Enhancement of Collapsible Soils

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Abstract—* Collapsible soils are those which shows relatively high apparent strength in their natural state (unsaturated condition), but have low density, porous Structure & are susceptible to large deformations upon wetting due to sudden reduction in their volume. It makes the construction of foundations extremely difficult in its natural state. Settlements which associate with development over untreated collapsible soils mostly leads to expensive repairs. The most important factor which is needed to produce the collapsible soil structure is the inter-particle cementing agent that stabilizes the soil in the unsaturated condition or bonding either by cementation, chemical or physical attraction or negative pore water pressure. These stabilizes the soil in its natural state (unsaturated condition). The adding of water to a collapsible soil effects the bonding (reduced) and the inter-granular contents resulting in reduction in total volume of the soil bulk. The settlement of a collapsing soil is prompt and happen upon the intake of moisture by the soil. Therefore, the objective is comprises to investigate the effect of improvement through wetting and dynamic compaction at subgrade preparation stage in controlling or limiting "C_P" This paper focusses on outcomes of experimental works performed to examine the overall performance of collapsible soil stepped forward via way of means of pre-production wetting and compaction power. The study confirmed that growth of each relative compaction power and diploma of saturation limit the hazard of collapsibility potential. Results are presented in terms of tables and graphs to reflect the effect of improvement mechanism on reducing collapsibility potential risks.

Indexed Terms—* Collapsible soils, Hydro-collapse, Undisturbed soil samples, Collapsible potential, Shape factor, Bearing Capacity.

I. INTRODUCTION

Collapsible soils are natural materials wherever the mixture of particle sort and deposit mechanism combines to administer collapsibility. The soil having collapsible properties are those who are stable in their natural state and looks like sturdy, however that quickly collapse thanks to wetting, generating giant and sometimes surprising settlements. this could yield calamitous consequences for structures engineered on such deposits. Such soils are often termed "collapsible" or "metastable" and therefore the method of their collapsing is commonly known as any of "hydro-consolidation" or "hydro-collapse." a part of the plain downside with hydro-collapsible soils is that they tend to possess comparatively low natural unchanged water contents. When soil comes with the moisture and development of soil will occur then due to extra wetting the moisture content of soil is increases. The most common artificial sources which are responsible for wetting are: (1) Landscaping irrigation or type of crops; (2) Quantity of outflow from various water bodies like swimming pools, unlined canal, water pipelines, etc; (3) Types of system for septic arrangement; and (4) variations in evacuation of fresh water on surface [1,2].

There are several papers concerning the collapse behaviour of natural loose and unsaturated soils and several references are found regarding collapse problems in compacted soils[2,3,4,5].

In Bihar, HAJIPUR region collapsible soil exhibits high susceptibility for collapse, referred to as hydro-compaction. The basic objective is comprises to investigate the effect of prewetting and compaction on the collapsibility characteristics of HAJIPUR soils under vertical different stress levels. A comparative study for soil parameters at natural and compacted conditions was performed to investigate the effect of compaction at different moisture levels. Also, the study evaluates the effect of preloading and compaction at different moisture contents in mitigating and preventing or limiting future foundation settlement upon inundation.

II. MATERIALS & EQUIPMENT USED

The system used for fulfil the objective is shown in figure. The arrangement shown in figure consists of all components. The arrangement consists of a bin commonly known a 'Soil Bin' which is used for the collection of soil sample. This bin is square in shape having internal dimensions of 600 × 600 mm and having a height of 700mm. The all 4 sides of tank consist of clear Perspex or plastic plates whose thickness is 12 mm which are braced with steel angles. These angles are used for stopping the lateral movements of soil from side of tank through putting and compacting the sample and loading of the footing. The bottom of soil bin consist a square plate of 40 mm thickness. After the setup of arrangements the soil sample is placed on the steel deck. A loading system of 1020 mm long consists of a rigid frame of steel connect with the steel column using a pivot system shown in the fig. given below. A shaft connected with proving ring having 2 KN capability of transmitting which provides accuracy up to 2 N[6]. The loads are gradually increases via loading lever exploitating the normal self-weight. Model footings of 40, 80, 160 mm diameter and 300 mm thickness and circular or square in cross section were used. The settlement in vertical direction of the loaded footing is measured using the mechanical gauges having an accuracy of 0.01 mm by exploitation. All tests were performed on folded soils from HAJIPUR, (Bihar). The study is a part of investigation program specially design for calculating the collapsibility potential on folded soils of HAJIPURA and to go looking for an appropriate technique to cut back their potential risk upon wetting. during this laboratory study, footing models of various sizes were loaded up to failure on un-improved and improved subgrade exploitation pre-wetting and compaction.

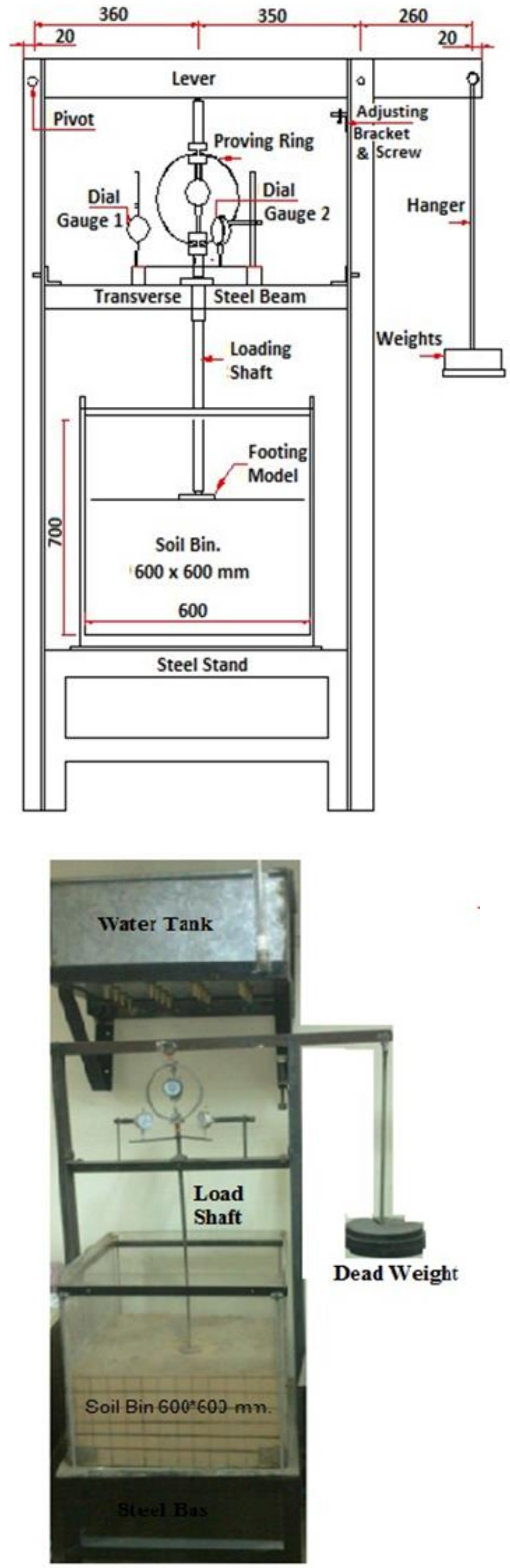

Figure-1. TEST EQUIPMENT

III. METHODOLOGY

The undisturbed soil samples from the collapsible soil have been collected from various locations located near the banks of Ganga River in HAJIPUR (Bihar). A laboratory testing program is performed on the undisturbed samples to evaluate their collapsibility potential and other physical geotechnical properties. The compression test consists of extruding a linear sample into the apparatus confining ring, loading it up to 200 kN/m^2, flood the sample and continue loading. The collapsible potential C_p is defined as a ratio between variation in height of a soil sample upon inundation at a particular confining stress in consolidation ring, dH, to the initial height of the specimen, H_o. Other physical properties, natural moisture content, density, gradation, and Atterberg limits are evaluated using common procedures[6,7]. Collapsible potential C_p of soil depends on soil composition, gradation, initial water content, density, and loading at the time of wetting. Tested samples have average clay percentage of 14%, silt percentage of 64% and fine sand percentage of 22%. Values of natural moisture content, density, specific gravity, liquid limit and plasticity index are 9.8%, 12.7 kN/m^3 2.68, 24%, 18% respectively, and the measured average collapsibility potential C_p is 14%. Maximum dry unit weights of compacted samples varied between 13.2 and 16.2 kN/m^3 with corresponding OMC varied between 10% and 13%. The samples are compacted and prepared on controlled condition having 95% dry unit weight. The maximum dry density of the sample is determined by the STP Test (Standard Proctor Test)

To achieve desired water content water is carefully mixed in the sample. The water is mixed in soil sample in different proportions in the bin. The thickness of soil sample is 50 mm up to a certain height, which is the 400 mm height inside soil bin. For each layer, the required soil weight was calculated, placed inside the soil bin and compacted using manually operated metal hammer, with a 50 mm diameter and weight 20 N, to the volume marked on the side of the soil bin in order to achieve the required unit weight.

After levelling the top surface of soil, the footing was placed on top of the soil in central position. The loads are applied gradually using loading layer & the relation between load and settlement is recorded during the test. For each load increment, settlement was measured with time till ceased, after which next increment was applied.

Two groups of tests were designed to study the effect of improvement of collapsible soils at different degrees of compaction. Also, different types of foundation models resting on compacted (improved) collapsible soils are investigated. To prepare a compacted soil sample, collected soil was air-dried followed by sieving on sieve No. 40. In group A, circular footing of 80 mm diameter used to investigate the effect of improvement of collapsible soil by increasing initial water content (pre-wetting) followed by compacting the soil surface to the maximum dry unit weight. In group B, footing models of different sizes were loaded up to failure on improved soil using pre-wetting and compaction.

The readings of whole program is discussed below in the table-

Table-1: Details of Tests

Group A: Effect of Initial water content and Compaction				
Test No.	Test 1	Test 2	Test 3	Test 4
Initial water content (%)	10	12	11.8	13
Maximum Dry unit weight (kN/m^3)	12.5	15.4	16.2	15.8
Degree of saturation, S (%)	43	57	68.5	77

IV. METHODOLOGY

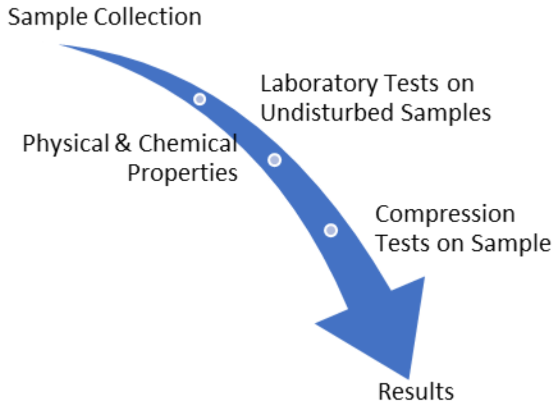

Figure-2. Shows the relationship between relative density of compacted collapsible soil and ultimate bearing capacity of circular footing model with different diameter. It indicates that compaction reflected by relative density reduces collapsibility settlement and increases soil ultimate bearing capacity. The relationship is shown a linear correlation. Figure 3. Shows that the increase in degree of saturation is another way to increase relative density and in turn improve degree of compaction. The effect of footing width on Stress -Strain relationship is well depicted by Figure 4. Soil supporting the footing behaves like cohesionless material when loaded where footings width has noticeable influence. At smaller footing width, failure pattern is more pronounced which may not be fully developed at larger footing width.

V. RESULTS

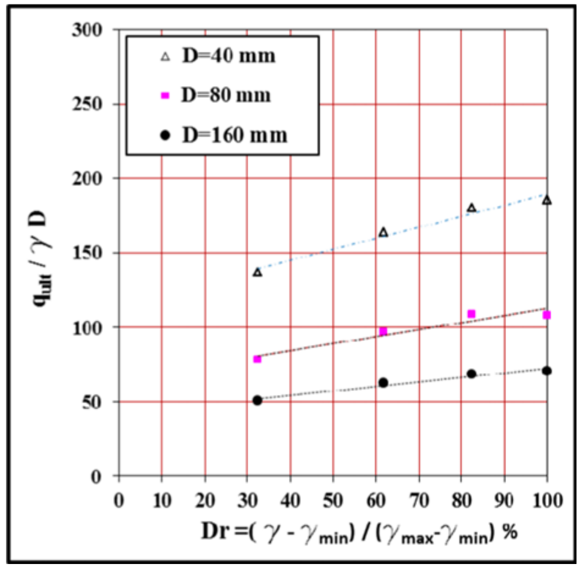

Figure-2. Ultimate bearing capacity versus relative density of compacted collapsible soils

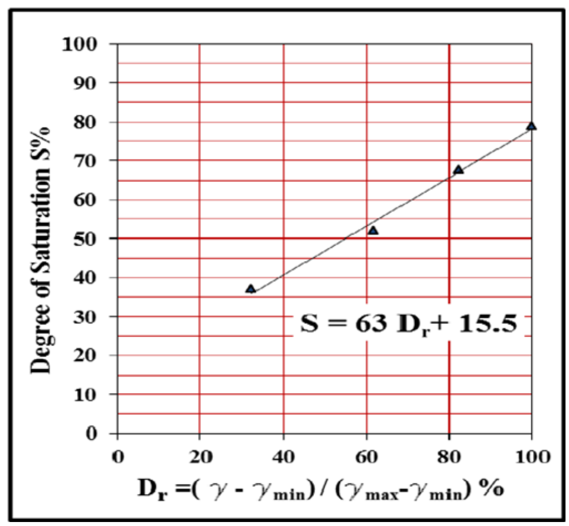

Fig.3: Degree of saturation versus relative density of compacted collapsible soils

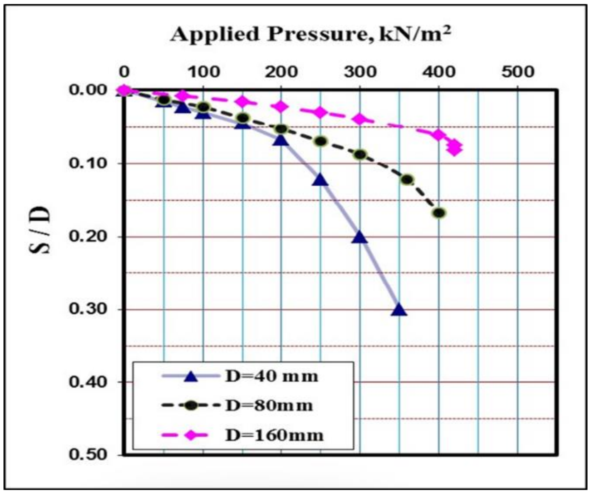

Fig.-4. Stress V/S settlement relationship for different sizes of circular footing models

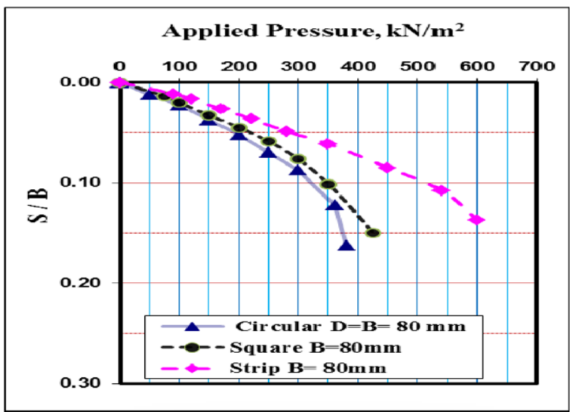

Figure.5: Settlement V/S applied vertical stress relationships for different shapes of footing model

Table 2. Test results of HAJIPUR collapsible soil compaction cases study

Group B : Effect of Footing Size			
Soil /Footing model properties	*Test 1*	*Test 2*	*Test 3*
Maximum Dry unit weight (kN/m³)	*16.2*	*16.2*	*16.2*
Circular footing model Diameter (mm)	*40*	80	160
Bearing capacity (kN/m²)	*330*	380	430
Maximum footing settlement (mm)	*0.30D*	0.163D	0.081D
Maximum Induced Strain (%)	*30*	16.3	8.1

Group C tests: Effect of Footing Shape Factor

Footing model Shape	*Circular D=B=80mm*	Square B=80mm	Strip B=80mm
Shape factor (L/B)	*1*	1	3
Bearing capacity (kN/m²)	*380*	425	700
Maximum footing settlement (mm)	*0.163B*	0.15B	0.14B
Maximum Induced Strain (%)	*16.3*	15.0	13.8

VI. CONCLUSION

Laboratory investigation program presented by this study reveals the following conclusions:

1) Collapsible soils of HAJIPUR (Bihar) region have average collapsibility potential with value as high as 14%.
2) Collapsibility potential risk could be reduced by the increase of relative density and initial degree of saturation. Linear correlation may exist between bearing capacity and relative density for a given footing width and unit weight of supporting soil. The same linear relationship related relative density and initial degree of saturation.
3) The influence of footing width on stress-strain relationship of collapsible soils is strong, as such at a same induced strain; the applied stress is higher for a larger footing width.

4) The larger is the shape factor, the less is the induced strain at the same applied stress on the footing.
5) To reduce the risk of collapsibility potential for a given site, it is recommended to increase relative density, initial degree of saturation, use larger footing width and higher footing shape factor or continuous large footings.

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