International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 05, May-2021

Egyptian Collapsible Soils, Case Study- Region Affected by Varying Moisture Content

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***Abstract*— After studied many practically collapse soil sites in Egypt, the main objective of this study has been evaluated the collapsible of soil in situ where many structure cracking and failure observed in site at Km 53 Matrouh-Alexandria coastal road. Soils in this region have been affected by varying of moisture due garden irrigation. Detailed and geographical of sub-soils in this site have been described as, very weakly cemented silt-fine sand with small per-cent of clay and seems contains many voids in its structure. Also, the soil has low natural water content which appear collapse with rapid bulk decrease upon wetting causing foundation differential settlement which has been affected on stability of this soil under any stress. Related to increase in moisture content of soil in site, foundation and infrastructure have been disaster and failure. In This study in-situ soil collapse has been evaluated at the bottom of a shallow augured hole (test pit), using controlled water quantity to saturate the soil after applied actual stress level. The investigation program developed to establish the soil different behavior under controlling wetting in field to predict the collapse time and stress-settlement relation. Also, settlement rate of soil collapsibility upon varying inundation has been recorded during the practical case study in situ. The field transient processes involving a change in volume during controlling inundation and collapse potentials have been measured. The study indicates that the total time of collapse process is more for collapsible soils with less initial moisture content compared to collapsible soils with higher moisture content and the collapse rate varies with each soil initial moisture content and its porosity. The field tests have been provided a good feedback about the performance of site collapse soil and the area that essential improvement, whereas the actually cost, safe and naturally environmentally combined are affected on selection techniques of mitigate and improved to avoid collapse settlement and Hydro-collapsibility.**

Keywords*— *Collapsibility site properties, Field test, Collapse process time, Collapse rate variation, Hydro-collapsibility.

I. INTRODUCTION AND CASE STUDY

Approximately dry or partially saturated soils below constant stress applied have been illustrated a volume decrease related to growth in its wetness content. Collapse strain was induced by this wetting in these collapsible soils, which usually due to its low dry density, and unstable its structure. Many researches and studies reported that, collapse strains induce settlements which can be the source of damage, such as cracks in housing walls, floor settling and the weakening transportation facilities support, [6,7,8,13]. Also, some research confirms that the problematic soils are firm in dry state, but suffer rapid reduction in its volume after growth in pore water pressure, which damage of suction, under constant or varies applied stress, [6,7,9,14].

As reported before the mechanical repetitive of cemented materials is categorized by a large preliminary stiffness, which reductions after the yield due to decreases their bonding and the progressive change of these cemented soil to a granular material, [3, 6]. Many studies described collapsible soil with its particle which generally ranges between silt and fine sand with may be a small amount of clay. The collapsible soil performance effected by many surroundings environmental, where climate is source periodic saturation the top soil layers in winter season, anther the low density of these soil and also, these soil particles bonding affected by wetting, [6, 9, 10,13]. A number of investigators have tried to represent collapsible soils considering field tests and laboratory tests. Many researchers develop laboratory tests to fake the effects of wetting on a collapsible soil to express prediction settlement assessment formulae taking into interpretation more features, [11, 12]. Other researchers were conducted to investigate the performance of loess soils to many general environmental factors and conditions such as, varying rainfall intensity and duration to studied many cases of soil structures as, slope height and gradient, soil properties and type of land-use, [12, 14].

Existence of collapsible soils has been reported in all of the world areas and similar cases of damage due wetting have been reported in many researches, [5, 6, 13]. Any structure found on such problematic soils becomes one of the major substantial tasks facing geotechnical and structural engineers. The problems of inundation of collapsible soil which induced loss in soil strength and resulting some risky deformation in structures founded on these soils have been studied experimental and numerical by several researchers, [7, 10, 13].

Recent year the horizontal growth in building for new urbans towards the desert in Egypt where partially saturated collapsible soil is spread. In the current work, it has been studied an actual case study old and new buildings considering various of walls and foot-paths at varied locations in study site which had suffered soil foundation failure or damage due to risky settlement of collapsible soil strata induced by varies of inundation from irrigation of adjacent gardens and other sources. The effective of these varying in founded soil moisture, Figure (1), which shows an architectural and structural problems caused by the collapse of soil foundation in the study site. In this site the most footing arrangements used are spired and strip footing connected with concrete tie beams, Therefor, case study considered in this research, will be focused on a simulated these footings performance and investigated their disaster

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and failure occurred in this site. Therefore, an important factors considered in this situ are taken into account, depths and thicknesses of the collapsible strata and its natural structural in-situ, applied stresses, water flow and irrigation sequences to inspect the reasons of the site problem and debate procedures of improving and mitigate this badly-behaved. The maximum settlement of some different footing in situ have been recorded and measured to compared with the predicated one after complete the investigations.

a. Test C near longstanding construction strip foundation

Figure 1 Architectural, other walls, Fence and structural problems in study site.

II. IN SITU SUBSOIL GEOTECHNICAL PRESENTATION AND TEST PROGRAM

Simulate soil wetting outline with subsurface leak water from controlled water tube as, a source of water infiltration and development of the wetting front to study their effects on the unsaturated soil strength and investigate the wetting front depth and variation of water content within the wetted zone extent trough collapse soil in situ study. The key factor has been considered for selecting in situ field tests arranged site is to be free from destruction, to keep the test arrangement system stable and un-disturbed during the testing period. Also, the paper examines method for predicting the settlement of footing results from vertical test load on circular plate and footing at foundation level within the footing actual vertical stress, as shown in, figure (2). The figure illustrated the collapse devise / foundation model which were used in measured the field collapse strains of collapse soil in situ under this study. The actual field transient processes involving a change in volume during controlling inundation and collapse potentials have been measured. Also, the total time of collapse process recorded of these collapsible soils with controlled moisture content and with varies moisture content to simulate actual case study. Also, laboratory tests have been conducted on block un-disturbed samples collected from situ using ASTM produced, [1, 2, 4]. Results tests of evaluated Per-cent of fines soil contained, soil index, collapsibility optional from standard Odometer tests, natural soil properties and its compressibility, have been documented in table 1 and fig. (3). Fig. (3) illustrates the results grain size distribution in dry condition where the grain size is in sand size with per-cent 56% fine grain compile / lumps but in wet sieving, when the bond and cementation between grains destructive under water flow the grain sand size decrease to per-cent 32% and the main grain size is silt with per-cent 68%, thus progressive collapsibility potential and permeability of inundated soil in field will be affected by dissolved of soil bond through infiltration depth.

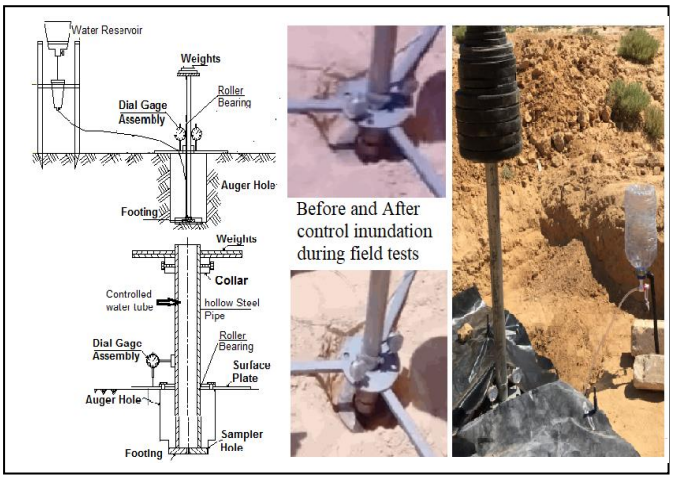

Fig. (2-a) Schematic and actual equipment to measure in situ settlement under controlling inundation Tests A, B and C.

Fig t
under controlling inundation, Tests A, B and C.

TABLE 1

Natural soil in situ properties and its Representative Collapsibility Potential		
Initial Water Content %	8.12	8.48
Natural Unit Weight kN/m^3	12.85	13.25
Specific gravity Gs	2.62	2.65
Percentage of Sand %	56.0	55.0
Percentage of Silt %	38.5	36.0
Percentage of Clay %	5.5	9.0
Lab. Collapsibility Potential C_p %	11.3	11.2
Initial voids ratio e_o	1.08	1.06
Permeability, Ks m/sec.	1.45×10^{-4}	1.1×10^{-5}

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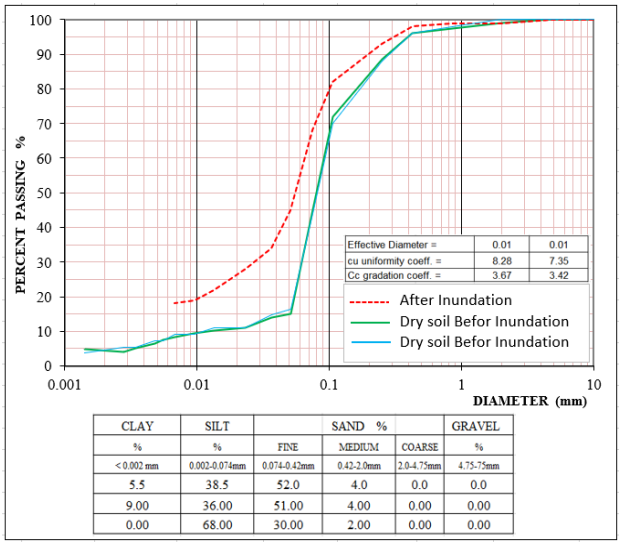

CLAY	SILT		SAND %		GRAVEL
%	%	FINE	MEDIUM	COARSE	%
< 0.002 mm	0.002-0.074mm	0.074-0.42mm	0.42-2.0mm	2.0-4.75mm	4.75-75mm
5.5	38.5	52.0	4.0	0.0	0.0
9.00	36.00	51.00	4.00	0.00	0.00
0.00	68.00	30.00	2.00	0.00	0.00

Figure (3). Soil Grain size distribution after dry and wet sieving analyses

III FIELD TESTING AND RESULTS ACHIEVEMENT

Figures (2) illustrates the saturate natural soil after loaded at a certain stress level by water tube directed contact with limit water tank. Also, in situ footing models have been loaded to failure and the load–settlement relationship and settlement rate with time till it ceases for dry and inundation cases have been recoded. Twenty-five liters of water used to inundation, they have been allowed dribbling on the soil surface at bottom of tested hole during time up to 48 hr., (two days). At the end of tests, the field collapsibility potential calculated by, Cp (%), ($C_p = \Delta H/H_i$), where Hi consider the water infiltration depth measured after ending test, after 48 hr. Getting samples for water content and soil properties determination after finishing each test extended to depth five times of foundation width or diameter.

Two field collapse tests, (A and B), on the simulate footing and plate, as shown in fig. (2), have been directed in situ at site approximately at 200-meter from the failure footing on natural soil and one plate test has been conducted adjacent to the failure fence footing edge, (test C). The collapsibility potential under controlled soil inundation results are illustrated in figure (4). The figure also, shows the time collapsibility settlements relation under actual field stress which is agree with the settlement occurred and mustered under failure strip footing of fence wall. The better representative of in-situ conditions, indicated that the predicted displacement is reliable with the observed in field and footpath deformation shape, fig. (1). In addition, the maximum settlement of the fence wall is actually measured 80 mm agree with the predicted settlement, test C. The amount of the field settlements, as shown in fig. (4), varies from three testes are dependent on the initial saturation of soil at location of test but such settlement will finally cease after a certain period of time. However, under a certain initial saturation conditions, subsequent wetting may cause additional settlement, related to rearrangement of soil particles and decrease soil suction.

By compared predicated results of degree of saturation in tests A and C, it can be interpreted the effect of time where irrigation leakage towards the fence footing through long time from fence constructed, (three year), led to excess settlement, although the fence founded on improved soil. But result of test C indicates there is another excess settlement will be expected occurred due to excess water leakage up to final degree of saturation. Compared between the field collapse potential measured in situ is smaller than laboratory measured, table (1), for the same undisturbed block sample at the similar applied stress, by about 15%.

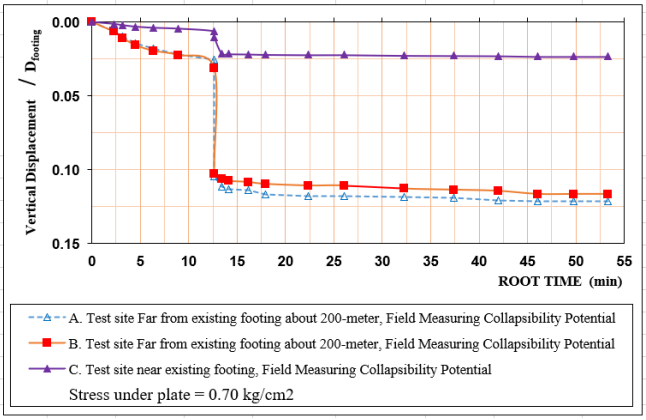

Figure (4). Filed collapsibility potential under controlling inundation, Tests A, B and C.

Fig. (5) shows the results of collapse soil progressive front saturation under controlled inundation with depth after water filtration through the test time. At actual filed stress 70 kN/m^2 final and initial saturation through soil layer depth at each test position in situ are illustrated to explain the advanced generating failure machines and hence submit probable improved procedures.

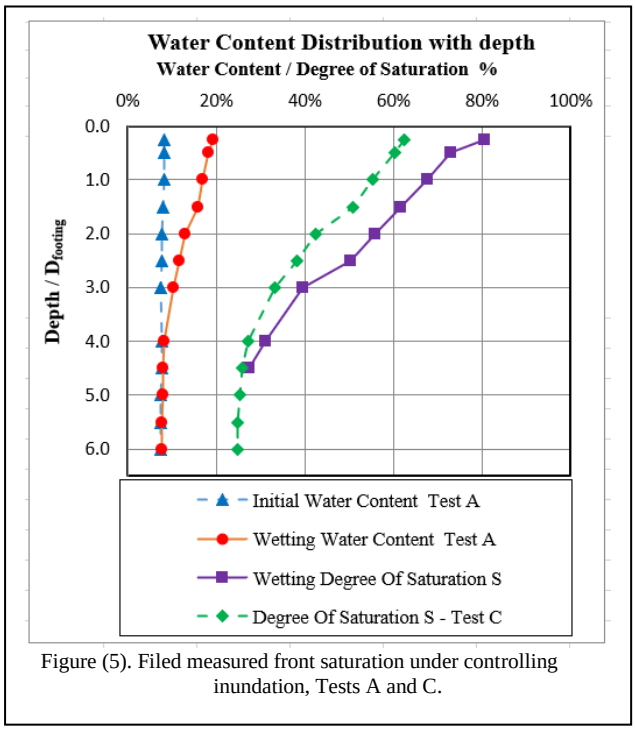

Figure (5). Filed measured front saturation under controlling inundation, Tests A and C.

International Journal of Engineering Research & Technology (IJERT)
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CONCLUSIONS

Based on in situ obtained results presented in this study and predicted laboratory results conducted on block un-disturbed samples from situ, the subsequent conclusion can be drawn,

Collapsibility of problematic soil in this case study in situ is strongly involved by moisture content and wetted front extent trough collapse soil layer.

In the present actually case study, variation in collapse soil water contents is limited to a certain depth not increased than four times of foundation width.

Due different per-cent of fines content in collapse soil and its permeability, externally affective on maximum post-wetting degree of saturation of sub-layers which was reached only approximately 62%, although increasing controlled amount of water used in inundation and its duration time applied.

The observation and measured in situ collapse potential is actual and indicated the natural soil performance, because of the field test considered all adjacent and ecofriendly state of in situ soil mass tested.

The study is attention on the significant of changing possibility of real collapse soil in situ for examination the hazard of foundation proposal and its building process.

It is of interest to note that the field collapse potentials measured in this site is lesser than laboratory measured for the same undisturbed block sample at the similar applied stress, by about15%.

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