STRENGTH CHARACTERISTICS OF CEMENT STABILIZED SOILS

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ABSTRACT

Soil stabilization is one in every of most significant for the development that is wide employed in reference to road pavement and foundation construction as a result of it improves the index properties like liquidity, plasticity, consistency, flow, toughness indices and conjointly engineering properties of soil like strength, volume stability and sturdiness. within the gift investigation is to judge the compaction, unconfined compressive strength and California bearing quantitative relation (CBR) of natural soil victimisation cement. the odds of cement mixtures that are wont to stabilize natural soil are two, 5 and 10. The study concludes that with share addition of cement improves the strength of natural soil and exhibit comparatively well-defined moisture-density relationship.

Keywords: Cement Stabilization, Unconfined Compressive Strength (UCS), Plasticity-Index (PI), Compaction, Regression Model.

1. INTRODUCTION

The materials that represent earth's crust are loosely classified into 2 classes as rock and soil. Rock may be a material powerfully warranted of materials whereas soil is Associate in Nursing assemblage of solid particles shaped by disintegration of rocks. It spreads below rivers and seas and toward land together with all organic and inorganic materials superimposed the bedrock. The kind and characteristic properties of the soil rely on its formation and deposition by transportation agents. Further particle binding takes place thanks to the presence of carbonates, oxides and organic matter. The exposure of soil with time develops a weathering profile from the bottom surface down. Changes in ground, once formation, occur thanks to totally different natural causes and man's activities apart from that made by structures. Artificial lands referred to as rescued lands are shaped in low lying areas and on water by land filling. The bottom shaped supported the higher than activities ought to have adequate mechanical and hydraulic properties, otherwise the bottom needs to be improved.

Soil Stabilization may be a technique wont to modification totally different soil properties and to reinforce its performance for engineering purpose. Choice of stabilizer for a specific field depends principally on the kind of soil, sort of construction to develop, and handiness of materials to be utilized in construction. Cement base pavement has a plus of nice strength and sturdiness. Also, it's wide obtainable therefore becomes the most effective material for stabilization of soil.

Several researchers have found that stabilization victimisation cement is a lot of appropriate for granular soil and clay soil having low PI. Supported UCS price, quality of soil utilized in sub grade classified as soft, medium, stiff, terribly stiff and onerous. UCS price of stable soils on natural process time will increase with the upper amount of cement extra to the soil. The natural process amount impact the UCS take a look at results of cement stable soil, and better strength obtains for the soil sample cured for fourteen days compared to seven days natural process.

For different forms of soil, a tenet for stabilization has issued specifying the physical property Index (PI) of sandy soil to be but thirty. For fine grain soil PI mustn't be over twenty and to make sure correct compounding liquid limit (LL) mustn't be over forty. For soil having a better quantity of clay 2 stage stabilization is also adopted i.e. the clay is treated with lime in stage I to cut back the worth of physical property and therefore to produce a facility for pulverization, whereas in stage II, the ensuing soil stabilizes with cement. Physical properties of soil like particle size distribution, clay content, liquid limit and physical property index play a serious deciding think about any project. Also, the chemical nature of soil incorporates a nice impact on deciding the sturdiness of roads. therefore to attain a solid and stable foundation we'd like stabilization technique.

2. MATERIAL AND STRATEGIES

The soil kind will have an effect on considerably the effectualness of cement stabilization. For this reason, 9 sorts of soils were stabilised with completely different quantities of cement so as to get an outsized variation of compressive strength values. Seven of the soils were inorganic clays of high malleability (CH) with a number of them containing goodly quantity of (SO4)-2, one soil was inorganic clay of medium malleability (CI) and one soil was organic clay of high malleability (OH) containing tenth of organic material. Portland cement with blaine fineness of four,500cm2/g, specific mass of three.15g/cm3 and 28-day compressive strength of forty five MPa, was used for stabilization experiments. Soils were treated with cement dosages starting from five to thirtieth by capacity unit weight of soil. Cement-soil specimens tested in unconfined compression were ready by at first mixture the relevant quantities of dry soil and water for a minimum of five minutes with a high rotating stirrer; the cement was then value-added to the mixture and additional mixture was performed till it absolutely was consistent in look. Cylindrical specimens were ready by running the soil-cement material into moulds, 35.5mm in diameter and 71mm height. Compressive strength tests were performed beneath a continuing strain rate of zero.6604 m/min.

To determine the properties of soil and soil with cement as a stabilised agents, tests like

1. Sieve Analysis
2. Specific Gravity
3. Liquid Limit
4. Plastic Limit
5. Direct Shear Test
6. Permeability Test
    1. Constant Head Method
    2. Falling Head Method
7. Standard Proctor Compaction Test
8. Unconfined Compaction Test
9. California Bearing Ratio Test

Primary ways of soil stabilization used are mechanical stabilization and chemical stabilization. In any construction, a mechanical technique conducted by compacting the soil through rollers, and chemical technique includes utilization of ash, lime, cement, etc. In chemical technique 2 sorts of additives used at the time of stabilization of soil. 1st one is mechanical additives and therefore the second is chemical additives. As a mechanical additives cement used associate degreed its main operate is to change the soil property automatically by adding an optimum amount, thereby to boost the soil bearing capability. In laboratory stabilization victimization cement was conducted in three steps. In the first step soil sample was ready afterward left it within the air to dry then place it within the kitchen appliance at 1000C for someday. take away the soil from kitchen appliance and crushed the sample victimization the crushing machine. In step second optimum amount of cement needed to the soil, stabilization method determines with the assistance of pH-test. within the third step, cement stable sample ready by compacting it at a most dry density (MDD) and optimum wet content (OMC).MDD and OMC of specimens were obtained victimization changed Proctor check.

Various physical properties of soil like malleability, compaction, and UCS were determined before furthermore as when the stabilization. The pavement performance of a stable road mostly ruled by the gradation and therefore the soil sort or granular material used for the aim of stabilization. The strength of stable materials will live by some ways, of that hottest is that the UCS check. the number of cement additional to the soil supported the kind of soil. Soil Cement specimens ready with numerous cement contents in constant volume mould. The compressive strength of those specimens tested when one, 3, seven and fourteen days of solidifying. A graph aforethought between cement content and compressive strength. Soils small-grained a lot of simply after they contain correct wet content. Pre-wetting helps in pulverization of dry, hard soils. different problems in soil cement are wet content throughout compaction, rolling to be completed among a pair of hours of blending and minimum seven days solidifying.

3. RESULTS AND ANALYSIS

Results of assorted tests conducted on soil samples Natural soil, 2% Cement, fifth Cement and tenth Cement contents like specific gravity; grain size distribution; consistency limits; direct shear check; permeability; normal proctor check; CMBR test and UCC test.

3.1. Specific Gravity

S.No	Soil Sample	Specific Gravity (G)
1	Natural Soil	2.44
2	2% cement blended soils	2.49
3	5% cement blended soils	2.54
4	10% cement blended soils	2.58

Table 1. Specific gravity values for different percentages

3.2.**Grain Size Distribution of Natural Soil**

IS. Sieve	Wt. of retained in each sieve (gms)	Percentage retained	Cumulative percentage retained on each sieve	Percentage finer
4.75mm	161	32.8	32.8	67.21
2.00mm	129	26.3	59	40.9
1.00mm	77	15.7	74.7	25.3
600 µ	34	6.9	81.7	18.3
425 µ	23	4.7	86.3	13.7
300 µ	17	3.5	89.8	10.2
150 µ	31	6.3	96.1	3.9
75 µ	12	2.4	98.5	1.5
Pan	7	1.5	100	0

Table 2. Grain size distribution values for different percentages

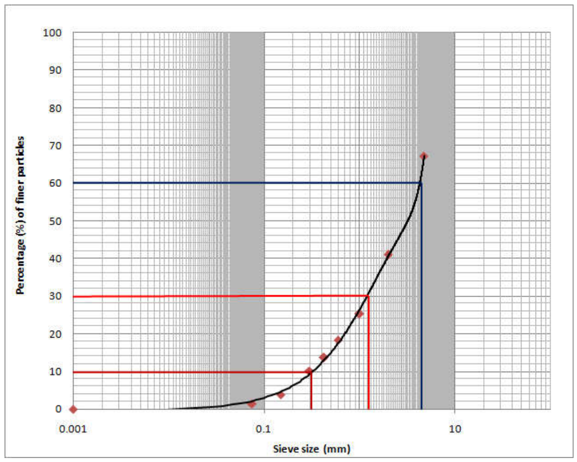

Figure 1. Grain size distribution

3.3. Liquid limit

S.No	Soil Sample	Liquid Limit
1	Natural Soil	36.5
2	2%Cement Blended Soil	47
3	5% Cement Blended Soil	46
4	10% Cement Blended Soil	44

Table 3. Liquid limits values for different percentages of cement

3.4. Plastic limit

S.No	Soil Sample	Plastic Limit
1	Natural Soil	33.3
2	2% Cement Blended Soil	32
3	5% Cement Blended Soil	27
4	10% Cement Blended Soil	35

Table 4. Plastic limit values for different percentages of cement

Consistency Indices

S.No	Soil Sample	Plasticity Index (%)	Liquidity Index (%)	Consistency Index (%)	Flow Index (%)	Toughness Index (%)
1	Natural Soil	3.2	20	80	5.7	5.6
2	2% Cement Blended Soil	15	60	40	7.2	2.1
3	5% Cement Blended Soil	19	73.7	26.3	12.4	1.5
4	10% Cement Blended Soil	9	66.7	33.3	8.5	1.1

Table 5. Consistency indices values for different percentages of cement

3.5. Direct Shear Test

S.no	Soil sample	Cohesion (kg/cm^2)	Angle of Internal Friction (Φ)
1	Natural Soil	0.31	60^0
2	2% Cement Blended Soil	0.57	66^0
3	5% Cement Blended Soil	0.39	70^0
4	10% Cement Blended Soil	0.28	71^0

Table 6. Direct shear test values for different percentages of cement

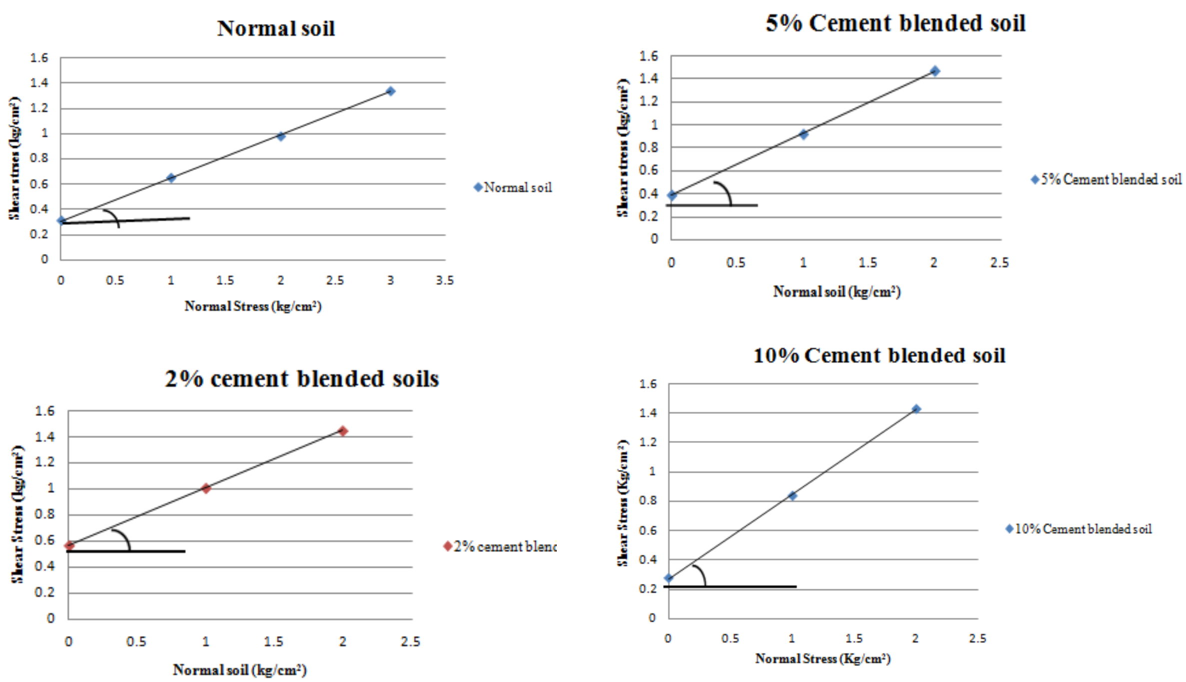

Figure 2. Variation of direct shear test for natural soil, 2% cement , 5% cement , 10% cement blended soils.

3.6 Permeability

S.no	Soil Sample	Coefficient of permeability (K) cm/s	
		Constant head method	Falling head method
1	Natural Soil	1.2×10^{-4}	1.9×10^{-4}
2	2% cement blended soil	3.1×10^{-4}	1.5×10^{-3}
3	5% cement blended soil	2.3×10^{-4}	1.4×10^{-3}
4	10% cement blended soil	1.4×10^{-4}	5.9×10^{-4}

Table 8. Permeability values for different percentages of cement

Soil type	K(cm/s)
Gravel	10^{0}
Coarse sand	10^{0} to 10^{-1}
Medium sand	10^{-1} to 10^{-2}
Fine sand	10^{-2} to 10^{-3}
Silty sand	10^{-3} to 10^{-4}
silt	1×10^{-5}
clay	10^{-7} to 10^{-9}

Table 9. distribution of particle sizes and particle shape and soil structure.

3.7 Standard Proctor Test

S.no	Soil samples	Optimum moisture content(%)	Bulk density (gm/c.c)	Dry density (gm/c.c)
1	Natural Soils	16	1.88	1.61
2	2% cement blended soils	16	1.89	1.63
3	5% cement blended soils	16	1.90	1.64
4	10% cement blended soils	16	1.94	1.68

Table 10. Standard Proctor test values for different percentages of cement

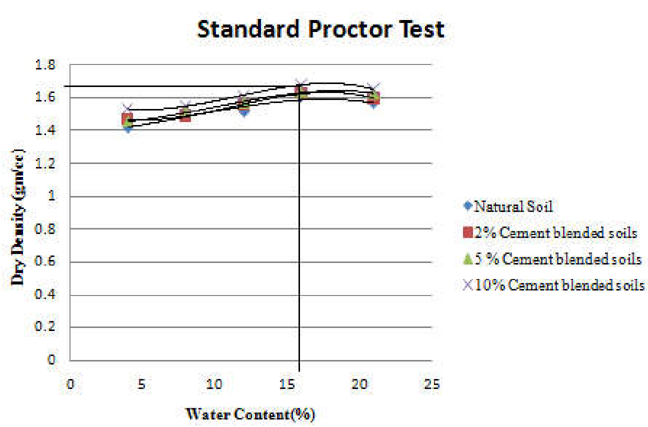

Figure 3. Variation of standard proctor values for natural soils, 2% cement, 5%cement, 10% cement blended soils

3.8 CBR (California Bearing Ratio) Test

Penetration (mm)	Natural Soil (kN)	2% Cement blended soils (kN)	5% Cement blended soils (kN)	10% Cement blended soils (kN)
0	0	0	0	0
50	2.2	9	4.8	4
100	3.2	13.5	7.5	5.6
150	3.8	16.4	9.1	6.8
200	4.3	18.8	10.4	7.8
250	4.6	20.7	11.6	8.2
300	5	22.8	12.1	8.4
350	5.2	23.3	12.7	8.6
400	5.3	24.5	13.1	8.6
450	5.5	25.4	13.5	8.7
500	5.6	26.2	13.8	8.7
550	5.8	26.8	14.1	8.7
600	5.8	27.2	14.3	8.7
650	5.9	27.6	14.5	8.7
700	6	27.8	14.6	8.7
750	6	28	14.8	8.7
800	6.1	28.1	14.8	8.7
850	6.2	28.1	14.8	8.7
900	6.2	28.1	14.8	8.7
950	6.2	28.1	14.8	8.7
1000	6.2	28.1	14.8	8.7
1050	6.2	28.1	14.8	8.7
1100	6.3	28.1	14.8	8.7
1150	6.3	28.1	14.8	8.7
1200	6.3	28.1	14.8	8.7
1250	6.3	28.1	14.8	8.7

Table 11. CBR values for different percentages of cement

S.No	Description	CBR values (%)
1	Natural Soil	34.2
2	2% cement blended soil	86.3
3	5% cement blended soil	98
4	10% cement blended soil	154

Table 12. The CBR values

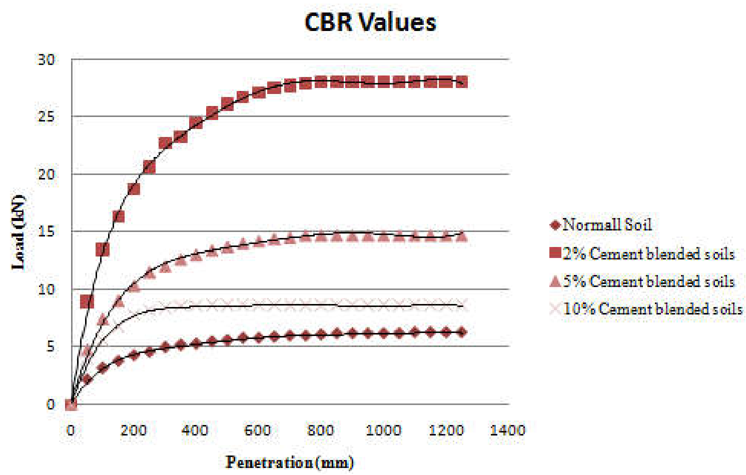

Figure 4. Variation of CBR values in natural soils, 2% cement, 5%cement, 10% cement blended soils

3.9 Unconfined Compression Test

Penetration (mm)	Natural Soil (N/mm^2)	2% cement blended soil (N/mm^2)	5% cement blended soil (N/mm^2)	10% cement blended soil (N/mm^2)
0.006	0.7	0.53	0.79	0.7
0.013	1.04	0.87	0.96	0.87
0.02	1.47	1.73	1.21	1.73
0.026	1.63	2.5	1.29	2.74
0.033	1.71	2.9	1.36	2.81
0.04	1.78	3.4	1.35	2.81
0.047	1.78	3.7	1.43	2.81
0.053	1.78	3.8	1.42	2.81
0.06	1.78	4.1	1.42	2.81
0.067	1.78	4.4	1.42	2.81
0.073	1.78	4.4	1.42	2.81
0.08	1.78	4.5	1.42	2.81
0.087	1.78	4.9	1.42	2.81
0.093	1.78	5	1.42	2.81
0.1	1.78	5.2	1.42	2.81
0.106	1.78	5.3	1.42	2.81
0.113	1.78	5.5	1.42	2.81
0.12	1.78	5.7	1.42	2.81

Table 13. Unconfined compression test values for different percentages of cement

S.No	**Description**	**UCC values(N/mm^2)**
1	Natural Soil	1.47
2	2% cement blended soils	1.48
3	5% cement blended soils	2.81
4	10% cement blended soils	5.3

Table 14. unconfined compression values

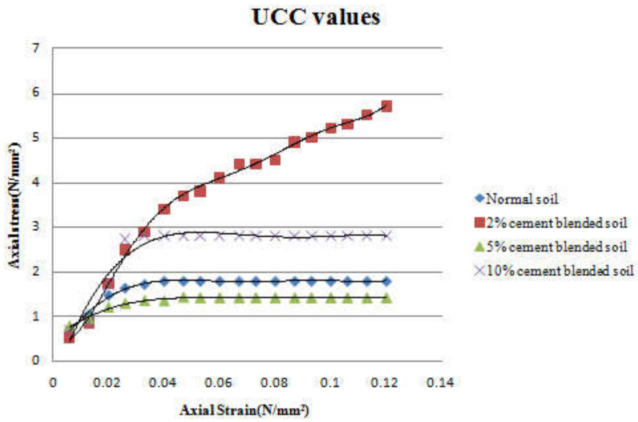

Figure 5. Variation of unconfined compression values for natural soils, 2% cement, 5%cement, 10% cement blended soils

3.10. Results for different percentages

S.No	Name Of Tests	Values	2% cement by adding natural soils	5% cement by adding natural soils	10% cement by adding natural soils
1	Specific gravity	2.44	2.49	2.54	2.35
2	Liquid limit (%)	36.5	47	46	44
	Plastic limit (%)	33.3	32	27	35
3	Atterberg Limits				
	a) Plasticity Index (%)	3.2	15	19	9
	b) Liquidity Index (%)	20	60	73.7	66.7
	c) Consistency Index (%)	80	40	26.3	33.3
	d) Flow Index (%)	5.7	7.2	12.4	8.5
	e) Toughness Index (%)	5.64	2.1	1.5	1.1
4	Permeability (K) (cm/s) a)Falling Head Method b)Constant Head method	 1.9×10^{-4} 1.2×10^{-4}	 1.5×10^{-3} 3.1×10^{-4}	 1.415×10^{-3} 2.3×10^{-4}	 5.915×10^{-4} 1.4×10^{-4}
5	Direct Shear Test a)Angle of Friction(φ) b) Cohesion(c) (kg/cm^2)	 60^o 0.31	 66^o 0.57	 70^o 0.39	 71^o 0.28
6	Standard Proctor test a)Optimum Moisture Content (%) b)Maximum Dry Density (g/c.c)	 16 1.61	 16 1.63	 16 1.64	 16 1.68
7	Unconfined Compression values(N/m^2)	1.47	1.48	2.81	5.3
8	California Bearing Ratio values (%)	34.23	86.3	98	154

Table 15. Final results of Cement stabilized soils.

4. CONCLUSION

The present study reveals the number of soil that's adopted for investigation has low strength in terms of CBR, is considerably improved with the addition of cement. the worth of CBR is additional once cement is employed within the soil. This proves to be effective in increasing the properties of the soil. the subsequent conclusions are often made up of this study.

1. The precise gravity is exaggerated once will increase the cement proportions of the soils.
2. Consistency limits is additionally well-preformed with cement alloyed soils.
3. The shear take a look at is additionally exaggerated with cement mixture.
4. Permeableness is will increase once increasing the cement proportions within the soils.
5. The optimum wetness content will increase significantly with cement alloyed soils.
6. there's associate improvement within the most dry density of the soil with the mixing of cement to the natural soils.
7. Each un-soaked further as soaked CBR of the combo will increase with the mixing of the cement with the natural soils.
8. The unconfined compressive strength additionally found to extend once cement is mixed with natural soils.
9. Since soil, 2% cement,5% cement and tenth cement alloyed soils mixes improves the geotechnical properties of the natural soils and there's substantial increase within the soaked CBR. These are often utilized in pavement sub bases and construction website. because the material is reasonable the matter of the procuring quality construction material is solved .

5. REFERENCES

1. Co., Chen, F.H (1988) - “foundation on expansive soils” Elsevier scientific publishing Amsterdam.

2. Gray, et.al (1972) – “Engineering properties of fly ash,” Journal of soil mechanics and foundation division, ASCE, Vol.98. NoSM4, proceedings paper 8840, pp361-380

3. Hass, R., walls, j. and Carroll, R.G. (1988) - “Geogrid Reinforcement of Granular basses in flexible pavements”. TRR-1188, TRB, pp19-27

4. I.S:2720, Part IV, 1965. - Determination of grain-size distribution by sieve analysis.

5. I.S: 2720, Part V, 1965. - Determination of liquid limit.

6. I.S: 2720 Part V, 1970. - Determination of plastic limit.

7. I.S: 2720 Part VI, 1972. - Determination of shrinkage limit.

8. Katti, R.K., (1979).-“Search for solutions for problems in black cotton soils”. Indian geotechnical journal, 9(1), 1-80 .11

9. Mukharjee, S.N.(1995).- “Lime stabilization of Black cotton soils with special reference to pavements.” Proc of IGC-95, Bangalore, pp. 153-156.

10. Phani Kumar, B.R and sriramarao (1996) – "Granular pile anchors in expansive soils," proc. National seminar on partially saturated soils and Expansive soils, Kakinada, India .PP-15-22.

11. Ramanamurthyet.Al (1996) – "Effect of chemical (calcium chloride) ponding on properties of black cotton soils,"IGC-96

12. Ramesh, et, al (1975)-"New and conventional use of fly ash." Transportation journal.

13. Salem, A. And Kathkuda , L.E.D(1982)-"Laboratory investigation of geotechnical properties of soil," location No.2, Amman , Jordan , Research reports, Building research center , Royal scientific society , Amman , Jordan.

14. Satyanarayana, B.,(1969).- "Behaviour of expansive soil trusted or cushioned with sand." Proc .of the 2nd International conference on expansive soils, Texas A and M university, Texas, 308-316.

15. Sethen, D.R. (1998)–"An evaluation of methology for prediction and minimization of detrimental volume changes of expansive soils in highway subgrades" research report Vol.1, Fedral highway administration, Washington D.C.

16. SubbaRao, K.S., (1999) - "Swell-Shrink behavior of expansive soils geotechnical challenges." IGS Annual lecture, Calcutta.