International Journal of Engineering & Technology, 7 (3.31) (2017) 214-218

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Experimental Study on Building Demolished Waste Stabilized Expansive Soil with Potassium Chloride

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Abstract

All the civil engineering projects such as highways, water reservoirs, railways, buildings etc. requires large quantity of earth material. The mankind was wondering about the instability of earth materials especially expansive soil for centuries. Large areas are being covered with highly plastic and expansive soil quite often which is not suitable for such purpose. They can be hard when dry and they can be soft in moist conditions. Soils subjected to volumetric changes with seasonal moisture variation always create problem for lightly loaded structure by consolidating under load. It results in excessive settlement of superstructures usually and differential movements causing damage to foundation systems, structural elements and architectural features. Promising results were obtained by various researchers for the application of such expansive soil after stabilization with additives such as sand, silt, lime, fly ash, etc. A relatively new solid waste, Building Demolished Waste (BDW), can be used for stabilization of expansive soils for various uses in combination with potassium chloride. This study was planned to access the role of potassium chloride inclusions in improving the weak expansive soil besides stabilizing it with Building Demolished Waste in different proportions.

Keywords: *Building Demolished Waste; Curing; Expansive Soil; Potassium chloride; Stabilization*

1. Introduction

Soil is an unconsolidated loose material derived from disintegration of rocks or decay of vegetation. The soil can be excavated readily with power equipment in the field or disintegrated by gentle mechanical means in the laboratory. The soil which supports the pavement from beneath is called sub grade. The sub grade is compacted by controlled movement of heavy compactors. Subgrade is an essential component of pavement structures and its inadequate strength is the root cause of many pavement failures. The saturated clay sub-grades may sometimes provide inadequate support. The soil with significant plasticity may be subjected to volume changes with changes in moisture conditions. These changes in volume can cause the pavement to heave or shift with changes in moisture content and may cause a reduction in the density and strength of the subgrade, accelerating pavement deterioration.

In India, the area covered by expansive soils is nearly 35% of the total area. They normally spread over a depth of 2 to 20m. In Rainy season, structures on this soil experience large-scale damage due to heaving accompanied by long strength, where as in summer season, they shrink and gain density and become hard.

Soil is a layered natural body where the horizons are primarily composed of minerals which differ from their parent materials in their structure, texture, colour, chemical, consistency, biological and other characteristics. Soil is the formed as a result of the influence of the temperature, precipitation, slope, organisms on parent materials (original minerals).

2. Review of Literature

2.1 Soil Fertility Studies:

The history of the study of soil is significantly tied to our urgent need to provide food for the living beings. It was always evident that civilizations have prospered or declined as a function of the availability and productivity of their soils.

2.2 Soil Formation Studies:

In the earlier stages of research the scientists investigated about the soil in connection with agricultural practices had considered it as a static substrate but the matter of fact is that the soil is formed from much more ancient geological materials. In the later stages other scientists began to study soil genesis and as a result also soil types and classifications. In 1860, in Mississippi, Eugene W. Hilgard studied the type of soils that were developed and the relationship among climate, rock material and vegetation. He realized that the soils were dynamic in nature and soil types classification was considered.

2.3 Problems Associated with Expansive Soils

The swelling and shrinking properties of the soil depends on the water content of the soil. The water content of soil is considerably reduced during summer hence the soil becomes stiff and shrinkage cracks develop. During the rainy season the water content of the soil is increased resulting in swelling when a building is constructed on this type of soils, the soil below the building is protected from excess heat even during summer. This soil swells because its evaporation is obstructed. However, the soil adjacent to the building which is open to atmosphere will experience normal swelling and shrinkage.

2.4 Previous Studies

Sharif et al. (2000) investigated about the burned sludge efficiency in soil stabilization when it is heated at 550^0 C. It is observed that the addition is limited to 7.5 % by weight then after the unconfined compressive strength and maximum dry density will decreases[1].
Parsons et al. (2004) investigated the use of cement kiln dust soil stabilization. The Atterberg's limits and strength results are the conclusive results for the research during before and after durability test in a curing period of 28 days. The results are significant with the addition of cement kiln dust in soil[2].
Seda et al. (2007) examined the use of waste tyre rubber for swelling potential mitigation in expansive soil. The present study gives the compaction parameters and index properties of the expansive soil-rubber mixture. The tests results showed that there was a significant decrease in swell and swelling pressure[3].
Okagbue (2007) studied the utilization of wood ash as an agent for clay stabilization. The CBR and strength tests were conducted for 28 days curing samples. The results concludes that plasticity was reduced by 35% and CBR and strength increased by 23–50% and 49–67%, respectively[4].
Choudhary et al. (2010) evaluated that the use of plastic waste in flexible pavement for improving the subgrade properties. In this study the effect of waste plastic strip on the CBR and secant modulus was investigated[5].
Rao et al. (2011) studied about utilization of industrial waste in expansive clay sub grades. The waste materials used in the study are Fly ash and GGBS. The results indicated a significant increase in the soaked CBR value[6].
Saltan et al. (2011) studied about the pumice waste potentiality sub grade stabilization for clayey soils.. The tests performed were solidity, strength, Consistency limits, California bearing ratio and dynamic repeated load triaxial[7].
Zhang et al. (2012) studied about the use of lime sludge as subgrade stabilizing agent. This study planned with addition of lime sludge and it reduces the plastic behaviour of soil and increases the soil deformation modulus[8].
Oormila.T.R , T.V.Preethi (2014) evaluate the efficiency of GGBS with fly ash for clay satbilization. The results indicated that clay can be effectively stabilized with the addition of fly ash-GGBS mix[9].
Ransinchung et al. (2013) investigated the potential of fines obtained from demolished concrete slabs as a soil stabilizing agent. It was observed that admixing of FDCS increases the unconfined compressive strength and soaked CBR value[10].
Rifai et al. (2014) checked the potential of volcanic ash in soil stabilization regarding geo-environment. The engineering properties, volcanic ash effect and the percentage of fines in the soil mixture were studied. By observing the results, the bearing capacity, decreases the consistency limits and obviously decreases swelling potential and become non plastic soil[11].

3. Materials for Study

3.1 Collection of Soil Sample:

- For conducting the study, soil samples were collected from Amalapuram in East Godavari District, A.P.
- The soil excavated from below1 ft depth. The soil sample is free from plant roots and stone pieces and rubbles.

3.2 Properties of Soil Sample:

The soil sample collected from Amalapuram, East Godavari District, A.P has been selected for the present study after having a visual inspection of it. When a lump of sample was cut with a knife it gave a shining surface hence, it was concluded that the sample is of clayey nature. The laboratory tests were performed as per the Indian Standards by pulverizing the lumps into individual particles to determine the properties of the selected soil sample as mentioned in below Table.3.1

Table. 3.1 : Showing the properties of Original soil sample

S.No	PROPERTIES	VALUE
1	Specific gravity	2.59
2	Differential free swell (%)	115
3	Atterberg limits Liquid limit (%) Plastic limit (%) Plasticity index (%)	 65.5 29.1 36.4
4	IS soil classification	CH
5	O.M.C. (%) M.D.D. (g/cc)	26.4 1.50
6	Un soaked C.B.R (%)	3.8
7	Soaked C.B.R (%)	2.1
8	Cohesion (C_u), (kpa) Angle of internal friction ($Ø_u$).(degrees)	42 0

3.3 Properties of Building Demolished Waste:

Concrete blocks and bricks were separated from demolition waste materials and were crushed using a sledge and laboratory crusher.

3.4 Properties of Potassium Chloride:

The below table.3.2 shows the properties of Potassium chloride

Table. 3.2: Showing the properties of Original soil sample

Purirty of Potassium Chloride	
1. Minimum Assay	1. Minimum Assay
2. PH (2% solution)	2. PH (2% solution)
Maximum Limits Of Impurities	
1. Bromide (Br)	1. Bromide (Br)
2. Iodie (I)	2. Iodie (I)
3. Sulphate (SO4)	3. Sulphate (SO4)
4. Phosphate (PO4)	4. Phosphate (PO4)
5. Total Nitrogen (N)	5. Total Nitrogen (N)
6. Heavy Metals (as Pb)	6. Heavy Metals (as Pb)
7. Iron (Fe)	7. Iron (Fe)
8. Calcium (Ca)	8. Calcium (Ca)
9. Barium (Ba)	9. Barium (Ba)
10. Magnesium (Mg)	10. Magnesium (Mg)
11. Sodium (Na)	11. Sodium (Na)
12. Loss on Drying	12. Loss on Drying

4. Results and Discussions

4.1 General

Various experiments like Compaction, Strength and CBR tests were conducted by replacing different percentages of Building Demolished Waste and also further stabilizing it with Potassium Chloride as a binder in expansive soil.

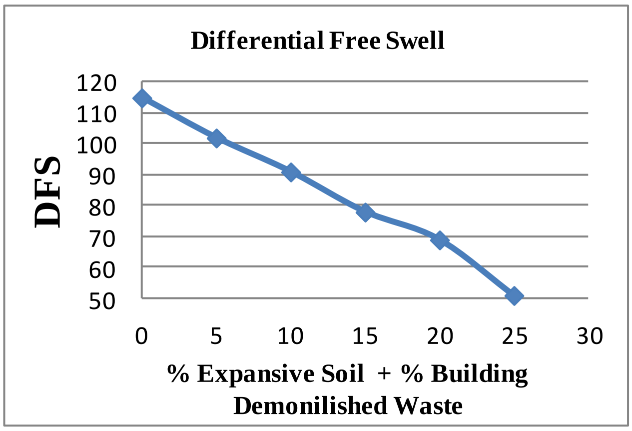
4.2 Effect of Strength for % Building Demolished Waste Replacement in Expansive Soil

The effect of Building Demolished Waste (BDW) on the Strength and Compaction characteristics of expansive soil. The percentage of Building Demolished Waste (BDW) was varied from 0% to

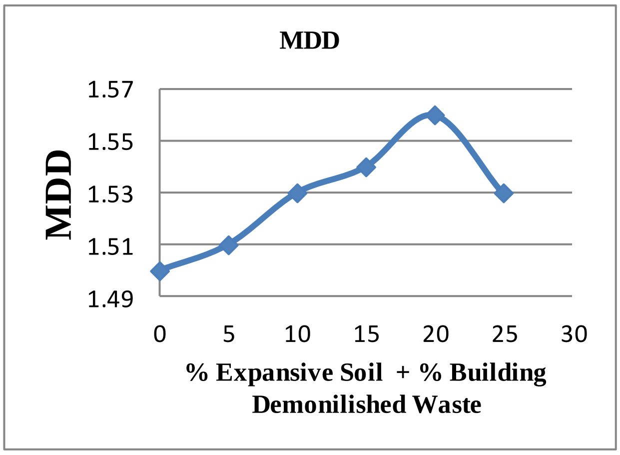
25% with an increment of 5% and the results are shown in the below table.4.1

Table. 4.1: Results showing the properties of expansive soil with building demolished waste

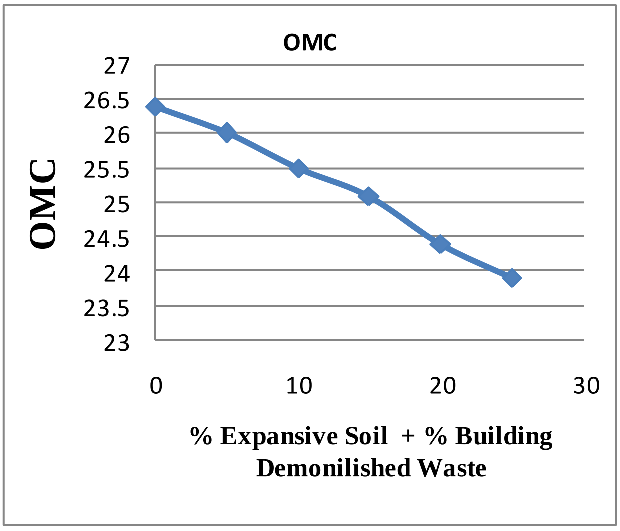
ES+BDW	MDD g/c.c	OMC %	DFS	C KPa	Ø
100+0	1.5	26.4	115	42	0^0
95+5	1.51	26	102	54	1^0
90+10	1.53	25.5	91	67	2^0
85+15	1.54	25.1	78	81	3^0
80+20	1.56	24.4	69	80	4^0
75+25	1.53	23.9	51	77	3^0



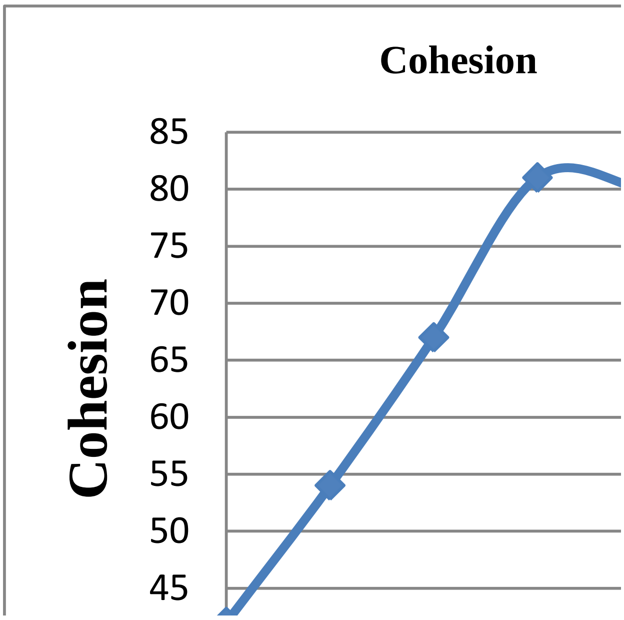
4.1 Plot showing the variation of Differential Free Swell with % replacement in Expansive soil with Building Demolished Waste.



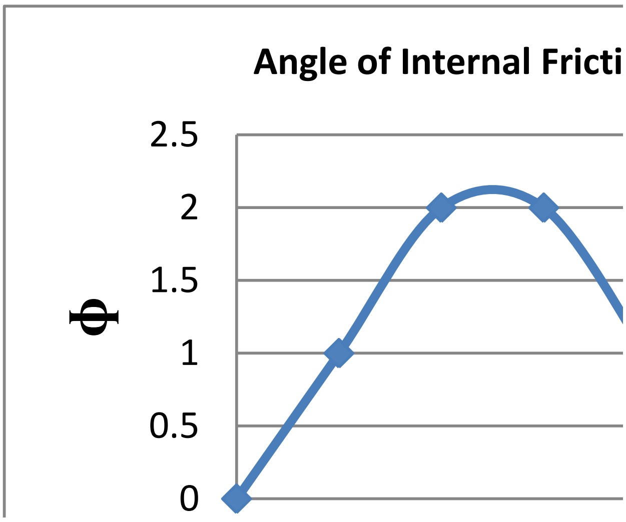
4.2 Plot showing the variation of Maximum Dry Density with % replacement in Expansive soil with Building Demolished Waste.



4.3 Plot showing the variation of Optimum Moisture Content with % replacement in Expansive soil with Building Demolished Waste.



4.4 Plot showing the variation of Cohesion with % replacement in Expansive soil with Building Demolished Waste.



4.5 Plot showing the variation of Angle of Friction with % replacement in Expansive soil with Building Demolished Waste.

4.3 Effect of Potassium Chloride on the strength Characteristics of expansive Soil + Building Demolished Waste (BDW) Mixes

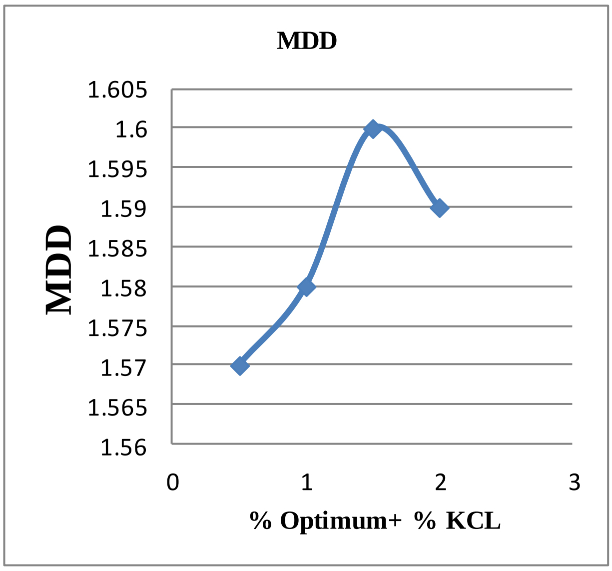
The percentage of Potassium Chloride was varied from 0% to 10% with an increment of 2.5%.

In the laboratory, tests were conducted by blending different percentages of Potassium Chloride to expansive soil + Building Demolished Waste (BDW) mixes with a view to determine its optimum blend.

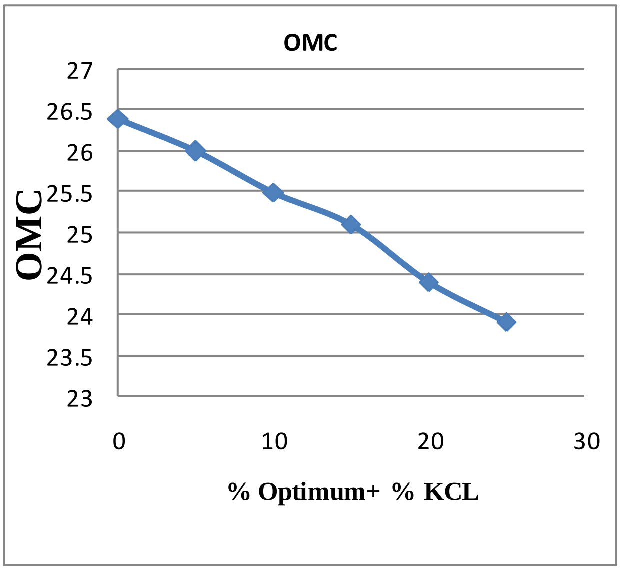
From the results it is evident that the addition of Potassium Chloride to the BDW–Expansive soil mix had improved its Compaction and Strength characteristics shown in the table. 4.2.

Table. 4.2: Results showing the properties of expansive soil with building demolished waste and Potassium chloride

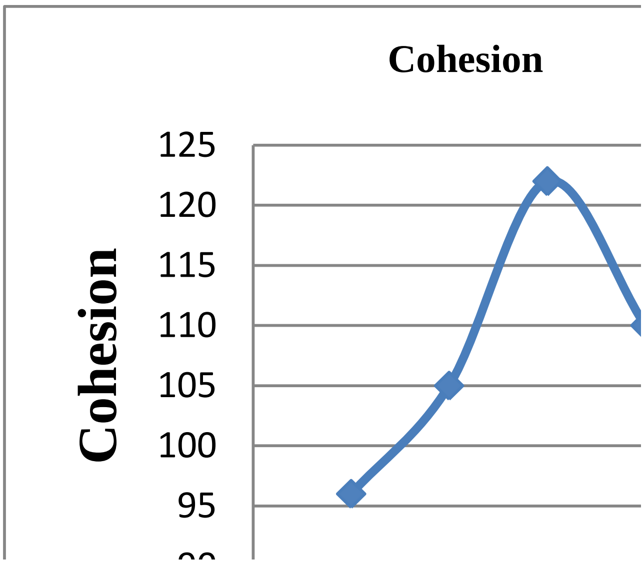
ES + BDW+ KCL	MDD g/c.c	OMC %	C KPa	Ø	Soaked CBR
80+20+0.5	1.57	24.9	96	4°	4.9
80+20+1	1.58	25.3	105	4°	5.5
80+20+1.5	1.6	25.5	122	6°	6.9
80+20+2	1.59	25.6	110	5°	6.7



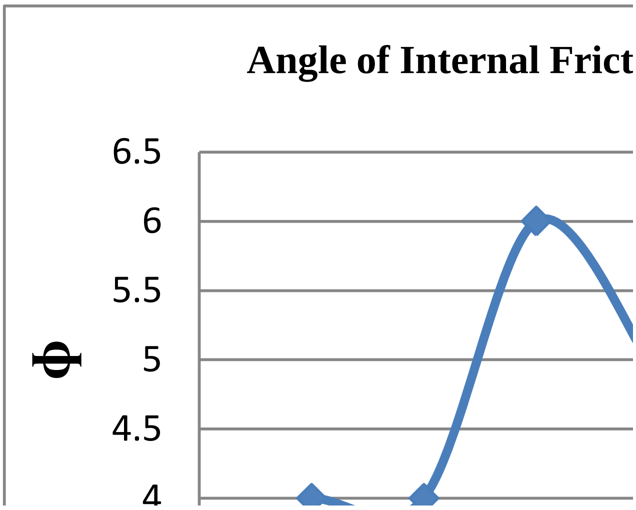
4.6 Plot showing the variation of Maximum Dry Density with % replacement in Optimum Mix with Potassium Chloride.



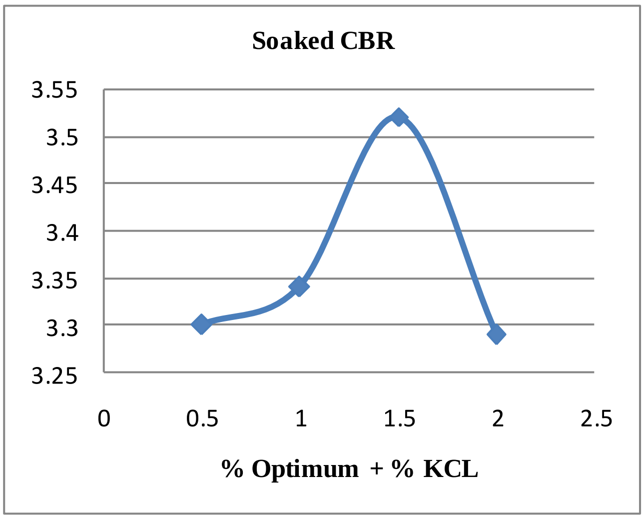
4.7 Plot showing the variation of Optimum Moisture Content with % replacement in Optimum Mix with Potassium Chloride.



4.8 Plot showing the variation of Cohesion with % replacement in Optimum Mix with Potassium Chloride.



4.9 Plot showing the variation of Angle of Friction with % replacement in Optimum Mix with Potassium Chloride.



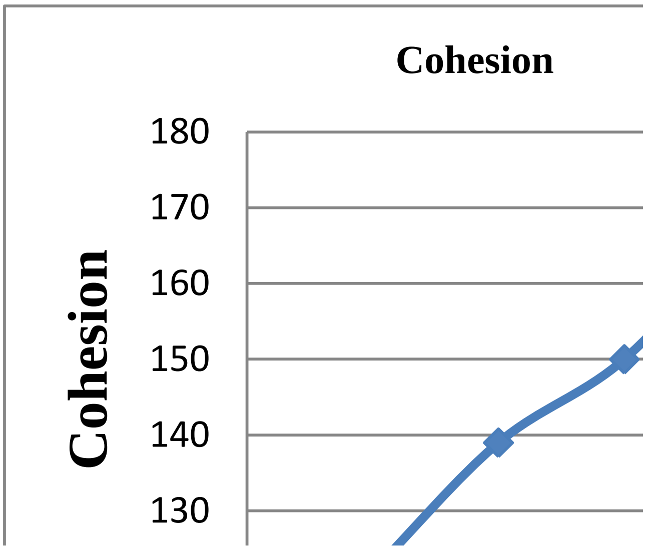
4.10 Plot showing the variation of Soaked CBR values with replacement in Optimum Mix with Potassium Chloride.

4.4 Curing Effect of Potassium Chloride on the strength Characteristics of expansive Soil + Building Demolished Waste (BDW) Mixes

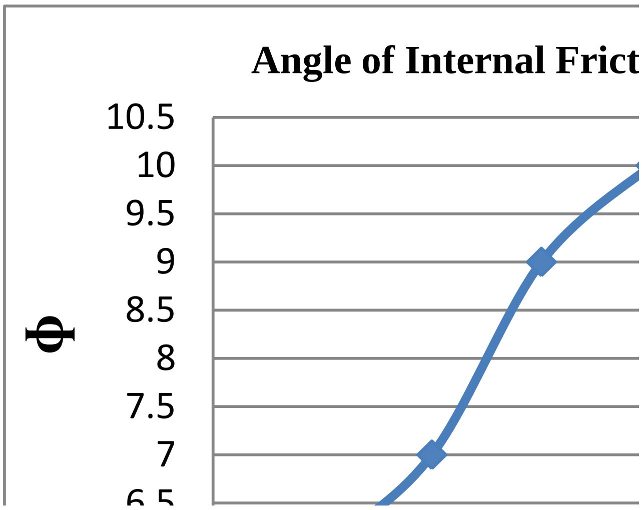
The following are the curing results on the optimum mix of building demolished waste stabilized expansive soil with potassium chloride in table.4.3

Table. 4.3: Results showing the properties of expansive soil with building demolished waste and potassium chloride in curing periods

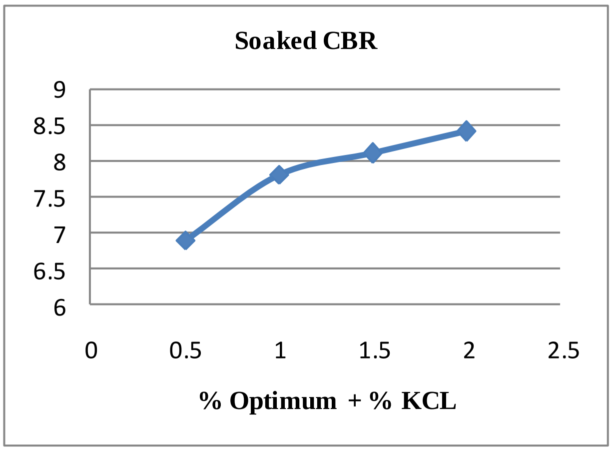
Curing Results for 80% Expansive Soil+20% Building Demolished Waste+1.5% KCl			
Curing Days	Cohesion	Angle of Internal Friction	Soaked CBR
3	122	6°	6.9
7	139	7°	7.8
14	150	9°	8.1
28	168	10°	8.4



4.11 Plot showing the variation of Cohesion with % replacement in Optimum Mix with Potassium Chloride after curing.



4.12 Plot showing the variation of Angle of Friction with % replacement in Optimum Mix with Potassium Chloride after curing.



4.13 Plot showing the variation of Soaked CBR values with replacement in Optimum Mix with Potassium Chloride after curing

5. Conclusion

From the experimental study, the selected soil is highly expansive in nature and it has more plasticity. A property of the clay has changed moderately with 25% BDW. The maximum dry density increased with increase in the percentage of BDW upto 20%. There is also increase in the maximum dry density (MDD) and strength parameters with increase in the KCL from 0 to 2%. It is evident that the addition of KCL in Building Demolished Waste (BDW) stabilized clay improves the shear strength perameters. Hence the stabilization of clay by the BDW and KCL, solves the problem of expansive clay and also disposal of waste.

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