL FRICTION AND COHESION OF SOIL CONTAMINATED WITH BATTERY EFFLUENT

Battery Effluent (%)	Cohesion (C)	Angle of Internal Friction (Φ)	Percentage Decrease in Cohsion(C)	Percentage Increase in Angle of Internal Friction(Φ)
0	65.04	3.4	---	----
20	61.214	4.3	5.88	26.47
40	58.762	5.4	19.652	58.82
60	55.721	6.3	14.33	85.29
80	53.857	7.25	17.2	113.23
100	51.60	8.03	20.664	136.18

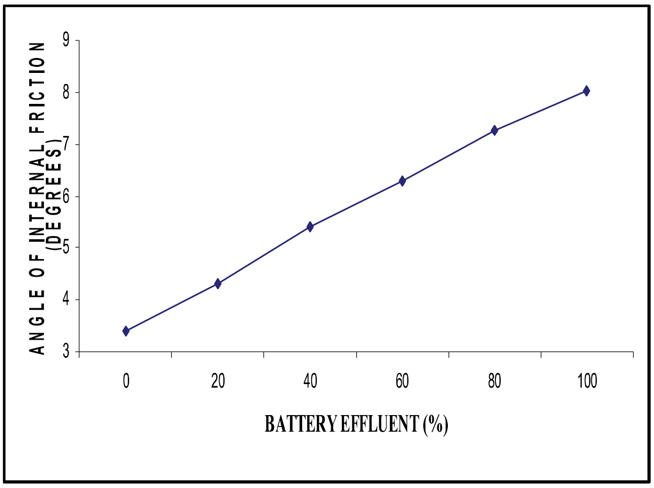

Figure 8. Angle of internal friction versus percentage of battery effluent

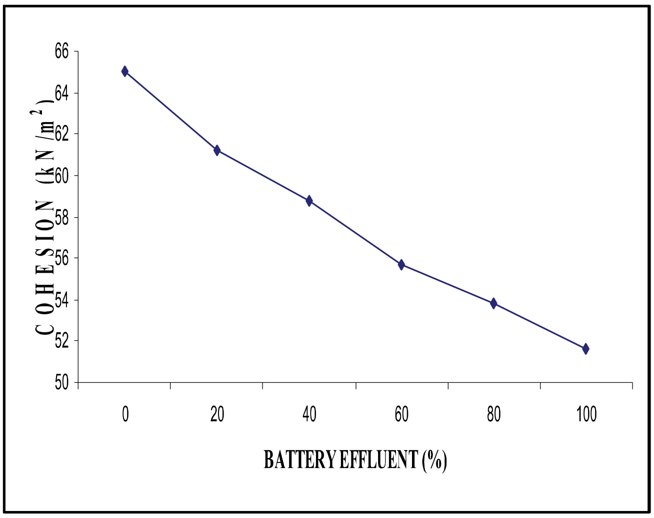

Figure 9. Cohesion versus percentage of battery effluent

V. CONCLUSIONS

1. With successive increase of 20% battery effluent Liquid limit varies 2% up to 60 and later varies in 1%. Plastic limit values of the contaminated soil varies 0.5%with increase of 20% Battery effluent.
2. The Plasticity index values of the contaminated soil also increases at a rate of 0.5% with increase of 20% Battery effluent.
3. pH of the soil increases at a rate of 1.5 with increase of 20% battery effluent
4. Differential Free Swelling index increases at rate of 1% up to 60% effluent, for 80% it increases 2.86% and for 100% it increases 7.15% and Swelling pressure increase slightly with increase in per cent Battery effluent.
5. The contaminated soil is susceptible to heaving and shrinkage at 100% Battery effluent.
6. There is a small increment (1 percent) in optimum pore fluid content as % increase in 20% of effluent from Battery.
7. The maximum dry unit weight of contaminated soil decreases slightly (1 percent) with increase in 20 percentage of effluent from Battery.
8. The California Bearing Ratio (CBR) values of the soil at 2.5 mm and 5.0 mm penetrations contaminated with Battery effluent decrease at a rate of 5 per cent increase in 20% of Battery effluent.
9. The Unconfined compressive strength of the contaminated soil decreases at a rate of 3 %with increase in curing period irrespective of per cent Battery effluent.
10. The Unconfined compressive strength of contaminated soil decreases at a rate of 2 % with increase in 20 percentage of Battery effluent irrespective of curing period.
11. The angle of internal friction of soil contaminated with Battery effluent increases at a rate of 1% with increase in 20 per cent Battery effluent.
12. The cohesion values of the soil contaminated with Battery effluent decreases at a rate of 2% with increase in 20 percentage of Battery effluent.
13. The stability of a soil mass is deteriorated due to contamination by Battery effluent.

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