INFLUENCE OF GEOTECHNICAL CHARACTERISTICS ON CRACKS IN BUILDINGS: A CASE STUDY

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***ABSTRACT*—Expansive soils are considered as problematic soils as they cause serious problems to Civil Engineering structures founded on them. Till recently the focus of investigations world over is on understanding the effect of swell-shrink on the swelling behavior of such soils and their control. However, in recent years, focus of research is in understanding the influence of Geotechnical characteristics of such soils on the distress of buildings / structures founded on them. Only a few studies have been reported in the Indian context. Hence, in this study six recent buildings covering the entire Pondicherry region, wherein distress in the form of cracks have appeared, are selected and soil samples were collected and various Geotechnical characteristics were determined. It is found that the expansive natures of the soil in the selected area are responsible for causing distress in the forms of cracks in the buildings.**

Key words: Expansive soil, swelling, shrinkage, cracks.

I. INTRODUCTION

Engineering problems due to 'expansive soils' have been reported in many countries all over the world. They cause damage to structures, thus impacting heavily on the economy of individuals and the Nation. Expansive soil deposits commonly occur in the arid and semi-arid regions of theworld such as: Africa, Australia, Indonesia, India, United States, Israel, Myanmar and somecountries inEurope. In India, it is estimated that the area covered by expansive soils is 20% of the total area, which is substantial. Several studies have been carried out to understand swell-shrink behavior of expansive soils and their damages [2]. More recently, emphasis has been on understanding the influence of geotechnical characteristics of such soils on the distress of buildings founded over such soils [4]. In the Indiancontext have invest [3] have investigated the influence of soil properties among other factors, to understand foundation failure of a residential building. However, such studies are rather scarce, in the Indian context.

Expansive soils have been found in several locations in Pondicherry, India. Several buildings located in Pondicherry and founded on such expansive soils have been subjected to distress, in the form of cracks. It is necessary in the larger interests public at large and for civil engineers to understand the nature of causes, determine the cause/(s) and suggest remedial measures, it in the context the present work assumes significance. In this work, 6 residential which are found to have cracks in them have been indentified and based on the various test on soil samples collected from the site, an attempt has been made to understand the influence of the geotechnical characteristics of the soil on the formations of cracks in the buildings.

II. BRIEF DETAILS OF STUDY AREA

Pondicherry is the capital of the union tertiary (UT) of Pondicherry, located in the east cost of India. It is one of the four enclaves constituting the UT of Pondicherry. It extends from 11.93˚ N latitude to 79.78˚ E longitude. The temperature of the above town ranges from 28-36˚C and north-east monsoon is the primary monsoon which contributes to 80% of the annual rainfall. The average annual rainfall is about 1200mm. groundwater is located at shallow depths within the old town area, where several heritage buildings are located. Residentialbuildings (six in number) were selected such that they are spread all over the Pondicherry region, covering the old town and recently developed areas located far from the old town. Salient details of the selected buildings are given in table 1.

IIIMETHODOLOGY

The study was carried out in three stages; reconnaissance survey/, building inspection and laboratory testing of soil samples collected from the study areas. Thereconnaissance survey was aimed at studying the immediate environment of the building in question, and building inspection was carried out to diagnose the distress ie. Cracks in the buildings based on their location, width, depth, orientation and pattern. All measurements for the above were based on standard method of building inspection. Soil sample were collected from six different locations in the near vicinity of buildings at depths ranging from 1-1.5m, and the locations are denoted as L1 to L6. Physical and engineering properties of soil sample were determined adopting relevant IS Codes. The above data is used to interpret the cause of cracks in the buildings.

IV. RESULT AND DISCUSSIONS

A. Reconnaissance survey

The preliminary survey conducted indicates that the building was constructed on a water logged area and the formation is capped with thinly laminated silt and clay. There are no any matured trees near the building which can influence the initiation of the cracks and all the drainage systems within the building area are concrete lined channels. Therefore, the cracks in the building are neither caused by ingress of tree roots in to the building nor due to movement of water penetrating into the ground due to lack of proper drainage system.

B. Building inspection

At the beginning of the study, the length and width of the cracks were marked and were monitored from time to time find out whether there is any change in the above over a period of time. In L1, cracks were observed near the corner of the wall along the vertical direction and the cracks are seen to have been initially developed from the floor towards the height of the wall. In L2, cracks have developed near the junction of columns and beams. Diagonal cracks have developed from the corner of window sill towards the wall end and vertical cracks have developed from the lintel towards the floor making the wooden frame distorted, in L3 and L4. Multiple hair line cracks have developed along the external wall of the buildings in L5 and L6. Fig. 1(a) to 1(f)shows the crack sizes and orientation in the buildings in locations 1 to 6. Details of cracks like length, width and orientations in all the buildings are given in table 2.

C. Laboratory test results

Results of the tests conducted on the disturbed and undisturbed soil samples collected from locations L1 to L6 are summarized and given in table 3.It is seen that the liquid limit (LL) of soil samples in L1 to L4 are greater than 50 and hence they are classified as 'silt and clays of high compressibility' i.e. 'CH' soil as per Is code. As the LL of soil samples in L5 and L6 are in the range of 35-50, they are classified as silt and clays of medium/intermediate compressibility i.e. 'CI' soil. The shrinkage limit (Sl) value of L1 to L4 indicate 'high shrinkage', whereas L5 and L6 are found to be low shrinkage. Further, it is seen that the natural moisture content in locations 2 to 6 is less than half the liquid limit of the soil specimens in the locations. This shows that the clay layer has undergone significant desiccation, this responsible for causing distress in buildings in locations 2 to 6. On the other hand, due to constant water logging the natural moisture content is on the higher side and that is reasonable for causing distress in the building in location1.

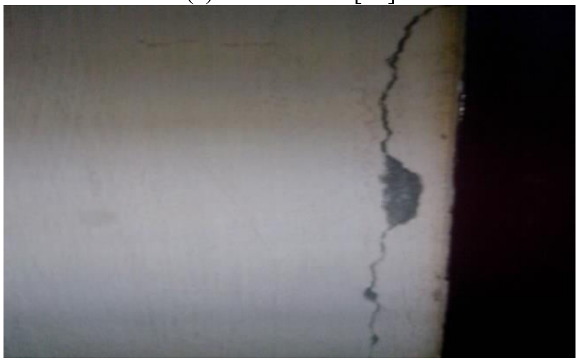
V. CONCLUSIONS

Based on field data collected, and laboratory test results and visual observations of cracks in buildings in location 1 to 6, it can be concluded that (i) The distress in buildings at locations 2 to 6 is attributed to the presence of CH/CI type of soil and their significant desiccation; (ii) the distress in building at locations 1 is attributed to constant water logging over CH type of soil.

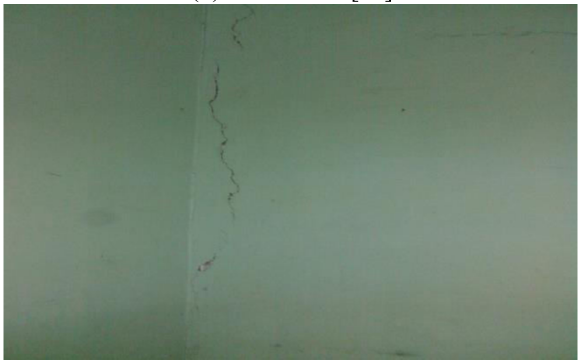
VI FIGURES

PHYSICAL OBSERVATION OF CRACKS PATTERN

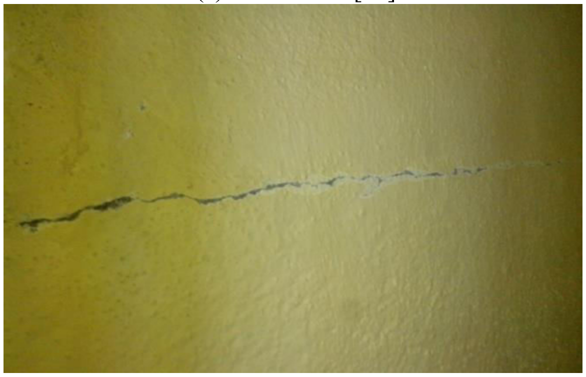
(a) Location1-[L1]



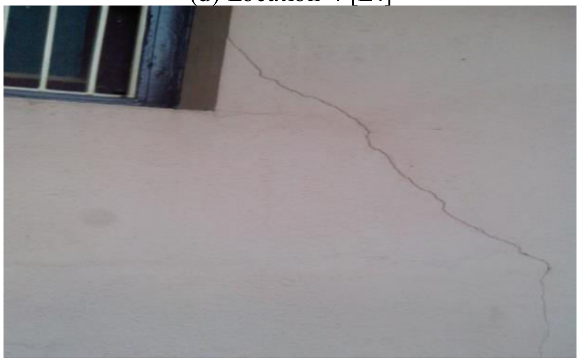
(b) Location 2 [L2]



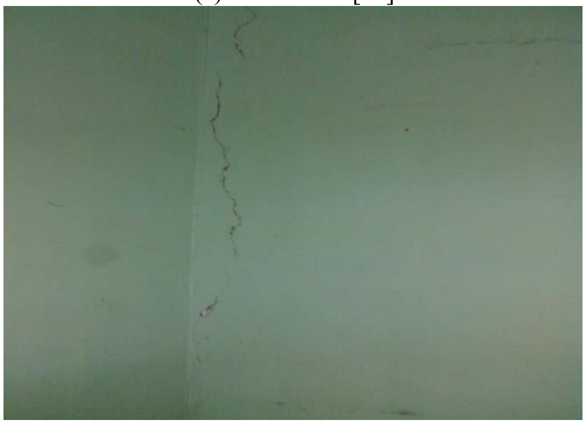
(c) Location 3 [L3]



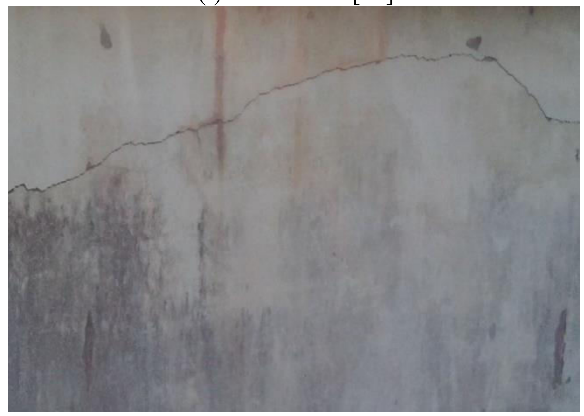
(d) Location 4 [L4]



(e) Location 5 [L5]



(f) Location 6 [L6]



VII TABLES

TABLE 1:

SALIENT DETAILS OF THE SELECTED BUILDINGS

SL.NO	DESCRIPTION	DETAILS OF SELECTED BUILDINGS AT VARIOUS LOCATIONS					
		L1	L2	L3	L4	L5	L6
1	Type of structure	Framed	Framed	Framed	Framed	Framed	Framed
2	Type of foundation	Pile	isolated	isolated	isolated	isolated	isolated
3	No. of storey	G	G+1	G+1	G+1	G	G
4	Age of building(app)	15 years	10 years	15 years	15 years	20 years	12 years

TABLE 2

DETAILS OF CRACKS IN BUILDINGS IN LOCATION 1 TO 6.

LOCATION NO.	DATE OF COLLECTION OF SAMPLES	APPROXIMATE LENGTH OF CRACKS AND DETAILS	APPROXIMATE WIDTH OF CRACKS (MM)
(1)	15.9.2018	750 mm	5
(2)	23.9.2018	From the bottom towards the roof (External walls) 1800 mm in length	3
(3)	01.12.2018	600 mm	5
(4)	03.12.2018	Diagonal cracks of length 1000 mm	7.5
(5)	22.12.2018	1500 mm in length	5
(6)	04.01.2019	Hair line cracks everywhere in external walls of varying length	5

Based on width of cracks, it can be stated that the visible damages may be classified as slight to severe, based on the categorization suggested by [1].

TABLE 3

RESULTS OF THE LABORATORY TEST ON SOIL SAMPLES FROM L1 TO L6

DESCRIPTION OF TESTS		L1	L2	L3	L 4	L5	L 6
Natural moisture content (%)		35.8	23.4	32.1	32.3	15.5	16.7
Composition	Clay (%)	72.0	70.41	73.0	70.0	68.0	71.0
	Silt (%)	28.0	29.71	27.0	30.0	32.0	29 .0
Liquid limit (%)		55.0	54.0	80.5	85.2	36.0	37.0
Plastic limit (%)		24.9	29.2	40.3	42.0	15.4	18.4
Plasticity index (%)		30.1	24.8	40.2	43.2	20.6	18.6
Shrinkage limit (%)		8.7	10	10.4	8.1	14.2	15.2
Maximum dry density (KN/m3)		14.23	15.80	13.68	13.19	18.10	17.35
Optimum moisture content (%)		35.8	23.4	32.1	32.3	15.5	16.7

Specific gravity (Gs)	2.22	2.61	2.2	2.2	2.34	2.33
Free swell (%)	42.9	37.5	61.1	63.3	40.6	44.0
UCC (KPa)	43.75	55.23	53.15	47.02	58.50	45.75
Un-drained cohesion (KPa)	21.88	27.62	26.57	23.50	29.25	22.80

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