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SYNOPSIS: This paper deals with a case history of a structural damage of college buildings lie in a nearly developed area at the north-east of Cairo. The building behavior and the factors cause the damage are contributed. As a result, the light on the importance of topographical condition of the site is sighted and recommended for such similar cases.

INTRODUCTION

Due to the increase of pobulation in Egypt and high demand of land use in the Nile Valley where old towns lie on the normal alluvial deposits, urbanization of the surrounding desert by building new suburbs and towns became a necessity. The engineers and planners were faced in these areas by a completely different types of problems regarding the geological formation of soils, the absence of ground water and other environmental factors. At one of these areas which called "Nasr City", many buildings were reported to suffer from cracks and damage as a result of soil movements. The study of the geotechnical characteristics of soil layers at this area was focused by many researchers such as El-Ramli (1965), Aboushook (1978), Mazen (1978), El-Sohby et al. (1981-1985). In the present paper the impact of an important environmental condition is sighted as a factor causes the heave of clayey shales. Therefore, firstly the site stratigraphy and soil profile are discussed. Secondly, The buidling structural system and footing type are mentioned. Then, the structue behavior is reported. Thirdly, both the in-situ and laboratory investigation are discussed. Finally, the fctors affecting the building damage are discussed and analyzed through the collected data.

SITE STRATIGRAPHY AND SOIL PROFILE

Fig. 1 shows the site stratigraphy where the college buildings lie as illustrated by the hatched mark. It can be seen from this figure that the campus of the university exists on an undulant topographical area between 65 and 100, showing a different in level equal to about 35 m. The collegebuildings lie on a relatively flat area underlying a steep boundary road surrounding the campus.

The geological structure of Nasr City where the campus liesis found to be marine sediments in some depressed areas and terrestrial sediments in high areas, (Shukri, 1953). The upper clayey beds lie in two categories of Oligocene ages and one of Pliocene ages, (Abou Shook, 1978). The beds of Oligocene age consist of alternative layers of medium to hard laminated silty clayey shale of different colors and sandy silty clay. The Pliocene age consists of medium to hard yellowish and greenish brown clayey sandy shale. The clayey shales of oligocene age characterized by high dry densties, low water contents and high swelling potential. While, those of Pliocene age have

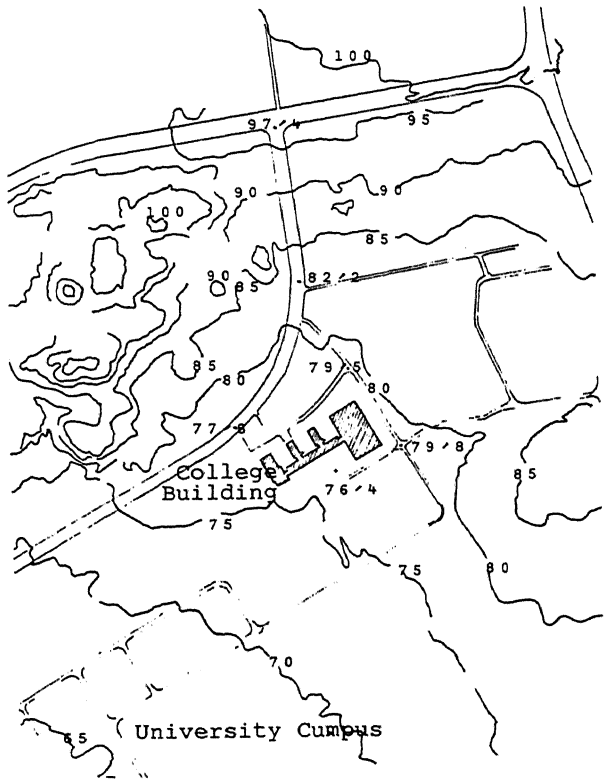

Fig. 1 Stratigraphy of Site at the Location of University Campus.

moderate dry densities, low water contents and medium swelling potential.

Fig. 2 shows the layout of the building under investigation and the locations of test pits carried out before and after construction. The average soil profile at the college site can be summarized as: 2.0 m top soil of sand and gravel followed by laminated layers of hard grey silty clay interfered by thin layers of fine to medium sand up to about 11.0 m below the ground surface. Then, clean medium to coarse sand is existed up to the end of the boring at about 16.0 m below the ground surface. The ground water table did not appear along all boring depths.

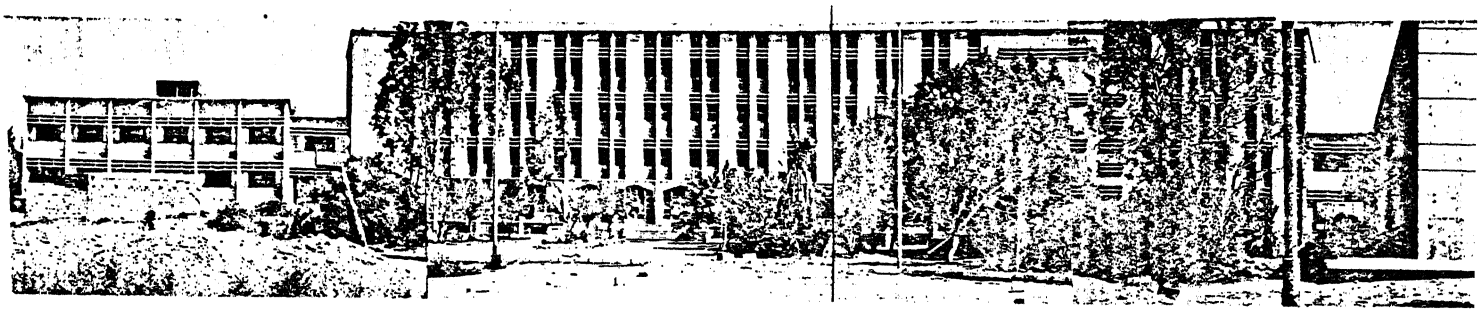

Photo 1 Front View of College Buildings.

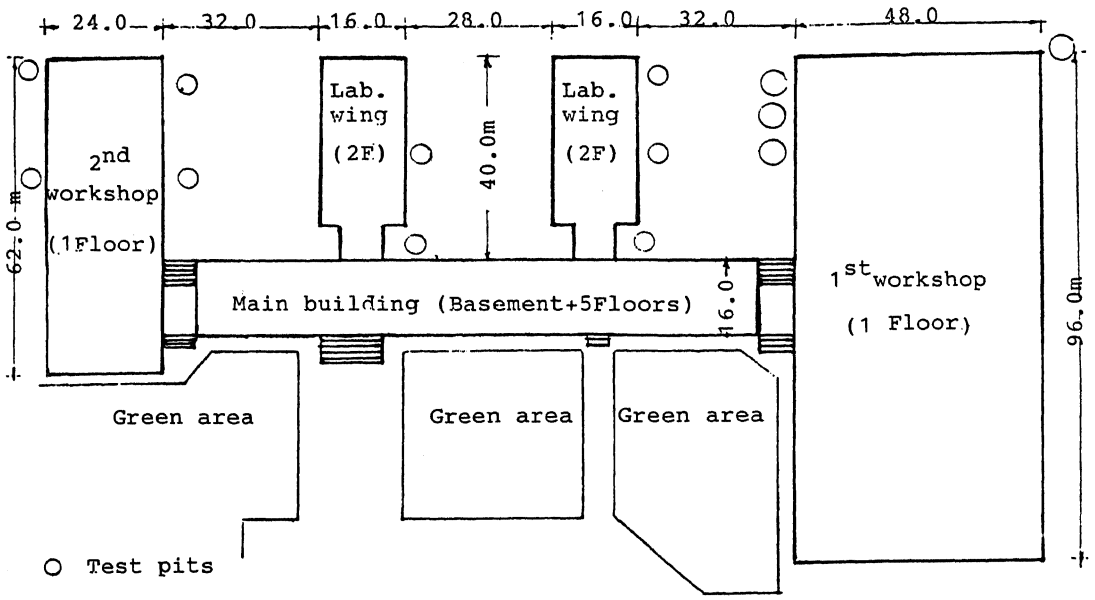

Fig. 2 Layout of Building Under Investigation and Test Pits Locations.

STRUCTURAL SYSTEM AND FOOTING TYPE

As can be seen in Fig. 2, the building consists of two parts of relatively flexiable and rigid parts. The main building consists of a basement, and four stories, while the workshops and lboratory wings consist of ground floor and only one story for the laboratory wings.

The selected type of foundations were plain concrete piers of about 1.0 to 2.0 m in diameter, resting inside the clean sand after penetrating the stratified clayey layers. The infra structure was reinforced conceret skeleton and its columns supported on isolated footings which rested on the piers.

It was clearly noticed that all footing ties were in direct contact with the upper clayey layer. Also, the basement floors were constructed directly on the natural soil. Besides, the sewer pipes were selected from asbestus type and bured directly inside the natural ground soil condition. The building was started to be in service in 1968.

TRUCTURE BEHAVIOR

Even the foundation levelis far below the shallow clayey layers, severe cracks were noted on many of building structural elements few years after their use. Photo 1 shows a front view of college buildings.

Firstly, cracks in the walls inside the water closets were observed to separate the ceremic diagnoally as shown in Photo 2. Then, at the beginning of 1970 the cracks appeared in the internal walls of flexible parts and spreaded to cover some parts of the rigid main building as can be sighted from Photos 3, 4 and 5.

Afterwards, cracks and damage were clearly noted for the basement of main building and inside the first workshop. Most severe cracks were reported for the left part of main building, in which damage spreeded to many of internal walls and beams as can be sighted from Photos 6 and 7. Besides, soil unequilibrium in the shallow layer caused ground movement and lefted walls from the underlying supports (Photo 8). This phenomenon was also reflected on the basement floor in which large rise at the mid point of

Photo 2 Example of Diagonal Cracks Inside Water Closets.

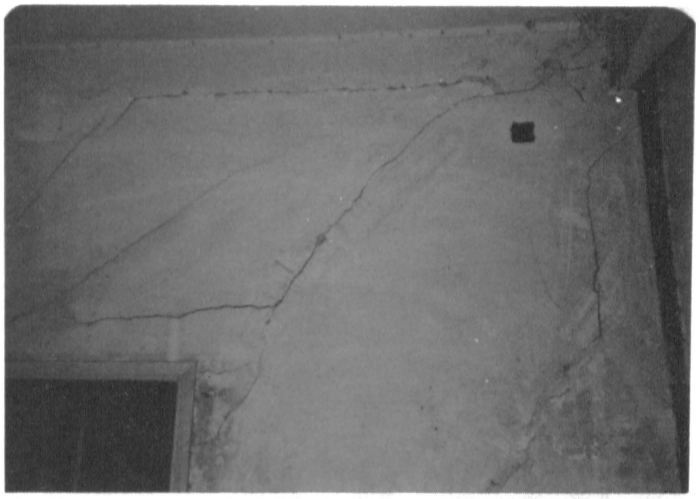

Photo 4 Example of Diagonal Cracks in Internal Walls of Main Building.

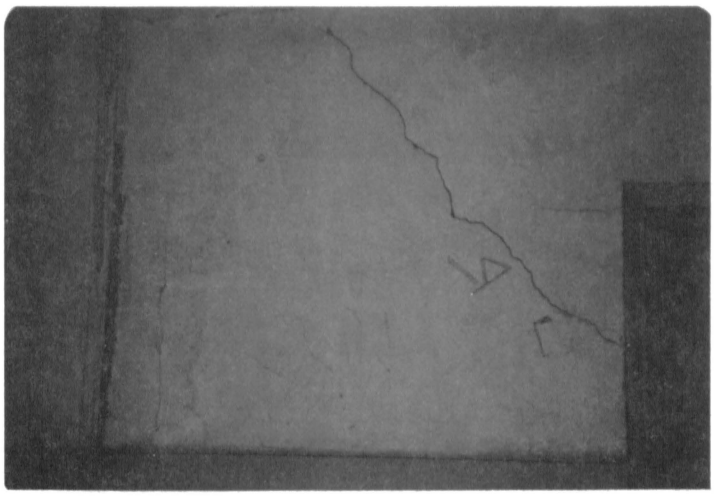

Photo 3 Example of Cracks in Internal Walls of Laboratory Wings.

Photo 5 Example of Cracks in External Walls of Main Building.

Photo 6 Example of Severe Cracks in the Internal Walls at the Basement of Main Building.

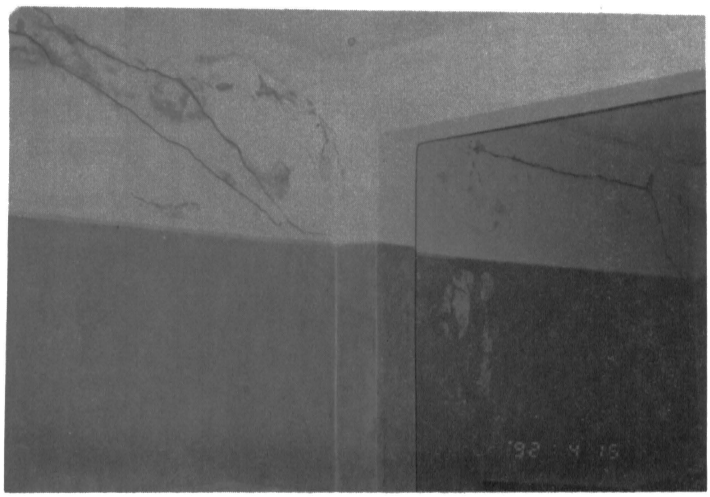

Photo 7 Example of Cracks in Beams at the Basement of Main Building.

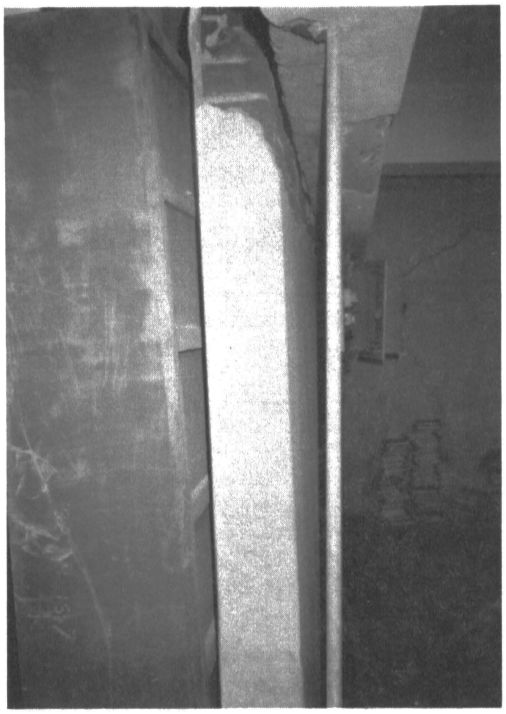

Photo 8 Example of Left Walls from the Underlying Support at the Basement of Main Building.

Photo 9 Example of Floor Rise at The Basement of Main Building.

the floor was easly noticed (about 40 cm) as can be seen from Photo 9. Moreover, as can be sighted from Photo 10 complete separation at the location of expansion joints between different parts along the buildings was also reported. The separation was recorded to, be widely at the top and narrow at the bottom (approximately 5 to 1 cm, respectively).

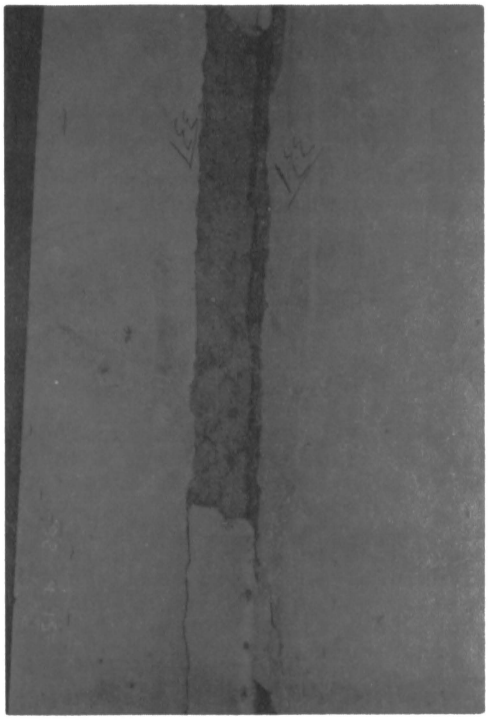

Photo 10 Example of Separation at the Location of Expansion Joints.

SOIL INVESTIGATION

In-Site Investigation

To restore the building, soil investigation was decided firstly by excavating open pits around the buildings, enclosed to footing locations. It was found that the heave of unepulibrium clayey shale due to the moisture diffeciency causes the separation of footings in some parts from the underlying plain concrete piers by about 15 mm. Also, horizontal cracks were observed in some of plain concrete piers along its depth. These cracks reflected the effect of the horizontal pressure on pier sides.

Laboratory Investigation

The extensive laboratory investigations on the physical and engineering properties of this type of clayey shale made by many of researchers indicate its high ability to swell. The swelling potential is reported in the range of 26% to 32% in the axial direction representing high to very high swelling potential. The swelling pressur determined by the conventional Oedometer by using different pressure method were in the range of 460 KPato 1450 KPa. Table 1 shows the summary of physical and engineering properties measured in the laboratory.

FACTORS AFFECTING ON BUILDING DAMAGE

Impact of Topography and Geology.

The site topography as illsutrated in Fig. 1 enhanced the collection of streams of water in the wet season around this area, where the campus exists on undulant topographical area and the college buildings lie on a relatively flat area underlying a steep boundry road surrounding the campus.

On the otherhand, the deposits consist of permeable layer on the top underlying by the clayey shales of high plasticity index. This allow water to be transported downdip, providing subsurface wetting fronts to the expansive clay. In this case the exapnsive potential of the soil profile is greatly enhanced the effect of site condition where wetting occurs from above. This agree with the study done by Mathewson and Dabson, (1982) on the influence of geology on the expansive potential of soil profile.

Impact of Planning and Design Pholosophy

Planning and design aspects also played an important factor in causing the cracks and damage, where the problem firstly appeared due to the leakage of water from the drainage and water supply system. So, when water reached the unequilibrium sallow layer and heave occured, the uplift pressure caused the broken of asbestus pipes and let the water to move through the clayey shale.

Moreover, the distribution of green areas nearly around the college with no control system on its irrigation enlarge the problem and made it to spreed on the ground side walks, stairs and tiles of internal roads.

TABLE 1. Physical and Engineering Properties of Clayey Shales

Depth (m)	Natural Water Content, wi (%)	Sepcific Gravity, Gs	Bulk Unit Weight (KN/m^3)	Dry Unit Weight (KN/m^3)	Liquid Limit, γ_d	Plastic Limit, W_L (%)	Plasticity Index, Wp (%)	Shrinkage Limit, Ip	Sand > 60μ m (%) Ws (%)	Silt > 2μm (%)	Clay < 2μm(%)	Activity
3-5	8.5-12.0	2.73-2.92	19.1-21.1	17.6-18.8	81-84	34-28	47-56	18-13	4-16	33-36	63-48	0.73-1.52

CONCLUSIONS

1. From this study it can be concluded that although the foundation level were well chosen and established deep in the sand layer after penetrating the problematic clayey shales, the overlooking of the site environmental condition in addition to the planning and design aspects played an important role on the damage of this building.

2. The study of this case history shed the light on impact of topography as an important factor which should be considered when dealing with similar cases.

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