Improvement of CBR and Compaction Characteristics of Bauxite Rich Dispersive Soils Available in Pakistan: A Case Study of Khushab Soil

S. Batool[1], A. A. Malik[2], A. Akbar[3], T. Sultan[4]

[1,3]*Civil Engineering Department, University of Engineering & Technology, Lahore*
[2]*NFC, IET, Multan*
[4]*Civil Engineering Department, University College of Engineering & Technology, BZU, Multan*
[1]saimabatool854@gmail.com

Abstract-Dispersion of dispersive soil occurs when it comes in contact with water and clay particles deflocculate and disperse away from each other. Thus dispersive soils undergo erosion under low seepage velocity leading to instability problems of slopes and earth retaining structures. The amount of dispersion depends upon the mineralogy and geochemistry of clayey soil as well as the dissolved salts of the pore fluid. The dispersivity of the soil mainly depends on the amount of exchangeable sodium present in its formation. Under saturated conditions, the attractive forces are less than the repulsive forces and this will help the particles to disperse and go into colloidal suspension. The use of chemical stabilizers such as lime and cement to bind the clay particles and reduce the dispersivity of soil and to improve the compaction and CBR characteristics of bauxite rich dispersive soil present in Khushab district have been studied in this research. Soil behavior was studied after addition of 2%, 4%, 6% and 8% Lime and Cement, at optimum level of 6% for Lime and Cement; it has been observed that the CBR and compaction characteristics of Khushab soil have been improved.

Keywords-Dispersive Soil, Repulsive Forces, Chemical Stabilizers, CBR Test, Compaction Characteristics, Bauxite

I. INTRODUCTION

Soils that are dislodged easily and rapidly in flowing water of low salt concentration are called dispersive soils. Structures such as embankments, channels, roads, pavements and other areas are susceptible to severe erosion, when such soils are used for construction. The erodabilty of clayey soil due to flow of rain water is a critical factor in long term performance of earth structures. The presence of dispersive soils at any construction site causes serious design and constructional challenges. The degree of dispersion is dependent on the chemistry and mineralogy of clay and salt dissolved in the interstitial fluid. Soil dispersivity is mainly due to the presence of exchangeable sodium present in the structure. Dispersive soils are defined as soils which ,when come in contact with relatively pure and still water, will disintegrate with some particles going into suspension. Dispersivity occurs in those soils wherein the repulsive forces between the clay particles when saturated exceed the forces of attraction. This is caused by a reduction in the concentration of cations in the pore fluids, resulting in deflocculation and dispersivity of the clay particles. Clays are renowned of their mysterious & dramatic behavior all over the world. One of the most important characteristics associated with them is a large variation in properties with the fluctuating index and physical properties such as relative density, degree of compaction and field moisture content etc. Such soils are known as problematic soils [i]. One of the most recognized problematic soils is dispersive, which loses attractive forces among the particles when come in contact with water. This dispersive property is also present in naturally available soil of Khushab District which has a very rich content of bauxite. This soil is structurally unstable dispersion of aggregates of the soil and collapse when the floor is wet, because the individual clay particles are dispersed in the solution. The problems associated with dispersive soils include surface erosion, tunnel formation, gully formation, sinkholes and high suspended sediment loads that can cause instability, cracking and breakup of pavements, building foundations, slab-on-grade members, and reservoir and channel linings. In Pakistan, many researchers have identified a number of potential soil sites exhibiting dispersive behavior such as in Kotly, Muzaffarabad, Ziarat, Sibbi, Attock, Hazara, Loralai and Khushab districts. Bauxite reserves of Pakistan are estimated about 74 million tons by Geological Survey of Pakistan [ii].

III. IDENTIFICATION OF DISPERSIVE SOIL

Successful use of the dispersion of soil requires the identification, proper recognition and when used in large construction works, appropriate engineering measures must be taken. Primarily any investigation in all fields should be done to determine whether there are any apparent surface indication, such as unusual erosion, deep ravines, Siwa and tunnels, concurrent with excessive turbidity in the water storage. Poor production acreage can also give an idea of saline soils, many of the dispersive character. However ELGES [iii] concluded that the variance of the soil may occur in neutral or acidic soils and can withstand the test lush grass surface can give a clear indication .Good tip soil if it clearly shows the type of soil and other research should continue.

Experiences has shown that dispersive soils cannot be identified by conventional tests such as visual identification, particle size distribution, Atterberg limits, specific gravity and compaction characteristic. One point should also be kept in mind during identification of dispersive soils that all materials having erosion gullies and channeling in the field are not necessarily dispersive. The materials could just be highly erodible and different construction techniques or material treatment would be necessary.

Therefore dispersive characteristics should be properly identified by performing various specialized tests on representative soil sample. Recently there are four laboratory test for the identification of dispersive soils which are being commonly used .these tests are the crumb test Pinhole test, double hydrometer test and various chemical analysis of the soil .usually the combination of the results obtained from these methods is used to determine the extent of soil dispersivity.

III. METHODS OF STABILIZATION OF DISPERSIVE SOILS

In most failures caused by the dispersive soils, the collapse of embankments is usually the first sign of the presence of dispersive soils in that area. Because the problems caused by the dispersive soils are more speedy, permanent and catastrophic so during the early stages of investigation, the suitable plan of available construction material and the possible presence of dispersive soils should be considered.

In case of earthen dams Elges [iii] suggested that the permeability of the densified material should be below or equal to 10^{-5}cm/sec. According to Elges [iii] the permeabilities of clayey material should be between the ranges of 10^{-5} to 10^{-7} cm/sec.In some cases, sand filters also can be used to prevent the leakage of dispersive material and hence sealing the material from erosion. But if the clay particles are in suspension then these filters cannot prevent the colloidal particles to pass through them. Another important method of stabilizing the dispersive soils is chemical treatment .by the addition of chemical agents such as hydrated lime (calcium hydro-oxide), gypsum (calcium sulphate), and alum (aluminum sulphate).these chemical agents provide the calcium source to replace sodium in the cation exchange complex providing the cohesion between the clay particles. These reagents enhance both the soil solution electrolyte concentration and the levels of exchangeable calcium in the soil, which reduce the swelling power and also the dispersivity of the soil. For a soil samples used for the research were obtained from Osun State (Nigeria) known as lateritic soil having similarities with Khushab soil having bauxite for aluminium-rich cemented crusts. Capacity of the samples A, B and C from above mentioned soil enhanced lime stabilization optimal to 8, 6 and 6%, respectively.Adding lime to the samples resulted in a decrease in plasticity indices. CBR increased from 10.6% to 29.0% 0% to 8% lime, while C was improved by 2.5% to 8.6% to 6% lime. Compressive strength is increased and shear compressive strength improved uncured B 119.13 kN / m2 at 0% to 462.81 kN / m2 to 6% lime [iv]. California Bearing Ratio (CBR) is a measure of the resistance of soil quality. In the design of flexible pavements value of this parameter is often used wet; whose evaluation laboratory test is a long and time-consuming [v]. The geotechnical properties of fly ash as a specific gravity, permeability, internal friction bearings and consolidation features make it suitable for use in the construction of roads and dams, structural fill and especially in clay soils [vi]. Admixture carbonate, lime or the fly caused an increase in the limit of plastic, while the yield strength, the swelling index decreases ductility soil. Other cost increase California bearing relationship obtained when the soil sample is mixed with lime. Increasing the optimum moisture content value increased CBR, in particular a high percentage of lime or flyash. Further, the maximum dry density decreases with the addition of lime and fly ash [vii]. In soft soil, fly ash can be used to reduce the compaction of the filler. Reference [viii] reduces swelling clay after stabilization of fly ash. The maximum density of dry clay, sand and fly ash mixture decreases with the addition of fly ash increases the optimum moisture content. Significant improvement occurred during pressing and CBR test compound containing clay, sand and fly ash [ix].

Hydrated lime is most commonly used chemical modifier because it is easily available and cheap chemical and its solubility is also high. Gypsum is also more effective reagent to reduce the dispersivity if the clay particles but its use is limited to some extent due to its less soluble qualities and relatively high cost. According to Elges [iii] 0.2% of lime or gypsum by mass of clay material is adequate in the laboratory but in actual practice in the field 2% of these stabilizers are generally used.

If precautionary measures are taken properly like proper compaction of dispersive soil at appropriate moisture content and provision of appropriate filter to prevent erosion of material, then chemical treatment of dispersive soil is not necessary. Elges [iii] suggested that for the slope protection, chemical stabilization is necessary.

Wagener et al. [x] recommended that for the construction of embankment dams in dispersive soil areas, five options should be kept in considerations. The first option is the choice of another site for the construction of dam which is not practical in most of cases. The second option is the construction of the dam at proposed site having dispersive soils but special measures should be taken under controlled conditions to cope with the problems associated with such type of soils. Another modification is the protection of upstream side of the dam structure by providing lining protections. The rest of the two options are the considerations of chemical stabilization techniques.

In case of road construction, if dispersive soils are susceptible in cuts then two options should be keeping into considerations, first is to remove the dispersive soils from the cuts to avoid the erosive problems and second is to stabilize this soil with chemical treatment. It states that care should be taken to not to let the material between the compacted layers of the soil to dry up because it may initiate the desiccation cracks [xi]. In a recent research, another method of stabilization of the dispersive soils is suggested by Paige-Green [xii] which states that it is also possible to use the sulphonated petroleum product (SPP) treatments, which will replace the sodium in the clays and stabilize the material.

IV. Research Methodology

Three sites were initially selected for preliminary studies in Khushab District and only two sites adopted for the detailed investigation. The sites were explored using test pitting and auguring. Representative samples were collected for laboratory investigations. The methods of sampling and sample preparation as well as test conducted are discussed.

A. *Soil Sampling*

Test pits were excavated using pick axe and shovel. The pits were sometimes supplemented with auger boring. The dimension of the test pit was 1meter-length by 1.5meter-breadth by 3meter-depth. A depth of three meters was chosen because the swell and shrinkage phenomena of dispersive soils have greatest effect on light weight structures such as pavements, one- and two- story buildings usually founded at depths shallower than three meters. Disturbed samples were taken from within 0.3m-1.4m from the Khushab area, packaged, labelled and sent to the laboratory for testing.

B. *Evaluation of Dispersiveness of the Soil*

Field and laboratory tests were conducted on selected samples retrieved from the pitting and borings to evaluate their physical and geo mechanical characteristics. The tests performed include the evaluation of the following: Free Swell Tests, Double Hydrometer Tests [ASTM D 4221-99], Crumb Tests [ASTM D 6572-00] and Chemical Tests.

V. Analysis of Experimental Results

A. *Free Swell Tests*

The soil sample of 10gms was mixed with 2, 4, 6, and 8% of lime by weight of soil. The mixture was diluted with water and made up to 100 ml and kept in a measuring jar. The mixture was left over for 24 hrs and the percentage dispersion was calculated. The dispersion was nearly 1000% for 0% of lime and there was no change for 1%, but significant decrease was observed for higher concentration of lime with the optimum content being 5% and the percentage dispersion being 400. This would have been due to availability of higher concentration of lime for flocculation of the particles, ion exchange reactions and thus increasing the force of attraction but for 9% there is not much decrease due to the saturation level of lime. As the higher percentage only helps in formation of cementatious compounds which are time dependent. Table I presents the variation of dispersiveness with lime addition. The addition of only lime to control the dispersion did not cause any predominant changes and the percentage of dispersion remained at 1000. The cement was the type of class A which has no good cementing properties due to the absence of calcium compounds so the process of flocculation and aggregation was not developed. But with the addition of activators like lime, cementing characteristics was imparted to mixing. 2% of lime was increased as according to above and then amount of cement was varied as 2, 4, 6, and 8% separately. The lime induces the flocculation process and the cement acts as a binding agent. The combined action of aggregation and mechanical binding reduces the dispersion. The percentage of dispersion reduces to nearly 420% for cement of 15% which was equivalent to the one with optimum lime content of 5% as can be seen from experiment, So the use of lime can be reduced to a very less quantity as it is very expensive and the amount of cement can be increased. As cement is a byproduct from the different mix industry and present in abundance, this can be a suitable and economical way for its disposal [xiii].

B. *Double Hydrometer Tests*

The double hydrometer test also known as soil conservation service laboratory dispersion test was performed to identify the dispersiveness of soil. Particle size distribution is determined first ground using a hydrometer nonstandard test where the soil was dispersed in distilled water under vigorous mechanical agitation and chemical samples dispersant. Parallel hydrometer replicated in a soil sample, but without mechanical agitation and without the chemical dispersant is a dispersion percent dry weight ratio particle size less than 0.005 mm in diameter of the second test are expressed on the first percentage. The value of greater than 50 is highly dispersive. The percentage of dispersion was calculated for different percentage of additives, the soil sample is highly dispersive with a dispersive percentage of 71 [xiii]. Smaller percentage of lime was not sufficient to reduce dispersiveness, the addition of 2%.then 4%, then 6% & at last 8% was highly suitable.

C. Crumb Tests

The crumb test was carried out as it gives a good quick indication of the dispersiveness of the soil. This test is used in conjunction with the pinhole test, and the double hydrometer test. Based on the tendency for clay particles to go into colloidal suspension that is observed after 5-10 minutes of immersion, soils are classified as non-dispersive or dispersive based on the reaction observed. The specimen of 1.5cm cube is placed in about 250ml of distilled water. The soil sample showed strong reaction getting into colloidal form in 5 to 10 minutes, whereas the other samples with additives took a longer time for dispersion. Thus from these tests it was clearly shown that the addition of lime, cement improves the properties of the dispersive soil. The degree of dispersion decreases for increasing percentage of additives [xiii].

D. Chemical Analysis

The chemical testing of the Khushab Soil is carried out to find the concentration of different ions [xiv]. This is important as there is a relationship between electrolyte concentration of the soil pore water and the exchangeable ions present and also to check the equilibrium of the soil with the environment. The presence of high sodium concentration makes the soil more dispersive. The two parameters which are often used to check the chemical compatibility are Sodium Absorption Ratio (SAR) and Percent Sodium (PS) [xv]. The soil samples, diluted to 1:10 ratio were acid digested for one day and the extracts were used to conduct chemical analysis. The concentration of Ca^{++} and Mg^{++} was found by titration methods and Na^{+} and K^{+} were determined by atomic absorption spectroscopy method. The values of SAR and PS were compared with Sherard Curve; Sherard et al [xxi] developed curves as Zone-A [PS≥60] for dispersive soil, Zone-B [PS: 0 to 40] for non-dispersive soil and Zone-C [60<PS≥40] for intermediate soil. From the comparison, it was observed that the original sample is reasonably dispersive, for the other samples, the sodium ion concentration was replaced by the calcium ions supplied by addition of lime & cement. And hence the values of SAR and PS were very less and classified as non-dispersive. The results of the chemical analysis are given in the Table I. In the 1960 Australian scientists recognized the exchangeable sodium as the main factor contributing to the behavior of the clay dispersion chemistry [xv]. The main parameter to quantify this effect, ESP (exchangeable sodium percentage), where:

ESP = Exchangeable Sodium x 100/CEC
CEC= (Cation Exchange Capacity)

Chemical evaluation of dispersive soil can also be compared as Harmse and Gerber [xxii] described a chart showing SAR <6 for non-dispersive, SAR 6-10 for intermediate and SAR >10 for dispersive, in addition to that pH was also indicative as pH <7.8 for non-dispersive, and pH >7.8 for dispersive Soil ESP value 10 or higher, free filtrate is subjected to the salt by filtration or relatively pure water are classified as dispersant. Another parameter commonly evaluated in the quantitative role of sodium with respect to the dispersion-free salts are present in an (sodium absorption rate), SAR of the pore water where:

SAR = Na/0.5 (Ca + Mg) with units of meqlL

Very often, this measure is used in terms of milliequivalents of solute per litre of solvent (or milliNormal, where meq/l = mN). SAR method is not applicable, if not free of salt present. Using SAR is based on the fact that the soil in nature is in equilibrium with the environment. In particular, there is a correlation between the concentration of electrolyte in the pore water and soil exchangeable ions in the adsorbed layer of clay. Australian researchers have shown that all the floors were so dispersed SAR exceeded 2. This shows a reasonable agreement on soils with TDS (total dissolved salts) from 0.5 to 3 mEq / L, but not outside of this range of soils [xv]. The currently accepted method of assessing chemical effect on the behavior of the dispersion in the USA is:

Percent sodium = Na (100)/ TDS with
TDS = Na + Ca + Mg + K

and all units in meq/L of saturation extract. In accordance with the above explained criterion, chemical analysis report for Khushab soil has been elaborated in Table I.

E. Physical Analysis

This laboratory is performed to determine the boundaries of fine-grained soils and the liquid plastic [xvi]. Liquid limit (LL) is soil moisture content, expressed as a percentage of the weight of oven dry soil at the interface between the liquid and plastic states consistency. The water content, in percent, where in the

TABLE I
CHEMICAL TEST RESULT FOR KHUSHAB SOIL SAMPLES

S. No.	Condition		PH	Co_{3-}	HCO_{3-}	Cl^-	SO_4^{++}	Ca^{++}	Na^+	SAR	P.S	CEC	Description
				meq/lit	meq/lit	meq/lit	meq/lit	meq/lit	meq/lit				
1	OS		10.7	1.6	4.4	5.3	27.8	15	71.3	8.83	58	12.4	Dispersive
2	CEMENT	2%	12	2	3	3.6	6.44	10	4.84	6.12	18	11.3	Non-Dispersive
3		4%	12.3	4.8	2.8	1	6.62	5.1	10.1	5.06	15	11.4	Non-Dispersive
4		6%	12.4	6.6	3	1.1	6.06	6.1	10.7	4.12	13	12.6	Non-Dispersive
5		8%	12.5	9.6	3.8	1.3	5.6	8.5	11.8	3.21	11	15.3	Non-Dispersive
6	LIME	2%	12.4	6.4	3	1.2	6.85	6.8	7.75	6.69	20	10.9	Non-Dispersive
7		4%	12.7	8.6	3.2	1.9	0.45	4	10.2	5.34	17	5.37	Non-Dispersive
8		6%	12.8	15.8	7.6	4.2	19.5	26	15.9	4.72	13	31.7	Non-Dispersive
9		8%	12.7	18.3	4.2	2	13.3	32	23.5	3.83	11	42	Non-Dispersive

pH & Sodium Absorption Ratio (SAR)tested according to Harmse and Gerber [xxii] & Percent Sodium (PS) Sherard et al [xxi] .

belt surface in the cup, and reduce the size of a standard gaming thus flowing to the bottom of the groove when subjected to the distance 25 mm punches cup drop assembly 10 in the reference liquid limit 13 mm (1/2 in.) operated at two strokes per second. Plastic limit (PL) is the percentage of water content, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling. For Khushab Soil, different analysis were performed to check the disperse behavior and also tests were performed after addition of lime with different percentage to check the stabilization. Three samples for 2%, 4%, 6% & 8% ration each were taken with the variable no. of blows the final results showed that from original sample to increased lime ration showed variable results, trend can be seen in given Fig 1.

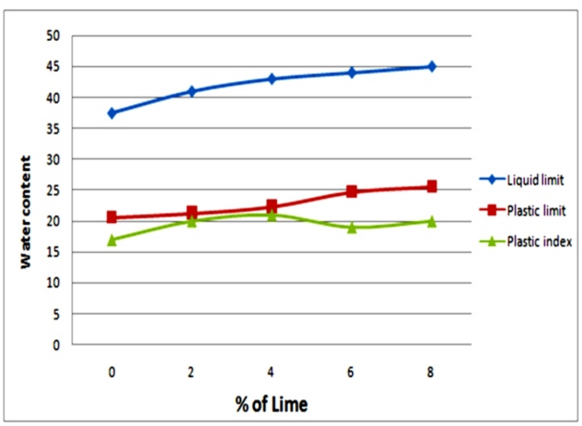

Fig. 1. L.L,P.L&P.I result for Khushab Soil(Original Sample+Lime)

For Khushab Soil, different analysis were performed to check the disperse behavior and also tests were performed after addition of cement with different percentage to check the stabilization. Three samples for 2%, 4%, 6% & 8% ration each were taken with the variable no. of blows the final results showed that from original sample to increased cement ratio showed variable results, trend can be seen in given Fig. 2.

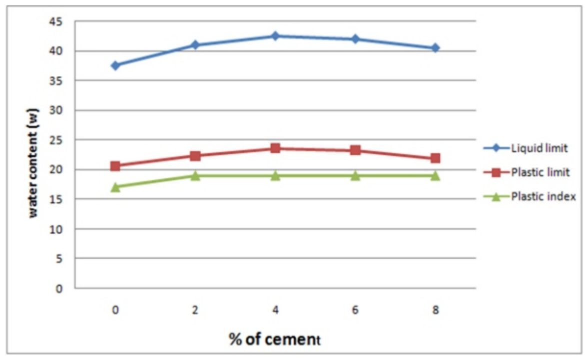

Fig. 2. L.L, P.L & P.I result for Khushab Soil (Original Sample +Cement)

F. Modified Proctor Test

The purpose of these tests is to test the soil generally and to determine the optimum moisture content for the subjected soil. In addition to soil other substance, such as a global, gravel or sand, may be measured. It is also used as a measuring device for testing the strength of the soil. As Khushab soil sample chemical testing as a dispersion stabilizer with the addition of various stabilizers and modified Proctor test was applied. Comparison of optimal water content for the original soil sample + 2%, 4%, 6% and 8% lime in the Fig. 4.

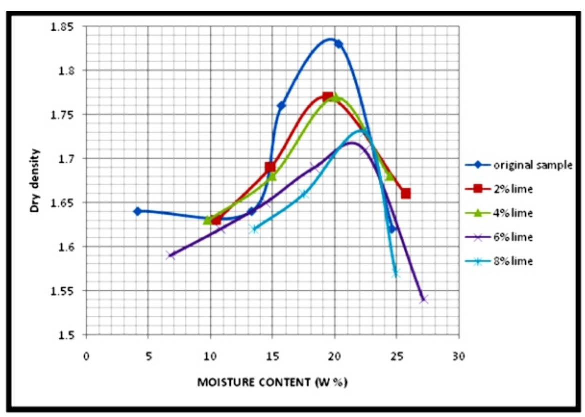

Fig. 4. Modified Proctor result for Khushab Soil(O.S+%Lime)

The purpose of the testing the soil generally is to determine the optimum moisture content for the soil. In addition to soil other substance, such as a global, gravel or sand, may be measured.

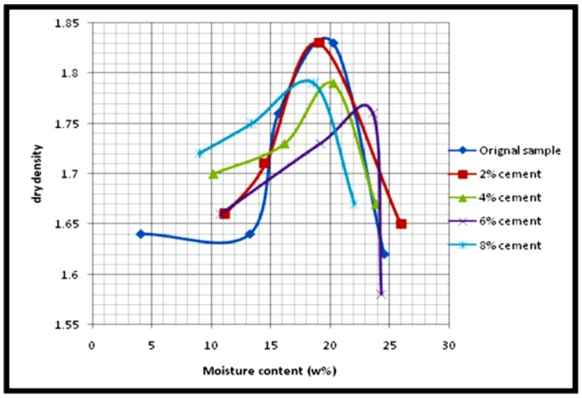

Fig. 5. Modified Proctor result for Khushab Soil(O.S+%Cement)

It is also used as a measuring device for testing the strength of the soil. As often Khushab soil sample chemical testing as a dispersion stabilizer with the addition of various stabilizers and modified Proctor test was applied. Comparison of optimal water content for the original soil sample + 2%, 4%, 6% and 8% cement shown in the Fig.6.

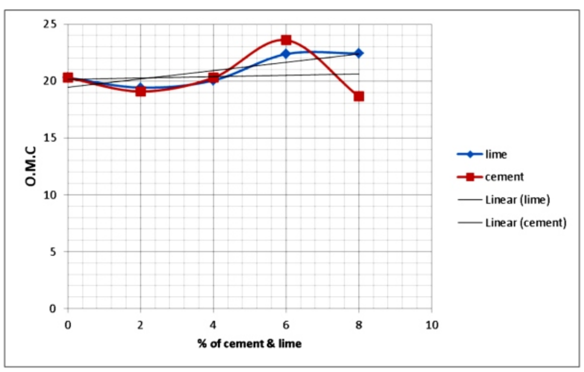

Fig.. 6. Modified Proctor result for Khushab Soil (O.S+%Cement)

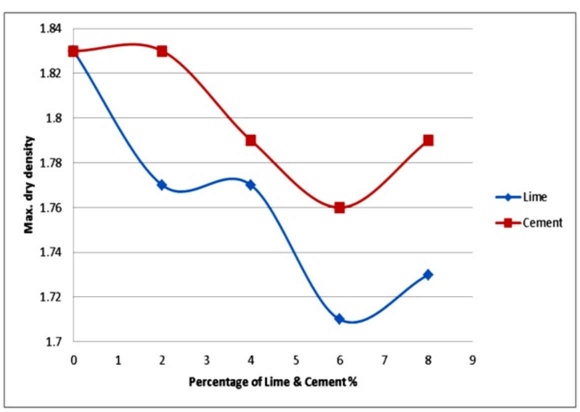

Fig.7. Modified Proctor result - The variation of Maximum dry Density with different

The aim of the soil test is to analyze the soil generally, to determine the optimum moisture content for the soil. In addition to soil other substance, such as a global, gravel or sand, may be measured. It is also used as a measuring device for testing the strength of the soil. As I often Khushab soil sample chemical testing as a dispersion stabilizer with the addition of various stabilizers and modified Proctor test was applied. Comparison of optimal water content for the original soil sample+ 2%, 4% and 6%, 8% limes & Cement can be seen in the Fig. 7.

G. CBR Test

CBR-value is used as an index of soil strength and load capacity. This value is a widely used and applied to the base structure and the underlying layer of material on the ground. Soil stabilized with fly ash and limestone, often used for the construction of pavement layers and filling. CBR-value is a relative measure of the test is used to evaluate the resistance of the soil for these applications [xvii]. CBR-test was performed to characterize the ability of resistance and support of the three studied soils and lime and cement mixture. Test procedures and preparation of samples were prepared according to standard procedures.

CBR-test was performed to characterize the ability of resistance and support of three of the soils and lime and cement mixtures with different percentages of 2%, 4%, 6% and 8% of them. Test procedures and preparation of samples were prepared according to standard procedures shown in Fig. 8.

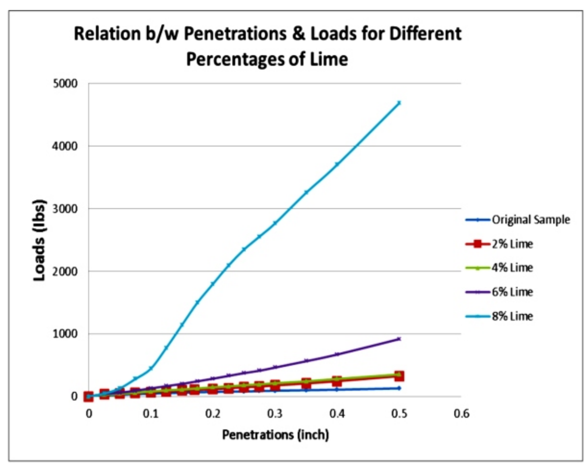

Fig. 8. CBR Test Analysis result for Khushab Soil(Original Sample+% Lime)

CBR-test shown in Fig. 9 was conducted to characterize the stability and support of three of the soils and lime and cement mixtures with different percentages of 2%, 4%, 6%, 8%, 10% and 12% thereof.

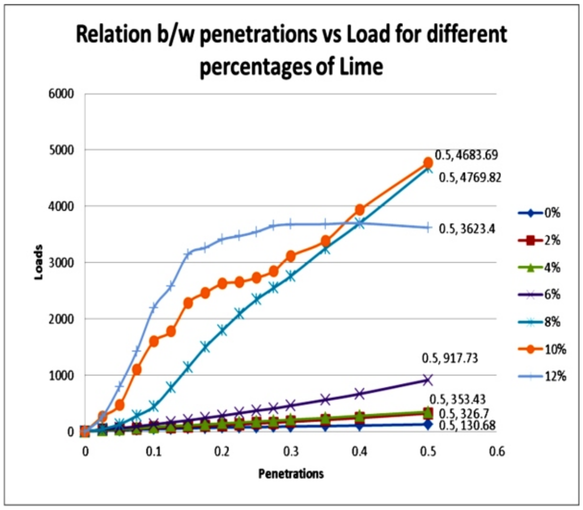

Fig. 9. CBR Test Analysis result for Khushab Soil(Original Sample+% Lime)

CBR-value is used as an index of soil strength and load capacity. This value is a widely used and applied to the base structure and the underlying layer of material on the ground. Soil stabilized with cement, often used for the construction of pavement layers and filling. CBR-test the relative indicator is used to assess the stability of soil for these applications. [xvii] CBR-test shown in Fig 10 was performed to characterize the ability of resistance and support of the soils and cement mixtures with different percentages of 2%, 4%, 6% and 8% of them. Test procedures and preparation of samples were prepared according to standard procedures

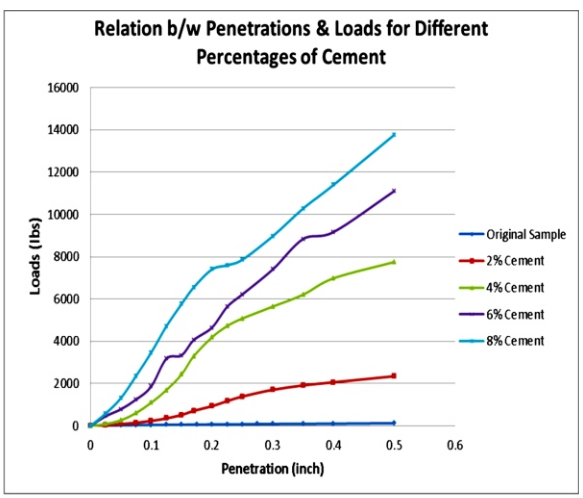

Fig. 10. CBR Test Analysis result for Khushab Soil(O.S+% Cement)

VI. Conclusions and Recommendations

Based on the results obtained from the Chemical along with Physical testing and analysis of experimental results, the following conclusions have been drawn

1. Chemical testing for soil sample showed that a reasonable quantity of sodium chloride was causing dispersion as the Khushab Distt. is linked with Salt Range. SAR (Sodium Adsorption Ratio) & Percent Sodium (PS) values showed that that there was an intermediate level of dispersion. After addition of stabilizing agents like Cement & Lime, non-dispersive behavior was observed with increase in percentage.
2. The Free Swell Test was performed for testing the dispersion of the given soil sample which was not obvious that there is some dispersion property in the soil.
3. Soil behavior was studied after addition of 2%, 4%, 6% and 8% Lime and Cement, from results CBR was improved at optimum level of 6% addition of different percentages of Lime and Cement, so it has been observed that compaction characteristics of Khushab soil has been improved.
4. The Double Hydrometer Test was performed for testing the dispersion of the given soil sample which was obvious that there is some dispersion property in the soil. After addition of stabilizing agents like Cement & Lime, non-dispersive behavior was observed with increase in percentage.
5. The Crumb Test was performed for testing the dispersion of the given soil sample which was obvious that there is some dispersion property in the soil. After addition of stabilizing agents like Cement & Lime, non-dispersive behavior was observed with increase in percentage.
6. In this research, the ASTM D 4221 - 99 [18], Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer, ASTM D 422 - 63 [19], Standard Test Method for Particle-Size Analysis of Soils & ASTM D 4647-06 [20], ASTM D 6572 - 00 (2000), Standard Test Method for Determining Dispersive Characteristics of Clayey Soil by the Crumb Test, were performed to analyze dispersive nature to non-dispersive improvement. More tests with other standards can be performed within advance laboratory setups.
7. The Physical properties were studied with three test procedures Atterberg Limit, Modified Proctor Test especially. Finally conclusions were in favour of successive stabilization process i.e addition of Cement & Lime.
8. Finally the CBR test results showed that Khushab Soil can also be used in Roads as after stabilization this soil can be helpful in accordance with economical point of view considering 6% of addition stabilizer like lime and cement as optimum.

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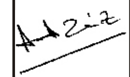
Authorship and Contribution Declaration			
	Author-s Full Name	**Contribution to Paper**	
1	Mrs. S. Batool (Main /Principal Author)	Proposed topic, basic study Design, methodology and manuscript writing	
2	Prof. Dr. Akhtar Ali Malik (2nd Author)	Data Collection and interpretation of results etc.	
3	Prof. Dr. Aziz Akbar (3rd Author)	Literature review & Referencing and quality insurer	
4	Mr. Tahir Sultan (4th Author)	Statistical Analysis