Pavement Design using Additives in Subgrade Soil

Theba Faizan[1] Trivedi Karan[2] Vadhiya Nilesh[3] Vasoya Kevin[4]
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]Shri Labhubhai Trivedi Institute of Engineering & Technology, India

Abstract— The road section is divided in several layers such as wearing, base, sub base & subgrade. The thickness of layers are made as per the strength of Subgrade layer. And the load of vehicle are transfer to the soil from wearing coarse to base to sub base to subgrade. As we can see ultimate load is resist by subgrade. The vehicle load and other load of layer also resist by subgrade. So strength of subgrade plays a very important role in road. Road are design as per the subgrade. In our project work the waste material such as steel scrap and aggregate dust is replaced in subgrage soil in some percentage of it is weight contain. The Test will be carried out such as sieve analyze, standard Procter test and C.B.R.

Keywords: Subgrade, Pavement, Stability
Abrasions: O.M.C. Optimum Moisture Content, M.D.D. Maximum Dry Density, C.B.R. California Bearing Ratio

I. INTRODUCTION

Our topic is PAVEMENT DESIGN USING ADDITIVES IN SUBGRADE SOIL. As a the subgrade is main layer in any highway is resist all the load of all pavement (layer) of road as well as the load of vehicular movement. The thickness of other pavement like base and subbase also depend on subgrade. If subgrade is of good quality the thickness of base and subbase course will thinner resulting in economic.

As the subgrade is main pavement in our project we will increase the load carrying capacity of subgrade by adding additives in it. The additives material we used are aggregate powder and scrap steel.

Scope - The scope of this project is to increase the strength of subgrade leading to construct less over all thickness of all pavements. By which the cost of overall road will be decrease. While making the subgrade stronger the maintenance of road low and road durability will be increase. Objectives - To have less maintenance work. To make road stand against the uneven loading. To make less mining work for raw materials of road section.

II. MATERIALS COLLECTED FOR ADDITIVES

A. Aggregate Powder

Aggregate powder is taken which is passed by 75 micron I.S. sieve.

Fig. 2.1: Aggregate powder passed from I.S. 75 micron sieve.

B. Steel Scrap

It is taken from industrial factory. Which taken as a waste of mould casting machine.

Fig. 2.2: Steel Scrap.

III. TEST AND RESULT ON NATURAL SOIL.

A. Sieve Analysis Test:

The objective behind this test is to know the grading and type of soil.

I.S. Sieve	Weight retain (gm)	Cumulative weight retained (gm)	Percentage weight retained (%)	Cumulative percentage retained (%)	Cumulative Percentage passing (%)
4.75mm	73	73	7.3	7.3	92.7
2.36mm	129	202	12.9	20.2	79.8
2mm	1	203	0.1	20.3	79.7
1.7mm	161	364	16.1	36.4	63.6
1.18mm	14	378	1.4	37.8	62.6
600micron	214	592	21.4	59.2	40.8
425micron	158	750	15.8	75	25
300micron	17	767	1.7	76.7	23.3
150micron	149	916	14.9	91.6	8.4
75micron	58	974	5.8	97.4	2.6
Pan	26	1000	2.6	100	0.0

Table 3.1: Sieve analysis result.

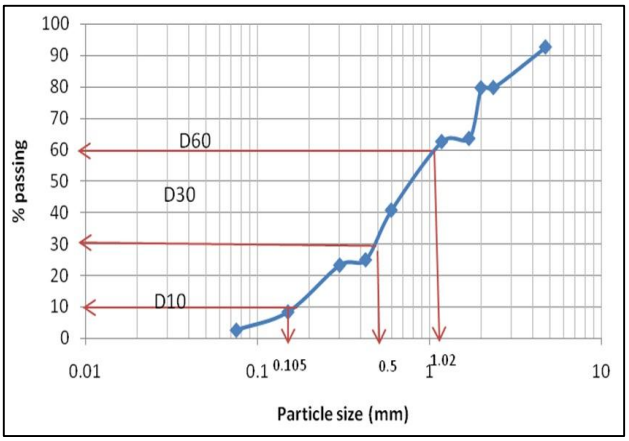

Fig. 3.1: cumulative passing soil v/s particle size.

1) Uniformity Coefficient:

Cu = D60 / D10

D60 = 1.02

D10 = 0.105

Cu = 1.02/0.105 = 9.714

From the above equation the soil is classified as mention below:

Medium graded soil (Sand)

2) Coefficient of Curvature:

Cc = $(D30)^2$ / (D60*D10)

D60 = 1.02

D10 = 0.105

D30 = 0.5

Cc = 2.33

From the Cc we can say soil as well graded soil.

B. Standard Proctor Test:

Carried out to know the maximum dry density and optimum moisture content of soil.

Test number	1	2	3	4
Mass of mould + compacted soil (gm)	5561	5785	5891	5838
Mass of compacted soil weight (gm)	1843	2067	2173	2120
Bulk Density, γ_b = weight/volume (gm/cc)	1.843	2.067	2.173	2.120
Average water content(W)	8.12%	11.19%	15.26%	17.33%
Dry density $\gamma_d = \gamma_b /1+W$	1.705	1.859	1.885	1.807

Table 3.2: Standard Proctor Test result.

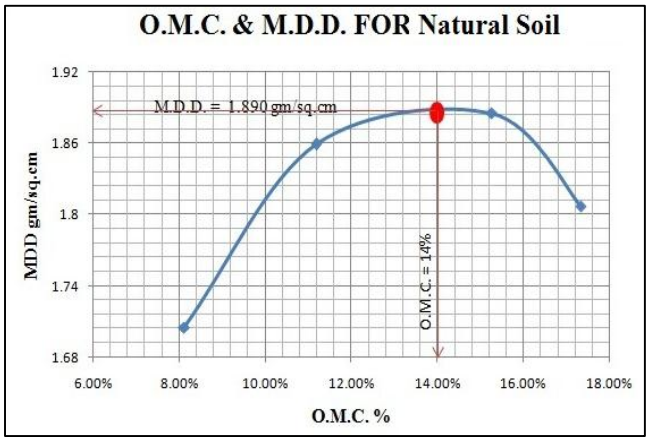

Fig. 3.2: O.M.C & M.D.D. Graph.

From graph we get, M.D.D. = 1.890gm/cc.

O.M.C. = 14% .

C. C.B.R.:

The objective behind caring this test is to know the bearing capacity of soil

Penetration(mm)	Load(Kg)	Stress(Kg/Sq.cm)
0.0	0	0
0.5	10.325	0.525
1.0	13.275	0.676
1.5	16.225	0.827
2.0	20.6	1.052
2.5	26.55	1.353
3.0	30.98	1.578
3.5	36.875	1.879
4.0	41.3	2.104
4.5	47.2	2.404
5.0	51.63	2.630
5.5	57.53	2.930
6.0	61.95	3.156
7.0	73.75	3.575

Table 3.3: Result of C.B.R. Test for Natural Soil.

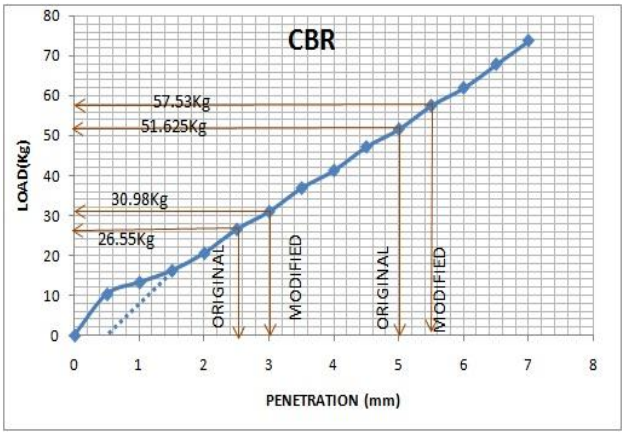

Fig. 3.3: Load v/s Penetration for C.B.R. Graph of Natural soil.

1) C.B.R. Value:

At 2.5mm penetration we get Modified load as 30.98Kg.

Therefore, (30.98/1370)*100 = 2.261%

IV. TEST SOIL WITH ADDITIVES.

A. 5% Steel Scrap As an Additives.

A. Standard Proctor Test:

Test number	1	2	3	4
Mass of mould + compacted soil (gm)	5629	5761	5933	5847
Mass of compacted soil weight (gm)	1911	2043	2215	2129
Bulk Density, γ_b = weight/volume (gm/cc)	1.911	2.043	2.215	2.1291
Average water content(W)	8.36%	13.15%	15.65%	17.13%
Dry density $\gamma_d = \gamma_b/1+W$	1.763	1.805	1.915	1.818

Table 4.1: Standard Proctor Test result.

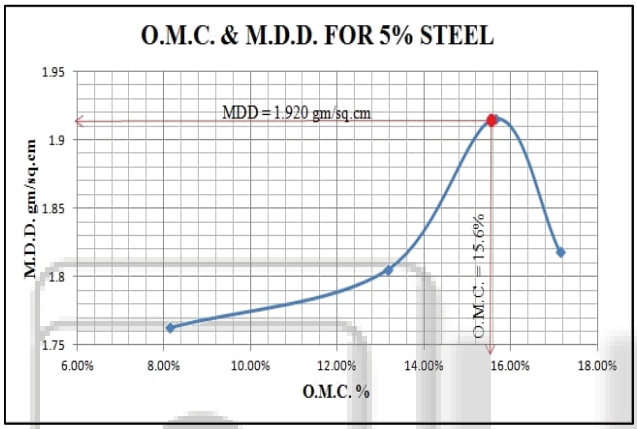

Fig. 4.1: O.M.C. & M.D.D. Graph.

From graph we get, M.D.D. = 1.920gm/cc

O.M.C. = 15.6%

1) C.B.R. :

Penetration(mm)	Load(Kg)	Stress(Kg/Sq.cm)
0.0	0	0
0.5	5.9	0.3
1.0	14.75	0.751
1.5	23.6	1.205
2.0	30.98	1.578
2.5	39.83	2.029
3.0	48.46	2.469
3.5	57.53	2.931
4.0	64.9	3.306
4.5	73.75	3.757
5.0	82.6	4.208
5.5	91.45	4.659
6.0	101.78	5.185
6.5	113.58	5.786
7.0	122.43	6.237

Table 4.2: Result of C.B.R. Test.

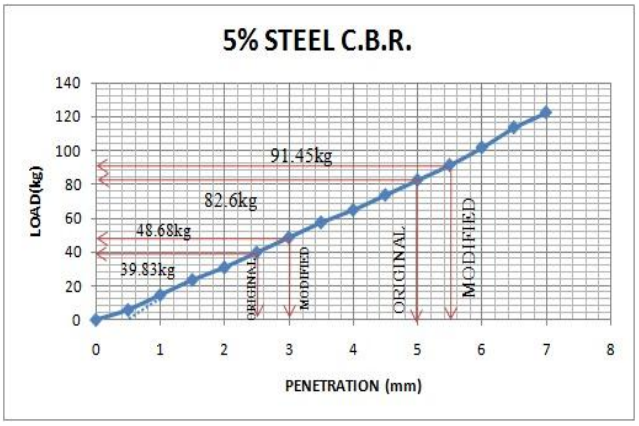

Fig. 4.2: Load v/s Penetration for C.B.R. Graph.

2) C.B.R. Value:

At 2.5mm penetration we get Modified load as 48.68Kg.

Therefore, (48.68/1370)*100 = 3.553%

B. 10% Steel Scrap as an Additives

1) Standard Proctor Test:

Test number	1	2	3	4
Mass of mould + compacted soil (gm)	5732	5949	5932	5913
Mass of compacted soil weight (gm)	2014	2231	2214	2195
Bulk Density, γ_b = weight/volume (gm/cc)	2.014	2.231	2.214	2.195
Average water content(W)	8.18%	13.05%	15.36%	16.69%
Dry density $\gamma_d = \gamma_b/1+W$	1.862	1.973	1.919	1.881

Table 4.3: Standard Proctor Test result.

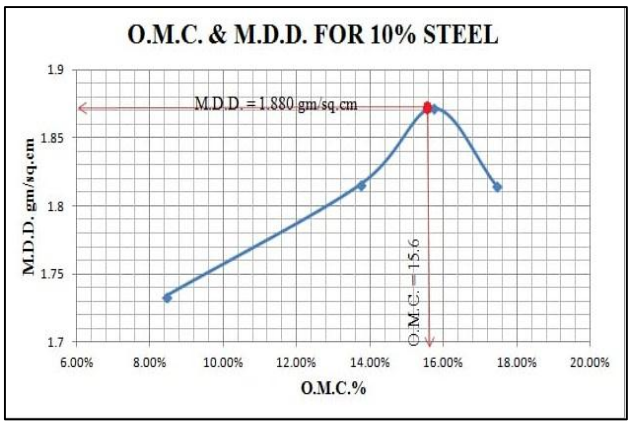

Fig. 4.3: O.M.C. & M.D.D. Graph.

From graph we get, M.D.D. = 1.880 gm/cc

O.M.C. = 15.6 %

2) C.B.R.:

Penetration(mm)	Load(Kg)	Stress(Kg/Sq.cm)
0.0	0	0
0.5	5.9	0.3
1.0	8.85	0.451
1.5	13.28	0.677
2.0	23.6	1.202
2.5	29.5	1.503

3.0	35.4	1.803
3.5	42.78	2.179
4.0	45.73	2.33
4.5	48.68	2.48
5.0	51.63	2.63
5.5	60.48	3.081
6.0	69.33	3.532
6.5	79.65	4.057
7.0	91.45	4.659

Table 4.4: Result of C.B.R. Test.

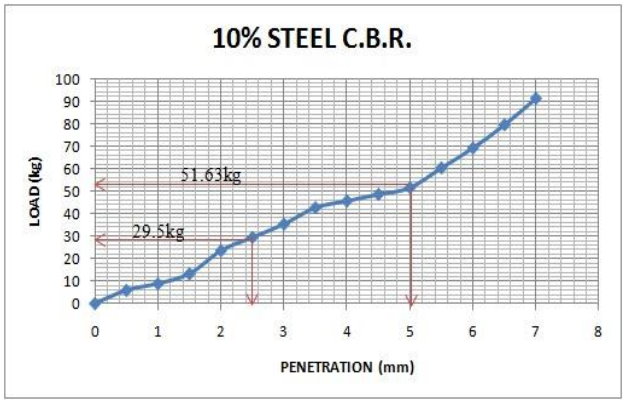

Fig. 4.4: Load v/s Penetration for C.B.R. Graph.

3) C.B.R. Value:

At 2.5mm penetration we get load as 29.5Kg.
Therefore, (29.5/1370)*100 = 2.153%

C. 5% Aggregate Powder as an Additives

1) Standard Proctor Test:

Test number	1	2	3	4
Mass of mould + compacted soil (gm)	5747	5973	5931	5903
Mass of compacted soil weight (gm)	2029	2255	2213	2185
Bulk Density, γ_b = weight/volume (gm/cc)	2.029	2.255	2.213	2.185
Average water content(W)	8.15%	13.17%	15.65%	17.60%
Dry density $\gamma_d = \gamma_b/1+W$	1.876	1.993	1.913	1.858

Table 4.5: Standard Proctor Test result.

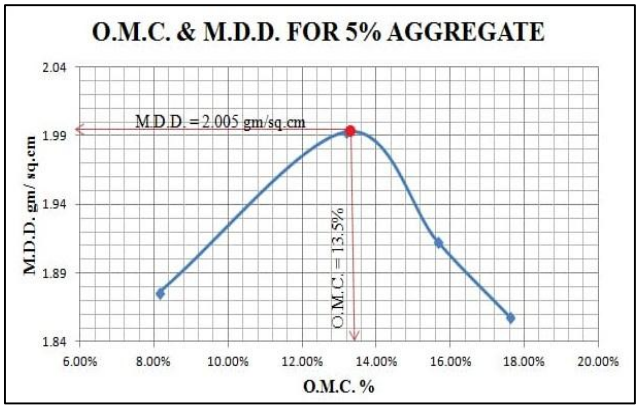

Fig. 4.5: O.M.C. & M.D.D. Graph.

From graph we get, M.D.D. = 2.005 gm/cc

O.M.C. = 13.5%

2) C.B.R.:

Penetration(mm)	Load(Kg)	Stress(Kg/Sq.cm)
0.0	0	0
0.5	9.64	0.491
1.0	16.52	0.842
1.5	25.47	1.298
2.0	33.64	1.714
2.5	44.68	2.276
3.0	55.61	2.833
3.5	68.59	3.494
4.0	77.18	3.932
4.5	88.64	4.516
5.0	96.95	4.939
5.5	106.45	5.423
6.0	118.74	6.049
6.5	129.85	6.615
7.0	140.39	7.152

Table 4.6: Result of C.B.R. Test.

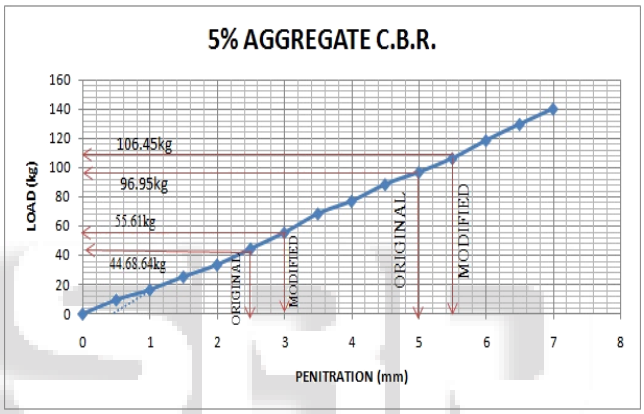

Fig. 4.6:- Load v/s Penetration for C.B.R. Graph.

At 2.5mm penetration we get Modified load as 55.61Kg
Therefore, (55.61/1370)*100 = 4.059%

D. 10% Aggregate Powder as an Additives

1) Standard Proctor Test:

Test number	1	2	3	4
Mass of mould + compacted soil (gm)	5732	5949	5932	5913
Mass of compacted soil weight (gm)	2014	2231	2214	2195
Bulk Density, γ_b = weight/volume (gm/cc)	2.014	2.231	2.214	2.195
Average water content(W)	8.18%	13.05%	15.36%	16.69%
Dry density $\gamma_d = \gamma_b/1+W$	1.862	1.973	1.919	1.881

Table 4.7: Standard Proctor Test result.

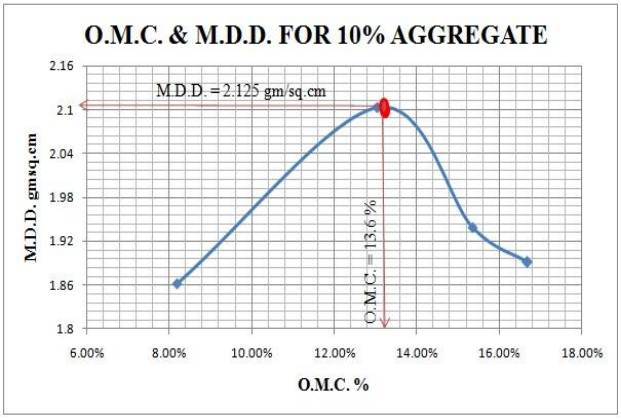

Fig. 4.7: O.M.C. & M.D.D. Graph

From graph we get, M.D.D. = 2.125 gm/cc

O.M.C. = 13.6%

2) C.B.R.:

Penetration(mm)	Load(Kg)	Stress(Kg/Sq.cm)
0.0	0	0
0.5	14.77	0.75
1.0	23.89	1.217
1.5	30.99	1.579
2.0	39.83	2.029
2.5	55	2.802
3.0	70.54	3.593
3.5	79.65	4.058
4.0	91.45	4.659
4.5	101.78	5.185
5.0	113.58	5.787
5.5	125.38	6.387
6.0	135.7	6.913
6.5	146.03	7.439
7.0	156.35	7.965

Table 4.8: Result of C.B.R. Test.

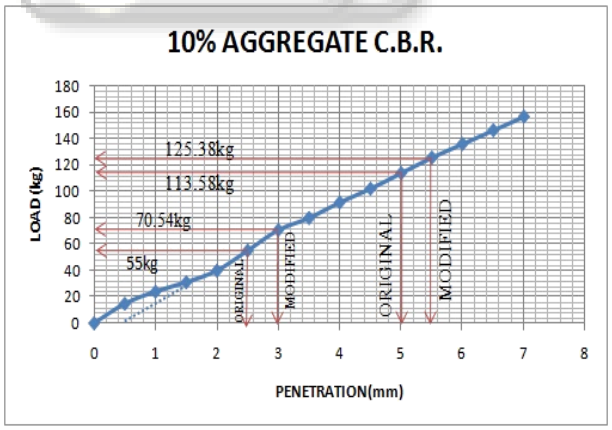

Fig. 4.8: Load v/s Penetration for C.B.R. Graph.

At 2.5mm penetration we get Modified load as 70.54

Therefore, (70.45/1370)*100 = 5.149%

V. COMPARISON RESULTS OF SOIL WITH AND WITHOUT ADDITIVES

A. M.D.D. Comparisons:

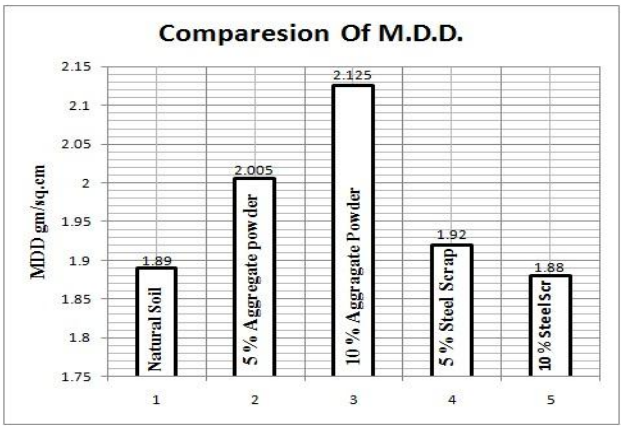

Fig. 5.1:- MDD Comparison Graph.

From test results we can see get Maximum Dry Density in 10% aggregate powder.

B. C.B.R. Comparisons:

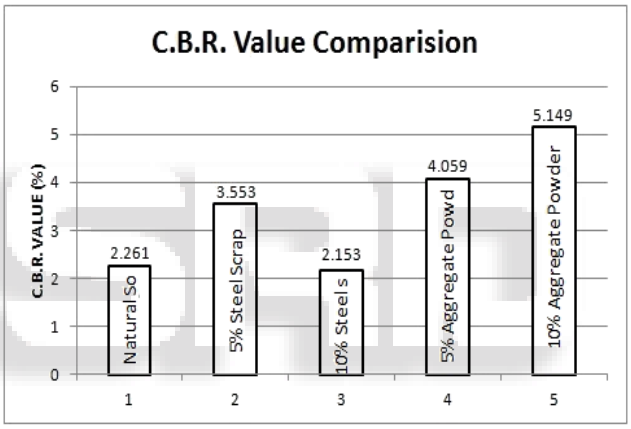

Fig. 5.2: C.B.R. Comparison Graph.

From test results we can see get Maximum C.B.R. value in 10% aggregate powder.

VI. CONCLUSION

We get C.B.R. value of soil as per mention below:-

Natural Soil CBR value - 2.261%, 5% Steel scrap CBR value - 3.553%, 10% Steel scrap CBR value - 2.153%, 5% Aggregate Powder CBR value - 4.059%, 10% Aggregate Powder CBR value - 5.149%

From our research we get maximum C.B.R. value in 10% Aggregate Powder. We get CBR value as 5.149%. It is 43.92% more than the CBR value of natural soil.

From our research we get minimum C.B.R. value in 10% Steel Scrap. Which lesser then the CBR value of natural soil. We get CBR value as 2.153%. It is 5% lesser than the CBR value of natural soil. At the time of test we notice that the compaction 10% steel scrap in mould was hard as air voids where more in that compare to natural soil mould for CBR.

REFERENCES

[1] Xingyu Gu, Bin yu,Qiao Dong, Yongfeng Deng. 'Application of secondary steel slag in sub grade'. Volume -1. 2017.
[2] Ali Jamshidi a, Kiyofumi Kurumisawa b, Toyoharu Nawa b, Mao Jize c, Gregory White d. 'Performance of pavements incorporating industrial by products A state-of-the-art study'. Volume -1.2015.
[3] Ambika Kuitya, Tapas Kumar Roy. 'Utilization of georgic mesh for improving the soft subgrade layer with waste material mix compositions'. Volume -2. 2009.
[4] Dallas N. Little, Syam Nair. 'Recommended Practice for Stabilization of Subgrade Soils and Base Materials'. Volume -3. 2009
[5] Agapitus Ahamefule Amadi, Shagba Lubem. 'Assessing Stabilization Effectiveness of Combined Cement Kiln Dust and Quarry Fines on Pavement Subgrades Dominated by Black Cotton Soil'. 2014.
[6] Neil N. Eldin, Member, ASCE and Ahmed B. Senouci. Use of Scrap Tires In Road Construction. 1992.

