LIME STABILIZATION ON INDUS RIVER SEDIMENTS
Aiming to explore Geotechnical Properties

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ABSTRACT

Laboratorial tests were undertaken to decipher the effects of lime on sediments of Indus River Basin. A series of tests, including California Bearing Ratio, Modified Proctor, Atterberg Limit, Relative Density, Direct Shear Box tests, were conducted on virgin as well as lime mixed soil. Hydrated Lime was added with an increment of 2 by weight and mixed in a dry state. The test results revealed that addition of lime till 10% significantly improved the dry density; reduced optimum moisture content; and increased the bearing value. However, the Plasticity Index increased at 6% lime addition and then decreased steadily. Based on the research it was concluded that sediments can be stabilized with the help of lime.

Key words: *Keywords: Lime stabilization; Indus Basin Sediments; Geotechnical Properties.*

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INTRODUCTION

Land scarcity has been major issue nowadays in the vicinity of existing urban areas [1] [2]. To solve this issue, poorer quality land and construction materials are used for construction projects [3]. While poor quality construction materials are profuse and inexpensive, such materials have unsatisfactory properties from an engineering perspective. In order to overcome this issue, geotechnical engineers devised soil stabilization method where an additive, abundantly and freely available, is added to enhance desired properties of local construction material [4]. With respect to this concept, this study aims to add lime in sediments of Indus River Basin in an attempt to enhance sediment's properties to level that it can be utilized as subgrade material.

Precisely, the soil will be modified with lime, added as 2% till 12% by weight. Quartering method will be used to mix the sediments and soil. The geotechnical properties, that this study intend to modify, include Atterberg limits, classification, shear strength parameters, moisture density relationship, CBR values of sediments of Indus River Basin. The sole purpose of selecting the sediments of Indus River Basin, at Kotri Barrage, is its profuse availability since river level dramatically drops in dry periods and the river bed is studded with sediments. In addition, fresh water flow from Kotri downstream has decreased from 150 MAF to less than 10 MAF. The reason for reduction of river level was mainly upstream diversion of River Indus by unchecked development during 20th century. This has significantly reduced flow from 150 MAF to 1 MAF annually [5]. Furthermore, the air pollution in the vicinity seems to increase in dry periods especially in windy days. The park near the vicinity of Kotri Barrage is suffering because of pollution as, thanks to sediments, it's deserted for 20 years.

LITERATURE REVIEW

Numerous studies have concluded which support the hypothesis that lime, when added till 8-12% or more, increases strength to desired level. A study concluded that by addition of lime in clay soil optimum moisture content increases while as maximum dry density decreases [6]. Another study stabilized A-7-6 material. At 14% lime content Atterberg limits were improved while as dry density decreased; unconfined compressive strength was achieved at 8% lime content for 7,14 and 28 days of curing period respectively. Therefore the study recommended third order polynomial model since improvements are inadequate for roadwork application [7]. In similar arrangement, study was carried out on effects of lime-stabilized soil cushioned with non-expensive cohesive soil. The non-expensive cohesive soil is added at 2% by dry weight till 10% followed by curing and soaking periods of 7, 14, 28 and 56 days. Soil strength factor tests were conducted on virgin as well as cushioned soil. The results conclude that maximum strength is achieved with 8% lime content and a 14 days of cure period [8]. Similar studies on expansive soil in Oman was conducted to evaluate swelling parameters [9]. 6% lime proved to reduce the swell index and pressure to zero. Moreover, it proves to be a superior additive as compared to cement, and Sarooj. Study on kaolinite-bentonite clay along with high plasticity clay soil also reached to similar conclusion [10]. Results shows that the addition of lime increase swelling potential at subsequent cycles; where as in the case of virgin samples, swelling potential decreased after the first cycle and reached equilibrium in the fourth cycle. In

another study, optimum percentage of quarry dust in an expansive soil to stabilize it. Later on, lime was added with 1% increment starting from 2% till 7% followed by curing of 7 and 28 days. The study concludes that lime has a positive effect on plastic limit, shrinkage limit, cohesion, angle of internal friction, optimum moisture content while liquid limit, plasticity index, maximum dry density of soil-quarry dust mixes significantly declining . In addition, curing had positive effect on shear parameters [11]. Lime has been used extensively to foster flexibility. In one of the study lime in clay was added to reduce the brittleness of soil along with polypropylene fiber at different ratios. The study reports that an incremental amount of lime content & curing duration results in increases in cohesion, angle of internal friction, unconfined compressive strength while declines in shrinkage and swelling potential which is counterbalance by the addition of fiber since it enhances swelling potential [12].

Furthermore, numerous studies [13] [14] [15] recommended lime for manure and fertilizer application mainly due to an increment of PH, efficient and economical binding agent, increment in crop yields.

MATERIALS AND METHODS

The lime chosen was hydrated lime that was initially sieved from # 40 sieve in order to be free from garbage.

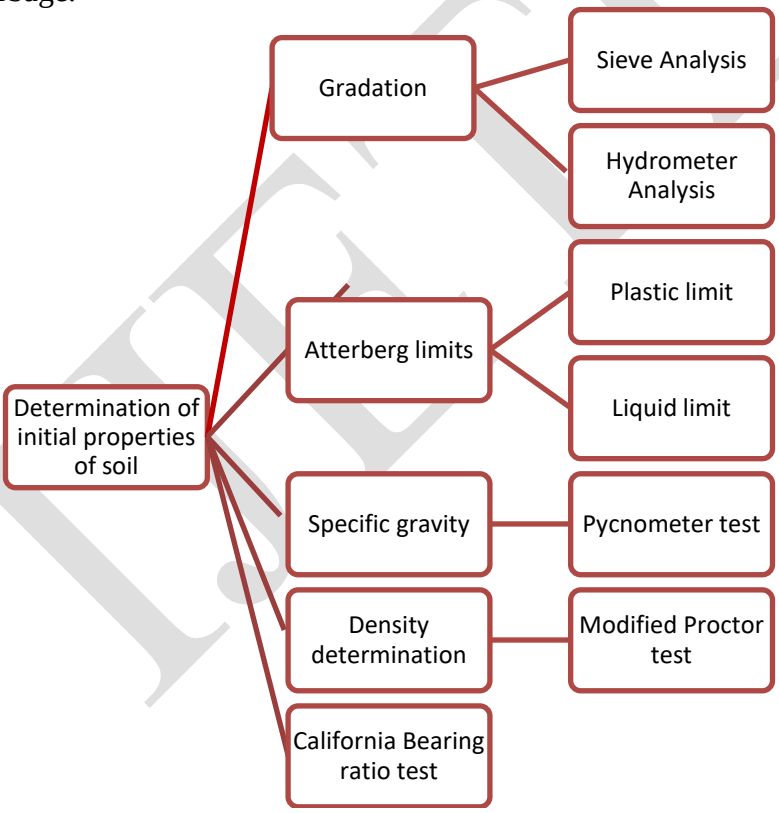

Figure #01: Tests performed on virgin soil

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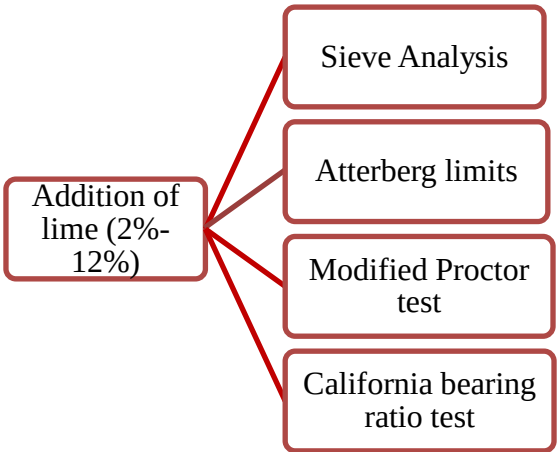

Figure #02: Tests performed after addition of lime

CONCLUSION / RESULTS

EFFECT OF LIME ON INDEX PROPERTIES OF SOIL:

Index properties of soil includes Atterberg's limits and consistency that can be computed by testing liquid limit, plastic limit and shrinkage limit. These properties help in fostering an overall idea for engineering properties. The index properties of untreated soil specimen is as shown in Table I. The colour of soil came out to be grey majorly comprising sand followed by silt and clay. It has been observed that soil is non plastic thus classified as A-3 material, according to American Association of State Highway and Transportation Officials (AASHTO), from Atterberg limit test.

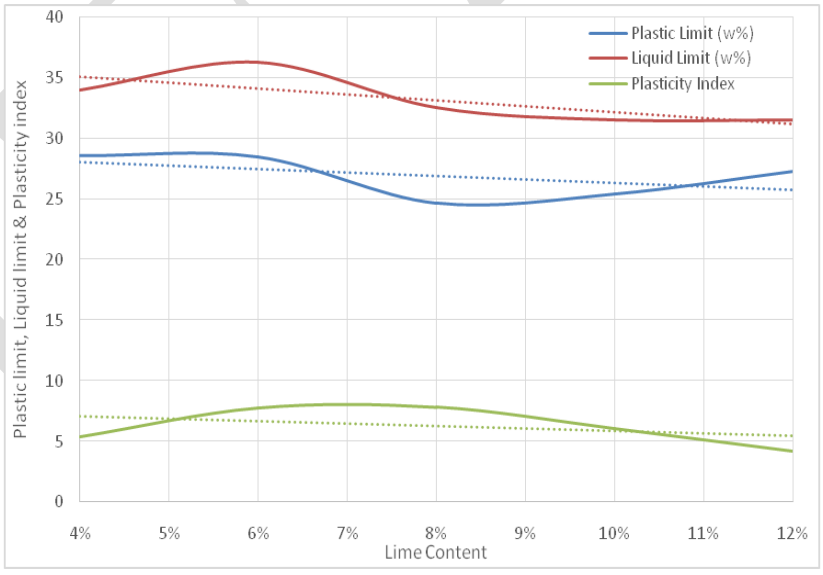

Figure #01: Effect of Lime on Index properties of Treated Soil

Gradation by Sieve Analysis	Percentage Passing B.S Sieve No. 200 (%)	4.54
Particle Size Distribution by Hydrometer Analysis	Sand (%)	94
	Silt (%)	5
	Clay (%)	1
Atterberg Limits	Colour	Grey
	Liquid Limit (%)	NP
	Plastic Limit (%)	NP
	Plasticity Index (%)	NP
	Shrinkage Limit (%)	NP
	AASHTO Classification	A-3
	Maximum Dry Density (g/cc)	1.68
	Optimum Moisture Content (%)	15.5
	Specific Gravity	2.855

Table I: Properties of Virgin Soil

Table II shows dramatic change in consistency limits. Soil has shifted from A-3 material to A-2-4 material that is acceptable as a subgrade material for road construction. Furthermore, soil has increased plasticity there by decreased plasticity index that makes soil as plastic material.

Properties	Lime Content (%)					
	2	4	6	8	10	12
Percentage Passing B.S Sieve No. 200 (%)	12.2	18	16.1	13.8	21.9	22.1
Plastic Limit (%)	NP	28.6	28.5	24.7	25.4	27.3
Liquid Limit (%)	34	34	25	32	28.5	31.3
Plasticity Index (%)	24	5.4	3.5	7.3	7.5	4.01
AASHTO Classification	A-3	A-3	A-2-4	A-2-4	A-2-4	A-2-4

Table II: Properties of treated soil

EFFECT OF LIME ON COMPACTION PROPERTIES OF SOIL:

Compaction is measured in terms of soil's strength, which is computed with the help of maximum dry density of soil. Density is an important parameter since it determines the load, which a structural fill will apply to itself and to its foundation. Density has also significant influence on permeability, stiffness and strength of fill, thus affecting the settlement and ultimate stability. The results of compaction tests carried out on sediments of Indus River Basin soil lime mixes are shown in Graph #03 & 04. Compared to Sediment, lime exhibit higher dry density and lower optimum moisture content. The optimum moisture content was obtained at 10% of lime

content, where dry density of soil was maximum i.e. 1.8 g/cc. Further addition of lime reduce the maximum density which could be due to an immediate formation of cementitious products which reduces the ability to compact and ultimately the density of treated soil (Lees1982).

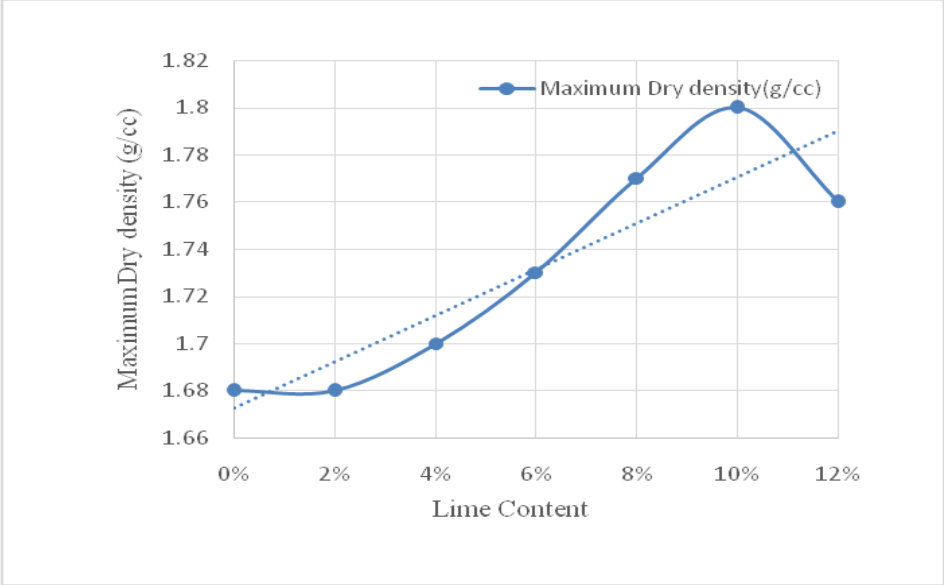

Figure #02: Effect of lime on maximum dry density of treated soil.

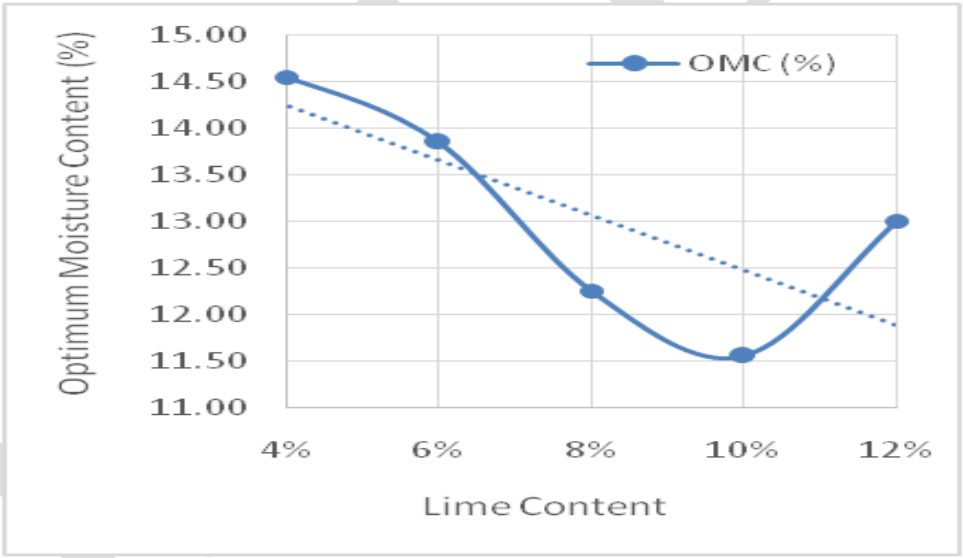

Figure #03: Effect of lime on optimum moisture

CONTENTS OF TREATED SOIL:

Similar way, California Bearing Ratio (CBR) value increase with the increment of lime content in case of un soaked CBR value while soaked CBR value almost remain same as shown in Graph # 05. The samples were compacted to their maximum dry densities at the corresponding moisture contents. The samples were immersed in water for 96 hours before subjecting them to test. The swelling potential and bearing value of these samples was obtained. The result indicated an optimal lime content at 10% that corresponds to 90% CBR value for un soaked while 15% CBR value for soaked soil samples.

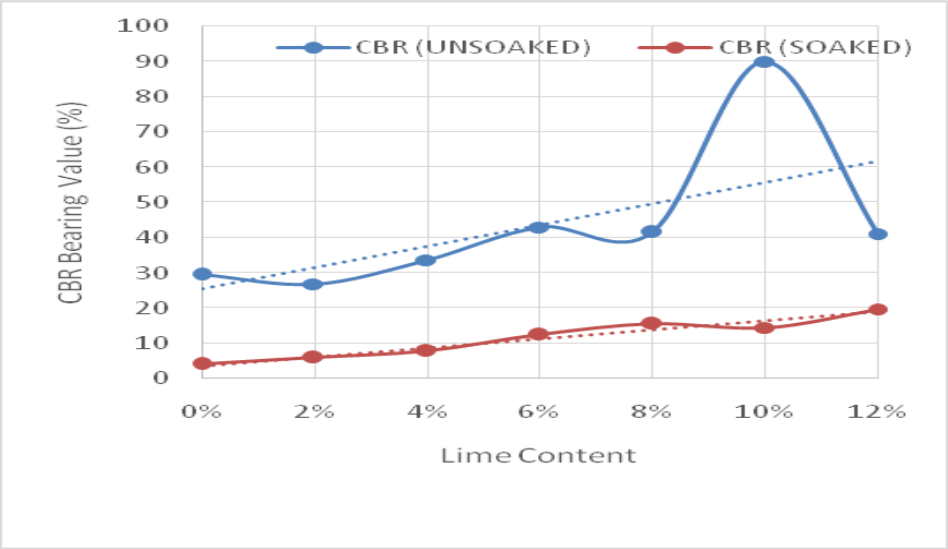

Figure #04: Effect of lime on CBR values of treated soil.

The study concluded the optimal point of 10% in order to add lime in the sediments of Indus basin. However, this doesn't prove the dead end for the study. We believe that if lime is added further the probability of improvement in properties is inevitable. On can also get precise result with thorough mixing; as during the research we came to realize that the more thoroughly mixing was done, better the results were obtained. Since we did not had any favourable equipment for mixing there might be in consistency with results. Summing up all, this study can be a starting point for further research in utilizing the sediments of Indus basin for road material.

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