Study of Partial Replacement of Construction Debris with Cement on Collapsible Potential of Soil

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***Abstract—* Collapsible soils are prone to hydro-compaction behavior, these soils in dry state posses high strength and shrink suddenly on flooding The drastic subsidence and settlement problems require a thorough analysis of collapsibility and treatment with suitable admixtures. Cement being more suitable but costlier the idea of the project was to replace a part of cement with Construction Debris. For which a controlled odeometer test was performed on the collapsible soil samples found at Moinabad Village around GIET campus, Hyderabad. The paper analyzes the percentages of cement and construction debris that reduce the collapsibility of the samples.**

***Index Terms*—collapsibility, soil stabilization, hydro-compaction, odeometer test, void ratio- effective normal stress plots**

I. Introduction

Development of construction activity around the world has extended the boundaries of cities worldwide, the development of infrastructure helped in regaining problematic sites and lands as well to meet the present day demand. Hence, proper decision on suitability of the soil can be expressed only when appropriate geotechnical investigations are carried out.

The goal of sustainable construction is to reduce the environmental impact of a constructed facility over its lifetime. Due to increase in Construction and Demolition activities worldwide, the waste concrete after the destruction of any infrastructure is not used for any purpose. The debris is also a major problem for municipal authorities to dispose of at particular location.

The collapse of soils due to wetting may result in settlements of 2 to 6 percent of their thickness. Collapsible soils are known to experience significant volume decreased due to the increase of soil moisture content, without an increase in the in-situ stress level.

The severity of settlement and impact to structures which can result from collapse of the subsoils depends on several conditions such as grading and drainage, Foundation loading and Depth of foundation structure. The collapse of soils due to wetting may result in settlements of 2 to 6 percent of their thickness. Collapsible soils are known to experience significant volume decreased due to the increase of soil moisture content, without an increase in the in-situ stress level.

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II. Objectives

The overall scope of the project is to contribute and develop the use of Construction Debris in collapsible soils and identifying the proportions of cement along with debris in dealing with collapsible soils used in compacted fills. To meet this aim, the following objectives were formulated.

- To collect Natural undisturbed and reconstituted soil specimens from GIET campus, Moinabad Village Hyderabad for experimentation.
- To find the collapsibility of soil.
- To test specific properties of construction materials ie... grain size analysis, strength characteristics, and aggregate impact.
- To determine the compressibility properties and collapse behavior of natural samples by testing specimens.
- To investigate the role of construction debris of different types and in different amounts and to determine the effect of these on the Hydrocollapse behaviour.

III. Soil Data Collection

Ten samples were extracted from the bottom of 5 test pits that were dug at GIET Campus Moinabad (M), Chilkur Village Hyderabad. 5 test pits were dug to a depth 0.50 m below ground surface and the sample was tested in the laboratory.

FIG 1 : Soil Sampling Site – GIET Campus

IV. Collapsibility Determination

The collapse potential is defined as the change in sample height (h) upon wetting compared to the original sample height (ho).

Collapse potential(I_c) of the soil is calculate as

$$I_c = \Delta e \ / \ (1+ e_o) = \Delta h \ / \ (1+ h_o)$$

Where..,

Δh is the change in the height of specimen upon flooding

h_o is the original height of the specimen

Δe is the change in the void ratio of the specimen upon flooding

e_o is the void ratio before flooding

Table 1: Collapse Percentage as an Indication of Potential Severity(Jennings and Knight 1975)

Collapse (%)	**Severity of problem**
0 - 1	No problem
1-5	Moderate trouble
5-10	Trouble
10-15	Troublesome
15-20	Severe trouble
Over 20	Very severe trouble

From the test pits dug the obtained soil samples were tested to record their collapsibility which showed an average value of about 11.7%.

V. TESTING

One-Dimensional Consolidation Test is usually carried out on specimens to determine the void ratio for the corresponding effective normal stress.

In this study, M43 grade cement in proportions of 0%, 2%, 4%, 6%, 8% and 10%, substituted along with Construction debris in proportions of 12%, 10%, 8%, 6%,4% and 2% of the dry unit weight of soil. Samples are used in dry state and prepared in odeometer setup at a dry density of 11, 13 & 15 KN/m^3. Samples were prepared in two states i) dry state and ii) with initial moisture content of 6%. The collapse potential was recorded corresponding to stress level of 200 KPa.

A) Collapsible potential of soil without cement admixture

Table 2: Void Ratios-Effective Normal Stress Values for the Samples Tested For Different Dry Densities at 200kpa

Effective Normal Stress (kpa)		Void ratio(e)		
		11KN/m3	13KN/m^3	15KN/m^3
Dry state	0	1.44	1.06	0.79
	10	1.36	1.02	0.79
	20	1.36	1.02	0.78
	50	1.35	0.99	0.77
	100	1.34	0.97	0.77
	200	1.31	0.94	0.75
Wet state (after flooding)	200	1.03	0.76	0.59
	300	0.99	0.68	0.53
	400	0.99	0.68	0.53
	500	0.96	0.65	0.48

Table 3: Collapse Potential at 200 KPa Normal Stress For Untreated Soil

Dry density (KN/m^3)	Collapse potential (CP) in %
11	10.09
13	9.13
15	7.63

B) Collapse behavior of cement and debris treated soil without initial moisture content

Table 4 Void Ratios-Effective Normal Stress Values for the Samples Tested for Different proportions of cement and debris at 11KN/m^3 Dry Densities and collapse potential at 200KPa

Effective Normal Stress (200 KPa)		Void ratio(e)					
		Cement 0% Debris 12%	Cement 2% Debris 10%	Cement 4% Debris 8%	Cement 6% Debris 6%	Cement 8% Debris 4%	Cement 10% Debris 2%
Dry state	0	1.44	1.44	1.44	1.44	1.44	1.44
	10	1.40	1.44	1.44	1.44	1.44	1.44
	20	1.37	1.44	1.44	1.44	1.44	1.44
	50	1.36	1.42	1.42	1.41	1.41	1.41
	100	1.33	1.35	1.36	1.35	1.35	1.38
	200	1.05	1.34	1.36	1.37	1.34	1.23
Wet state	200	0.99	1.09	1.09	1.20	1.13	1.23
	300	0.94	1.08	1.09	1.20	1.13	1.22
	400	0.91	1.07	1.09	1.19	1.13	1.22
	500	0.79	1.05	1.08	1.19	1.13	1.22

Table 5: Collapse Potential at 200 KPa Normal Stress, 11 KN/m^3 Dry Density and for soil treated with different proportions of Cement and Construction Debris.

Cement %	Construction Debris in %	Collapse potential (CP) in %
0	0	11.48
2	10	10.25
4	8	11.1
6	6	7.42
8	4	8.56
10	2	6.27

C) Collapse behavior of cement and debris treated soil with initial moisture content of 6%

Table 6: Void Ratio - Effective Normal Stress Values for the Samples Tested for Different proportions of cement and debris at 11KN/m^3 Dry Densities, 6% moisture content and Collapse Potential at 200KPa Normal Stress.

Effective Normal Stress (200KPa)		Void ratio(e)		
		Cement 4% Debris 8%	Cement 6% Debris 6%	Cement 8% Debris 4%
Dry state	0	1.44	1.44	1.44
	10	1.44	1.44	1.44
	20	1.44	1.40	1.40
	50	1.40	1.36	1.30
	100	1.30	1.29	1.20
	200	1.18	1.19	1.11
Wet state	200	1.05	1.12	1.09
	300	1.04	1.10	1.07
	400	1.01	1.05	0.99
	500	0.97	0.92	0.80

Table 7: Collapse Potential at 200 KPa Normal Stress, 11 KN/m^3 Dry Density, 6% moisture content and for soil treated with different proportions of Cement and Construction Debris.

Cement %	Construction Debris in %	Collapse potential (CP) in %
4	8	5.17
6	6	2.75
8	4	0.65

This is because of the moisture present in the sample causing lubrication and hence the decrease in void ratio is possible as when compared to the dry sample. From the results discussed and presented above it is particularly noticed that the samples prepared at 6% moisture content and cement proportions of 6% and 8%, debris of 6% and 4%, the collapse potential of soil is seen to show higher reduction in collapsibility

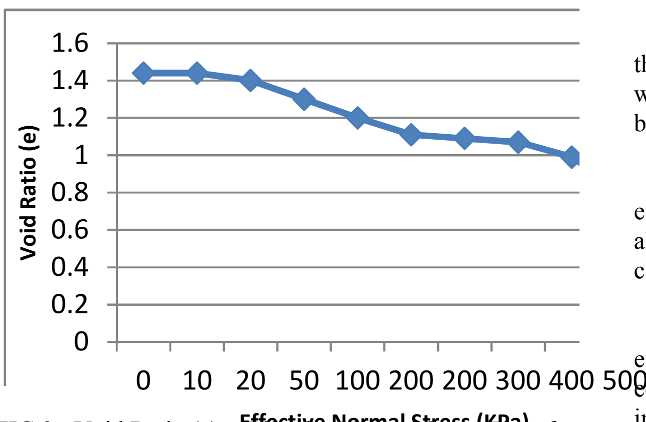

FIG 2: Void Ratio (e) – Effective Normal Stress Plots for sample Dry Density of 11 KN/m^3, Cement 8% and Debris 4%, Initial Moisture Content of 6%, Collapse at 200 KPa Stress.

Table 8: %Change in Collapse Potential at 200 KPa Normal Stress, 11 KN/m^3 Dry Density, at 6% moisture content and for soil treated with different proportions of Cement and Construction Debris compared with natural soil.

Cement %	Construction Debris in %	Collapse potential at 6%watercontent (CP) in %	% Change in the collapsibility of treated soil in comparison with natural soil
4	8	5.17	55.9
6	6	2.75	76.5
8	4	0.65	94.4

The soil tested with 8% cement and 4% debris is seen to have highest reduction in collapsibility of soil that is 0.65% from the collapsibility of about 11.7% around 94.4 % to that of natural soil thereby making the severity of collapsibility safe in limits.

VI. CONCLUSIONS

The main aim of the study being the partial replacement of cement with construction debris in order to control the collapsibility of soil the tests are performed with a slight addition of water for the effective binding of the admixtures to the soil and thereby reducing the collapsibility. The conclusions drawn are

- The decrease in the void ratio corresponding to the samples loaded at dry state are minimal as when compared to the wetted samples.
- The samples tested at density around 11KN/m^3 and vertical stress of 200 KPa are seen to best represent the field samples.
- The samples tested for an initial water content of 6% and cement of 8% and debris 4% to that of the weight of sample is seen to decrease the void ratio to least values.
- Hence it can be recommended for the actual field utilization in effectively controlling the collapsibility

VII. FUTURE SCOPE OF WORK

Although many traditional practices are put into use for the reduction of soil collapsibility, methods such as soil wetting, compaction and soil stabilization are usually preferred because of their cost effectiveness.

The work can further be progressed by studying the effect of wastes such as blast furnace slag, fly ash, fibers… along with chemical admixtures to suit the location, local climatic conditions and the purpose of stabilization.

The work done utilizing the wastes can be more effective in making the soil stabilization economic and eco-friendly. Utilization of alternative materials apart from insight soil modification with semi- model prototype tests can be made on samples to make the idea technically and economically feasible.

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