

DETERMINATION AND EVALUATION OF CBR AND RESILIENT COEFFICIENT TO ESTABLISHED LAYERS OF ROAD PAVEMENT IN KHUZESTAN PROVINCE: A CASE STUDY

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ABSTRACT

Among materials that are useful for stabilization or improvement of soil materials are lime and cement. The most important effect of stabilizer materials on properties of soil materials are modification of soil with least resistance, reduction of the scope of dough, increasing the CBR, increasing soil stability against (repeat frost - melting ice), reduction of permeability and effective use of the collateral loan. Since the stabilizing of soil with lime or cement as the basis and sub-basis is considered as effective method that results in increasing load capacity and reduction of the plastic deformation and dough properties of many materials in the construction projects, so for economic optimization of scheme it is recommended that the percentage of lime and cement must be discussed and determined to increase mortar resistance and reduce costs. Because design of the layers of pavement is done based on CBR and resilient coefficient of materials so economically, implement of soil layers, the sub-basis and base of pavement are function of the items on materials procurement, distribution, sprinklers, squash as well as also carrying materials and travel distance of these items has effects on costs, therefore this present study aimed to combine lime and cement with available materials in region to increase CBR and rebound coefficient in the design that finally it would be reduced in thickness of the designed layers and under effects of its size and distance transportation of materials and efficient use of materials, cost of the project would be decreased.

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KEY WORDS

Resilient coefficient, CBR, stabilized layers

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INTRODUCTION

Increasing of the cost of building roads, dams, railways, airports and generally, of soil structure due to the limited budget and speed of execution makes engineers to prevent the movement of large volumes of local materials and to get maximum use of it. Local materials do not have specifications for use in engineering structures. Change and improvement of soil materials in order to improve application of engineering is called stabilization of materials. Improving local soil materials is a good option that is often the most economical way to solve geotechnical engineering problems. Using local materials and improvement of them in projects makes annual savings of billions of dollars and run-time will be shortened accordingly [1]. Lack of procedures of optimization and stabilizing will cause that proper materials be shipped from great distances in terms of the need. Modified soil in all engineering elements of soil materials particularly, under poor condition is addressed. Regardless issues in Soil Mechanics and its Applications and etc. one of the most common application is its application for strengthen the construction of highways and runways. So what concern for the designer is how to modify unsuitable soil for the intended use?

Pavement design is based on the principle that each layer of pavement can provide the soil with at least structural quality characteristics, each layer must be able to provide resistance, it should prevent many forms of change that causes fatigue cracks in a layer or top layers as well as the it prevent creation of permanent deformation due to excessive changes [2]. Soil stabilization method that is used to improve the quality of materials in road construction, and the use of this method allows obtaining materials with suitable characteristics for use in the layers of pavement. The decision to use this method is made after comparing different acceptable solutions. Because design of the layers of pavement is done based on CBR and resilient coefficient of materials so economically, implement of soil layers, the sub-basis and base of pavement are function of the items on materials procurement, distribution, sprinklers,

squash as well as also carrying materials and travel distance of these items has effects on costs, therefore this present study aimed to combine lime and cement with available materials in region to increase CBR and rebound coefficient in the design that finally it would be reduced in thickness of the designed layers and under effects of its size and distance transportation of materials and efficient use of materials, cost of the project would be decreased [3].

In this study by obtain basic properties of materials used containing sulfated soils, limestone and slag, so parameters of soil strength and main tests including CBR tests for dry and saturated and soil resilient coefficient were done. In addition, way of construction and combination of samples were specified [4].

MATERIALS AND METHODS

Soil used in this study were taken from fine-grained soil in southern part of Khuzestan with 4 percent sulfate (Khorramshahr), fine-grained soil with 2% sulfate in center of Khuzestan (Ahwaz) and sulfate-free territory in north of Khuzestan (Dezful) . For soil stabilization ,Lime and blast furnace slag from steel were used. Karun River water was used as also fresh water. Early detection tests conducted on materials used in the tests and the results will be mentioned below.

The composition of the sample construction

In this study lime and cement added to fine sand. With regard to the optimal percentages of lime in a number of projects in Khuzestan province, optimum percentage of lime and slag were three percent and five percent respectively. In this study for the analysis effects of moisture on soil strength parameters, moisture content of samples varied. Three groups of samples were made with different materials. A group of the samples containing 2 and 4 percent of sulfate and lime taken from the territory of South and Central of Khuzestan. The other group contains sulfate-free soil, ground limestone and taken from north of Khuzestan and last group taken from the south and center of Khuzestan contains limestone and slag [5]. Each group was created in five different moisture contents. Also samples have been studied in both 7 and 28 days

Five values of moisture added to samples containing different moisture levels from less than optimal humidity to moisture more than optimum moisture . For this purpose, a separate density testing was performed for each composition and optimum moisture content of each composition was determined. In this study, each combination was marked with symbols that are also shown in [Table-1](#).

Table: 1. specifications and Symbols of test samples

Symbol	Specifications	Duration (days)for preparation
3L-M	3% lime - soil -Centre (Ahvaz)	7
3L-M-5B	- 3% lime - soil of the territory of the center (Ahwaz) -5% of slag	7
3L-S	3% lime - soil south (Khorramshahr)	28
3L-S-5B	3% lime-soil of the territory of South (Khorramshahr) - 5% of slag	28
3L-N-5B	3% lime-soil north (Dezful) - 5% of slag	28,7

RESULTS

Results of the CBR test

For CBR tests,3 different combinations of materials during curing time of 7 days in five different moisture content were built. Also three different combinations of materials in curing time of 28 days and in combination of 5% moisture were built. In addition, the CBR tests were conducted in both dry and saturated conditions. According to this description, finally 60 samples for testing CBR built. Results of CBR test and equivalent of resilient coefficient of composition are provided in [Table- 2](#).

Table:2. Results of CBR test and equivalent of resilient coefficient

Test number	Sample combination	humidity	Duration(day)	Type of test CBR	CBR (%))Kg/cm2(resilient coefficient
1	3L-M	19	7	dry	16	819
2	3L-M	22	7	dry	19	861
3	3L-M	25	7	dry	15	805
4	3L-M	28	7	dry	14	781
5	3L-M	31	7	dry	8	630
6	3L-N-5B	19	7	dry	15	805
7	3L-N-5B	22	7	dry	20	875
8	3L-N-5B	25	7	dry	18	847
9	3L-N-5B	28	7	dry	11	721
10	3L-N-5B	31	7	dry	6	560
11	3L-M-5B	19	7	dry	19	861
12	3L-M-5B	22	7	dry	24/5	938
13	3L-M-5B	25	7	dry	19	861
14	3L-M-5B	28	7	dry	15	805
15	3L-M-5B	31	7	dry	10	700
16	3L-M	19	7	saturated	4/5	472
17	3L-M	22	7	saturated	5/5	542
18	3L-M	25	7	saturated	6/2	567
19	3L-M	28	7	saturated	7/3	605
20	3L-M	31	7	saturated	4	420
21	3L-N-5B	19	7	saturated	15/8	816
22	3L-N-5B	22	7	saturated	16/5	826
23	3L-N-5B	25	7	saturated	16/2	822
24	3L-N-5B	28	7	saturated	10	700
25	3L-N-5B	31	7	saturated	6/5	577
26	3L-M-5B	19	7	saturated	5/8	553
27	3L-M-5B	22	7	saturated	8	630
28	3L-M-5B	25	7	saturated	12/5	752
29	3L-M-5B	28	7	saturated	13/5	773
30	3L-M-5B	31	7	saturated	8	630

31	3L-S	19	28	dry	25	945
32	3L-S	22	28	dry	27	1000
33	3L-S	25	28	dry	23	917
34	3L-S	28	28	dry	21	889
35	3L-S	31	28	dry	16	819
36	3L-N-5B	19	28	dry	29	1050
37	3L-N-5B	22	28	dry	31	1100
38	3L-N-5B	25	28	dry	28	1025
39	3L-N-5B	28	28	dry	34	1150
40	3L-N-5B	31	28	dry	21	889
41	3L-S-5B	19	28	dry	22/5	910
42	3L-S-5B	22	28	dry	29	1050
43	3L-S-5B	25	28	dry	31	1100
44	3L-S-5B	28	28	dry	34	1150
45	3L-S-5B	31	28	dry	21	889
46	3L-S	19	28	saturated	7	595
47	3L-S	22	28	saturated	8	630
48	3L-S	25	28	saturated	9	565
49	3L-S	28	28	saturated	16/5	826
50	3L-S	31	28	saturated	13	763
51	3L-N-5B	19	28	saturated	23	917
52	3L-N-5B	22	28	saturated	26	970
53	3L-N-5B	25	28	saturated	25	945
54	3L-N-5B	28	28	saturated	23	917
55	3L-N-5B	31	28	saturated	11	721
56	3L-S-5B	19	28	saturated	8	630
57	3L-S-5B	22	28	saturated	20	875
58	3L-S-5B	25	28	saturated	28	1025
59	3L-S-5B	28	28	saturated	23	917
60	3L-S-5B	31	28	saturated	20	875

Analysis of CBR tests in saturation

It can be seen as the increasing of moisture content of the samples, CBR value first increased and then reduced. It is known that by increasing moisture density or weight is increased and so resistance increases. However, with further increase of moisture, some part of the load applied to the soil is tolerated by water instead of soil structure in the sample, so typical resistance is reduced.

Comparison between the CBR resistance in samples containing sulfate and lime and samples containing lime and sulfate and slag under saturated condition during 7 and 28 days showed beneficial effects of slag. It is clear that in both 7 and 28 days of curing time, adding slag to samples containing sulfate may increase the sample resistance in different moisture content. Also, as increasing period, the difference between non-furnace slag samples and slag samples in term of resistance has been increased. In addition, by increasing the moisture content of the samples, difference between the slag and non- slag samples has been more obvious. Sulfate accelerates hydration of the slag so during 7-day, samples containing sulfate and slag get major percentage of its strength . But samples without slag showed no completed resistance reactions and resistance less than samples containing slag due to lack of sufficient time. Samples contain slag due to consumption of lime and sulfate for the hydration of slag showed more resistant. More there is moisture content of the soil more difference between samples with no slag and with slag is observed due to above mentioned faster and better reactions[6].

In **Table- 3**, the maximum strength of CBR and resilient coefficient obtained for samples with different composition is provided.

Table: 3. maximum strength of CBR and resilient coefficient

sample	CBR(%)	(Kg/cm ²)	Duration(day)
3L-M	7/30	606	7
3L-M-5B	13/50	775	7
3L-N-5B	16/50	832	7
3L-S	16/50	832	28
3L-S-5B	28	1025	28
3L-N-5B	26	1000	28

Analysis of CBR tests in the dry state

According to figures of CBR resistance against moisture, it can be seen that in all the samples as increasing moisture content of the samples, CBR value first increased and then reduced. Despite the humidity difference between samples series in any combination, is approximately 3%, but in most compounds when the moisture content is too high, CBR resistance is also reduced with more intensity.

It is observed that samples containing slag show more resistance than samples containing no slag. On the other hand, in the samples without slag, resistance reactions like pozzolanic reactions will not be completed during this time, for this reason samples without slag has resistance less than samples with slag .

Presence of sulfate besides slag may increase resistance of samples so that increasing resistance can be seen in all the moisture conditions. It should be noted that reaction between limestone and slag in the absence of sulfate is a long term reaction and during 7 days has little impact on increasing resistance; But the addition of sulfate would make reaction so rapid and therefore samples containing sulfate and slag get high resistance during 7 days, but samples containing only slag need more time for getting their resistance. The maximum strength of CBR and resilient coefficient for samples with different composition are provided in **Table-4**.

Table: 4. maximum strength of CBR and resilient coefficient

sample	CBR(%)	resilient (Kg/cm ²) coefficient	Duration
3L-M	19	861	7
3L-M-5B	24/50	938	7
3L-N-5B	20	875	7
3L-S	27	1000	8
3L-S-5B	34	1150	28
3L-N-5B	31	1100	28

As it seen resistance of dried samples is more than saturated samples ,it would be due to saturation and inflationary minerals.

Economic Assessment

Economic assessment for a given axis is calculated based on the following characteristics and presented in **Table-5**.

- Asphalt Institute method.
- Daily Traffic 4000
- width of axis(7 meters)
- Stabilized layer (30 cm)
- Transport distance : 10 km to the north, 170 to center and 300 to south .
- The basis for calculating in the price list of 2013
- The cost of implementing for layer in length and a width 1,7 meters respectively (Rial)
- Price for stabilized with lime equal £ 300,000 and with slag and lime equals £ 350,000 for any 7 meters in width axis
- Fixed asphalt layer thickness equals 10 cm
- Conversion ratio of asphalt layer to basis layer equals 2.

Table: 5. Economic Evaluation

3L-S-5B	3L-S	S	M	N	Type of soil
28	16.5	3	4	5	(%)CBR
10	20	56	47	42	Thickness of basis (CM) layer
10	10	10	10	10	Thickness of (CM) asphalted layer
783.930	1.167.860	2.430.000	1.136.658	356.328	costs of basis layer(rial)
32.2	48	100	46.7	14.6	Cost percent for sample s

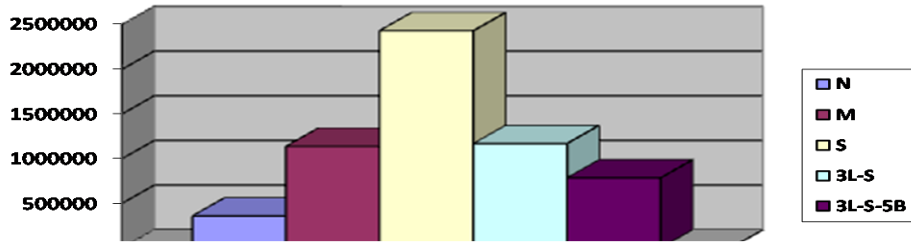


Fig:1.costs of basis layer

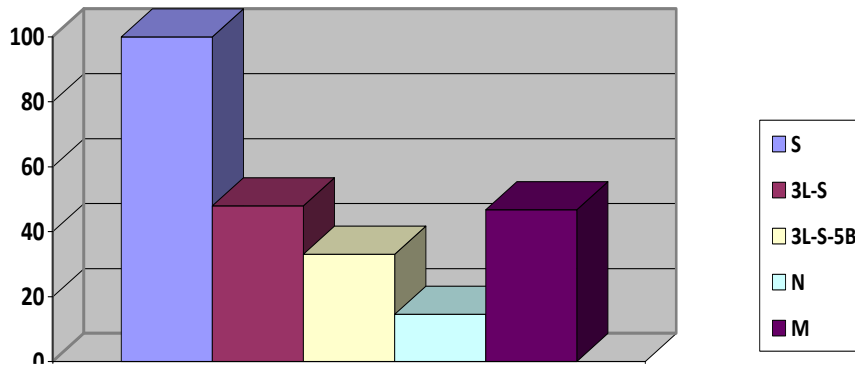


Fig:2. Cost percent based on samples

CONCLUSION

By comparing CBR resistance between samples containing sulfate and slag with samples containing only sulfate, it is observed that if there is sulfate in the environment and the slag also be used, so sulfate that is deemed undesirable it is not only harmful but also contribute to the strength. And samples containing more sulfate are more resistant than samples containing only sulfate. As well as the cost of implementing a base layer on soil stabilized with lime and on soil stabilized with lime and slag will decrease 52% and 67/2% respectively.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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None.

FINANCIAL DISCLOSURE

None declared.

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