ENGINEERING PROBLEMS ASSOCIATED WITH THE QUATERNARY EXPANSIVE CLAYS, CASE STUDY FROM SHARORAH REGION, K.S.A.

By

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Abstract:

Severe and widespread damage in residential buildings, sidewalks and pavements in various parts of the Sharorah region of Saudi Arabia is caused by the development of heave and swelling pressure in the expansive clay in the region. This paper presents the problems and the geotechnical and physicochemical properties of the tested clay. The swelling potential was determined using various methods. Swell tests were conducted under different loading conditions and following different procedures to quantify the amount of vertical swell and swelling pressure.

Three sites, representative of known problem-areas in Sharorah region were selected for geotechnical tests. Geotechnical site investigation consisted of open trial pits, profile description and the collection of both disturbed and undisturbed samples. The collected samples were submitted to soil laboratories at Najan University for mineralogical composition tests, natural water content, density, atterberg limits and swell tests (free swell and swelling pressure). From the field observation, lithologic character, dedifferentiation in color and hardness, clay content and stander penetration test (SPT), the Quaternary sediments in Sharorah region can be subdivided into three units, from top to base are;

1- Loss to medium dens yellow silty sand with SPT 24/50 2- Medium dens dark brown silty sand with SPT 40/50 3- High dens dark brown silty sand with SPT 15.

The results of this investigation indicate that soil in Sharorah contains clay (70%), have medium liquid limit (57%) and plastic limit (30%) which indicate medium potential swell. Since swell potential and swell pressure are key properties of expansive soils, the swell parameters were measured by free swell tests and one-dimensional oedometer swell tests respectively. The free swell ranged from 41% to 71% and the swell pressure was in the region of 47 kPa.

The properties of expansive soils were confirmed by the x-ray diffraction test which showed the presence of montmorillonite in the soil. It is from this fact that the source of the problem is in the expansive soils coupled with poor building materials. Finally, suggested are the ways forward to solve the problem of foundation on expansive soil.

1-Introduction:

Sharorah is a small town in Najran Province, southern Saudi Arabia, approximately 360 km east of the town of Najran. It is located in the Empty Quarter desert near the Yemeni border, and functions mainly as a border town at 17° 28′ 0″ N, 47° 6′ 0″ E (Fig. l).

The engineering properties of any type of soil are controlled by its mineralogical constituents, especially those comprising the clay fraction. Clay minerals are important in civil engineering because they dominate the behavior of

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soils. Clays are also a specific size of particles; they are very small particles, colloidal in size, so their behavior is controlled by surface forces. To understand the behavior of soil clays, it is necessary to consider the chemical composition and the crystal structure of clay minerals and the surface chemistry of clay-water suspensions.

Damage to structures from the swell of foundation soils due to changes in moisture conditions are common problems that occur frequently in many parts of the world including vast areas of the Kingdom of Saudi Arabia. Damage inflicted on superstructures by expansive soils each year is enormous. Although there has been no precise estimate, annually in Saudi Arabia, expansive soils are responsible for millions of dollars worth of damage to man-made structures (Ruwaih, 1987; Dhowian *et al*., 1990). Damage ranges from minor cracking of pavements or interior finishes in buildings, which is very common, to irreparable displacement of footings and superstructure elements (Al-Mhaidib 1998).

The focus of this study is on potential problems resulting from construction on expansive soils in Sharorah region. For the fact that most of the affected structures are founded on expansive soils, a clear understanding of the soil behavior and their interaction with structures, specifically as they relate to shallow foundations, has been of more interest to the study in order to evaluate properly the source of the problem. The geotechnical behavior of expansive clay soils is investigated by looking into the geomorphologic, geological and mineralogical composition of the soils in the study area. The geotechnical results are linked with the performance of the foundation as well as structures.

The work presented in this study is part of the research dedicated to the behavior of Sharorah expansive soils. Sharorah is one of the cities severely affected by problems associated with expansive soils. It is located within an arid to

semi-arid zone where temperature in hot summer desiccate the subsurface soils and causes dry to semi dry near surface formation. Water is introduced to the subsurface soil through different forms. These include waste water disposal, storm water, and rising ground water table. Rain water is common in the central, north and north-west cities of the country (KSA) during the winter. Damage due to expansive soils in Saudi Arabia is estimated to hundreds of millions US dollars annually. Sharorah region is one the most suffering part of the country where the problem is a nightmare for the administrative, municipality officials and legal authorities.

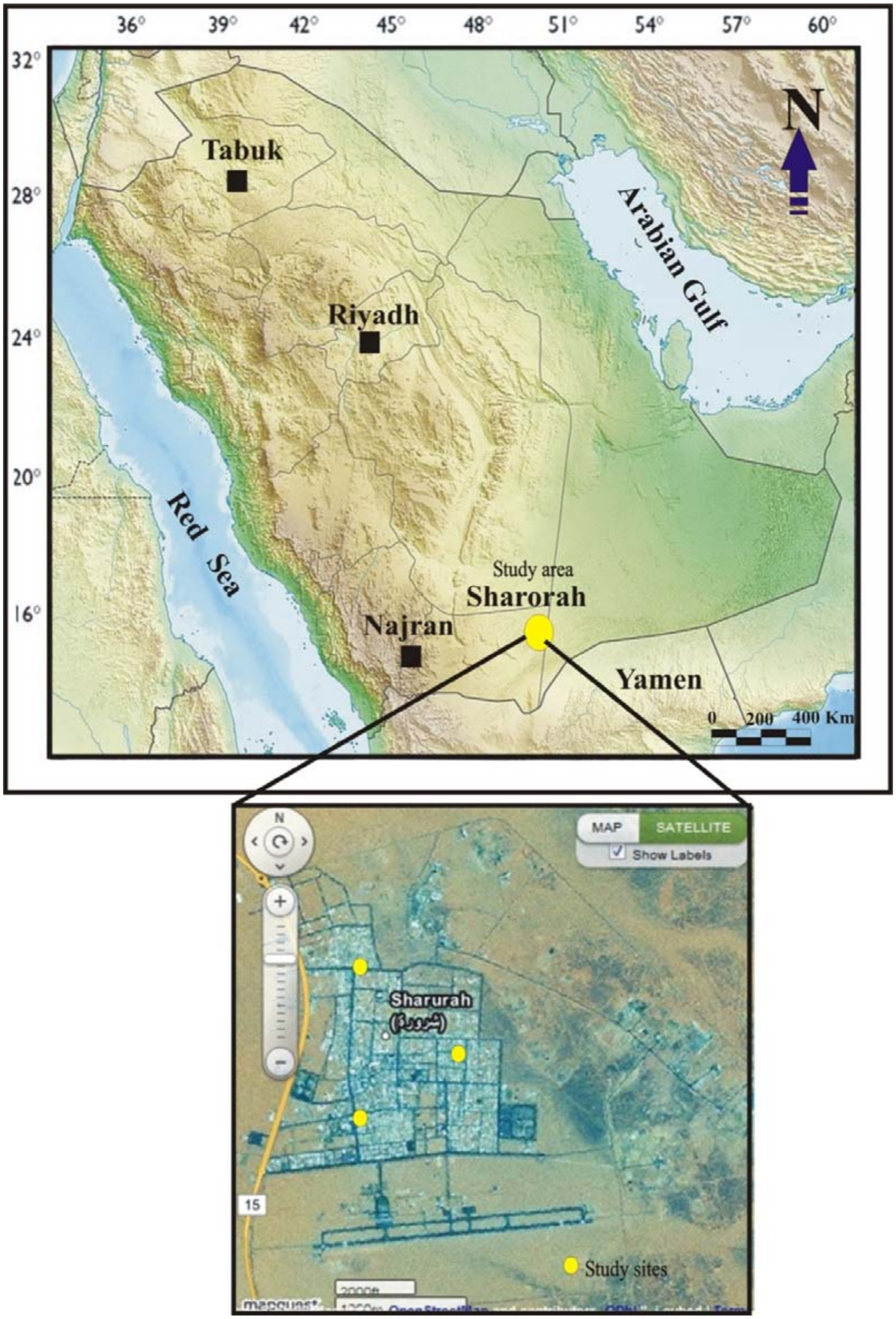

Fig. (1): Satellite images showing the location map of study area and study sites.

2- Iithology:

The Quaternary silty sandstone is rests disconformably on crystalline rocks of the southern part of the Arabian shield. Scattered outcrops extend over an area about 450 km north-south and 300 km east-west. The southern part of the formation, near the Yemen border, consists of fluvial sandstones and very minor siltstones and silty shales. The fluvial origin is demonstrated by the presence of channels, trough cross bedding, and absence of all organic traces. The northern part of the outcrop area consists of internally homogeneous, tabular cross-bedded, horizontally bedded sandstones apparently formed in a shallow marine environment. Quaternary deposits include alluvial, eolian, colluvial, and possible thin lacustrine sediments. The units were mapped on the basis of a few ground observations augmented by study of 1:60,000-scale and 1:50,000-scale aerial photographs. Terminology relating to sand dune deposits and forms generally follows that of McKee (1979). Information given here is largely qualitative.

From the field observation, lithologic character, dedifferentiation in color and hardness, clay content and stander penetration test (SPT), the Quaternary sediments in Sharorah region can be subdivided into three units, from top to base are;

1- Loss to medium dens yellow silty sand with SPT 24/50

2- Medium dens dark brown silty sand with SPT 40/50

3- High dens dark brown silty sand with SPT 15 (Fig. 2)

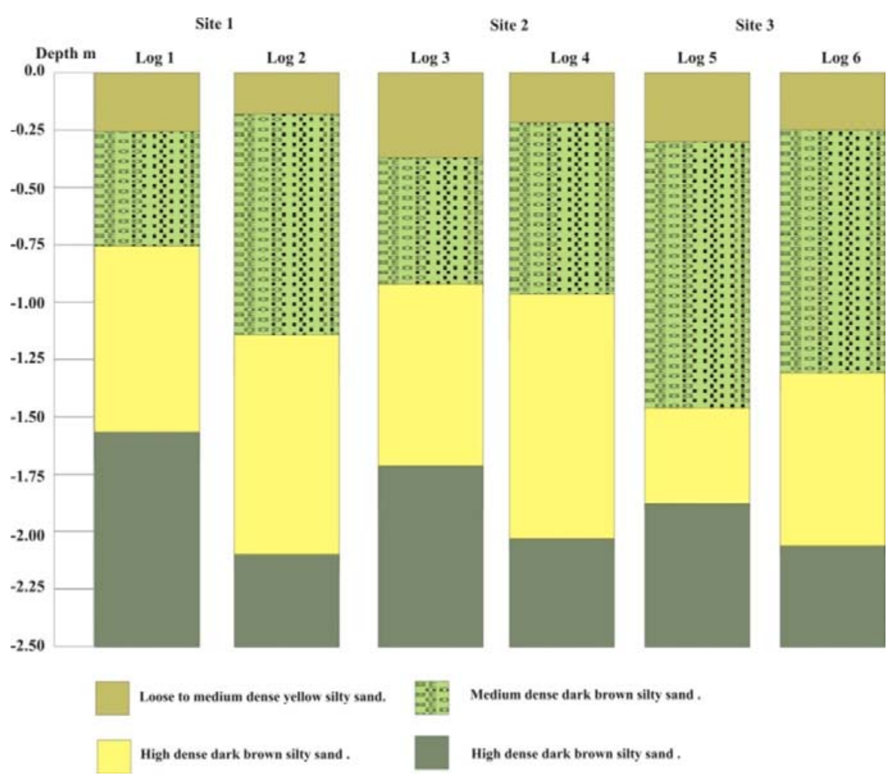

Fig. (2): Soil profile at different study sites.

3- Tectonic setting:

The abundant cross bedding in both facies of the Wajid sandstone indicates a northward transport direction, toward what is now the center of the Arabian shield. The southern part of the Arabian shield, which was cratonized about 500 to 600 Ma ago (Pan-African age), was apparently still a depositional area receiving sediments from a southern source in Early Paleozoic time. Other, older, shields also show a tendency to be areas of deposition shortly after their apparent age of stabilization, becoming sources of clastic sediments only after several hundreds of millions of years. The conversion from basin to uplifted source may indicate a prolonged process of shield maturation after initial stabilization.

4- Causes Clay Swelling: -

The question of why some clays swell and others do not can best be answered by considering swelling to result from colloidal interactions. The term clay can refer both to a size and to a class of minerals. As a size term, it refers to all constituents of a soil smaller than a particular size, usually 0.002 mm in engineering classifications. As a mineral term, it refers to specific clay minerals that are distinguished by (1) small particle size, (2) a net electrical charge, (3) plasticity when mixed with water and (4) high weathering resistance (Mitchell and Soga, 2005). Three important structural groups of clay minerals are described for engineering purposes as follows:

A- Kaolinite group - generally non-expansive:

Kaolinite crystals consist of tetrahedron and octahedron sheets. The bonding between successive layers is by van der Waals forces and hydrogen bonds. The bonding is sufficiently strong that there is no interlayer swelling in the presence of water (Mitchell and Soga, 2005) (Fig. 3- A).

B- Mica-like group:

Includes illites and vermiculites, which can be expansive but generally do not pose significant problems. Illite has a basic structure consisting of a sheet of alumina octahedrons between and combined with two sheets of silica tetrahedrons. In the octahedral sheet there is partial substitution of aluminum by magnesium and iron, and in the tetrahedral sheet there is partial substitution of silicon by aluminum. The combined sheets are linked together by fairly weak bonding due to (non -exchangeable) potassium ions held between them (Craig, 1997) (Fig. 3-A).

C- Smectite group:

Includes montmorillonites, which are highly expansive and are the most troublesome clay minerals (Nelson and Miller, 1992). Montmorillonite is formed from weathering of volcanic ash under poor drainage conditions or in marine waters. The basic building sheets for smectite are the same as for illite except there is no potassium ion present. The space between the combined sheets is occupied by water molecules and exchangeable cations. There is a very weak bond between the combined sheets due to these ions. Considerable swelling of montmorillonite can occur due to additional water being absorbed between the combined sheets (Craig, 1997; Oweis and Khera, 1998). Geotechnical engineers need to understand clay crystal structures and the effects of surface chemistry in order to understand these swelling behaviors (Mitchell, 1993) (Fig. 3-B).

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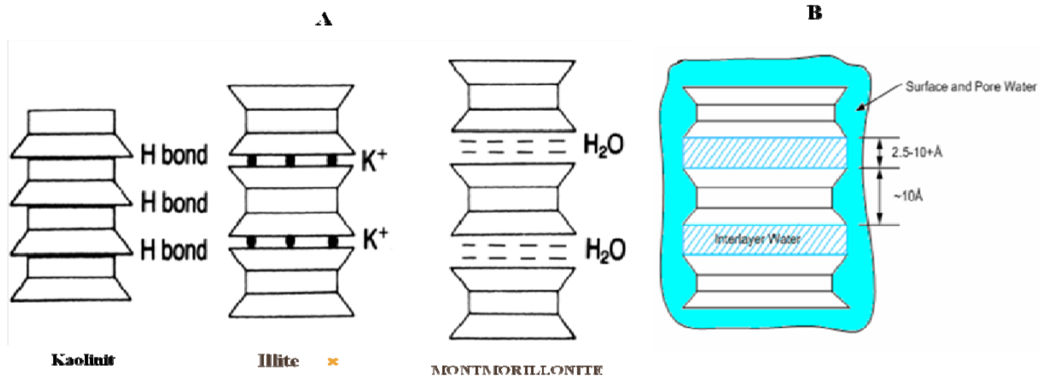

Fig. (3): (A) Schematic Representations of Clay Minerals (after Craig, 1997), (B) Surface and interlayer water (montmorillonite) .

5- Problem Of Swelling

The swelling behavior is usually attributed to the intake of water into the montmorillonite, an expanding lattice clay mineral in expansive soils. According to Chen, F. H. (1988), montmorillonite is made up of a central octahedral sheet, usually occupied by aluminum or magnesium, sandwiched between two sheets of tetrahedral silicon sites to give a 2 to 1 lattice structure. The three-layer clay mineral as shown in Fig. (3-B) has a structural configuration and chemical makeup, which permits a large amount of water to be adsorbed in the interlayer and peripheral positions on the clay crystalline, resulting in the remarkable swelling of soil (Patrick, and Snethen, 1976). The presence of various minerals such as montmorillonite in the expansive soil is determined by the use of x-ray diffraction method, among other methods.

More than 450 one-story residential buildings were constructed as part of a housing development. The buildings are made of rigid reinforced concrete frames with hollow concrete block partitions and panels. The problem in this town started with the development of cracks after the buildings were occupied. The cracks extended to include slabs, beams and columns..

Damage to the buildings has been caused mainly by differential heave of the foundation sub-soils. The damage includes cracking of masonry walls in a diagonal pattern (Fig. 4); the cracks are typical expansive soil cracks being wide at the top and getting narrower at the bottom of the wall. In addition, it includes cracking of reinforced concrete gates, columns and ground beams, as well as cracking of a road pavement in the town. Damage was attributed to the excessive moisture content increases due to water infiltration from domestic sources and garden watering as well as the surface cover by paving the areas around the buildings which protect the moisture of the ground from outside dry weather. Domestic waste water soaks into the soil as there is no public sewerage system in the town (Dafalla and Shamrani, 2012).

6-Geological Description:

Geology provides good information about the method of forming a mass into size, shape and behavior (Lambe and Whitman, 1996). A good well documented geological information will facilitate quick decision for the selection of relevant methods and the extent of geotechnical site investigations. It is the base to judge the efficacy of the test methods and assess the validity of the results. Geological description is usually obtained by the study of the site history and geological maps. Information on the maps can give valuable idea of the soil composition as the preliminary information for further investigation.

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5-Statement of The Problem:

The presence of the expansive soils, also known as shrink-swell or swelling soils in Sharorah where semi-arid clayey soils are predominant has caught many builders unawares. Swelling or expansive clay soils are those that comprise swelling clay minerals such as montmorillonite (smectite), which expand when the moisture in the soil changes. In addition, expansive soils have high degree of shrink-swell reversibility with change in moisture content. A large number of structures especially lightweight structures found on these expansive soils have met with widespread problems associated with serviceability performance mainly in the form of cracks or permanent deformation. While very little work has been done to study the extent of expansive soils in Sharorahon one hand, on the other hand the damages in buildings founded on expansive soils have been very poorly documented. The scarce knowledge about the behavior of foundations in swelling soils is obvious behind the damages of structures supported on the foundations mainly due to the uplift of the foundations (dooming or centre heave) following wetting of the soil. Although the accusing finger is mainly pointed at the expansive soils, other contributing factors such as poor design, poor construction, inadequate observation of the construction processes

6. Tested Soil

Six expansive soil samples collected from three different sites (see fig. 1) at the Sharorah city were used for the laboratory-testing program. Soil samples were collected in an undisturbed state using the open pit technique at a depth of about 2.5 m (See fig. 2). The physical and engineering properties of the soil sets were measured and the results are shown in Table (1).

1-Particle size distribution (PSD)

The inherent swelling potential of soil is directly related to the total amount of clay mineral particles (particles that are <2μ m in diameter) in it. The swelling potential increases with the increase of clay minerals. Moreover, particle size distribution of soil mineral separates are critical for getting hold of many soil properties such as water holding capacity, rate of movement of water through the soil, kind of structure of soil, bulk density and consistency of soil. All these are important in the identification of expansive soils. Classification of the soils for engineering purpose depends very much on the system used. In this study, the USCS system (Unified soil classification system) and AASHTO is used to classify the soil sample. According to USCS the soil sample are commonly CL type. According to AASHTO, the soil are A-3 type (Table 1).

2-Liquid limit (LL)

In the fall cone method, liquid limit is the moisture content corresponding to a specified depth of penetration for a cone of known geometry and weight (Farrell et al., 1997). The liquid limit of the soil is widely varied. The highest percentage of liquid limit is recorded at the sample no.1 by about (57%), but the lowest percentage of liquid limit is detected in sample no. 5 (33 %).

3-Plastic Limit (PL):

Plastic limit is the water content at which the soil begins to crumble when rolled into 3 mm threads. The Plastic limit of the different types of soil at the study area is varied, in the range (22 to 30 %), (Table 1).

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Fig. (4): Damage to the buildings has been caused mainly by differential heave of the foundation sub-soils, A; B; C and D, the cracks are typical expansive soil cracks being wide at the top and getting narrower at the bottom of the wall. G and D cracking of reinforced concrete gates, columns and ground beams at different sites of study area.

4-Swell test:

Swelling index tests point out the potential expansiveness of soils. Two common laboratory test methods to determine the swell of soil, namely free swell test and the swell in oedometer test are covered in this study. The Swelling index of the studied soil samples is varied, the highest percentage of Swelling index is noticed at the sample no. 2 by about (0.1 %). The lowest percentage of Swelling index is detected in sample no. 3 (0.4 %)

5-Free swell test:

According to Holtz and Gibbs (1956), the free swell test is defined as the ratio of the increase in volume of the soil from a loose dry powder form to the equilibrium sediment when it is poured into water, expressed as the percentage of the original volume Fig. (5). The percent of free swell is expressed as:

Free swell percent = $\Delta V/V*100\%$

where $\Delta V = V_s - V$ = change in initial volume (V) of a specimen and

V = initial volume (10 mm3) of the specimen

Vs = final volume of the specimen

Soils with free swell less than 50% are not likely to show expansive property, while soils with free swells in excess of 50 percent could present swell problems. Values of 100% or more are associated with clay which could swell considerably, especially under light loadings. The swelling pressure can be taken as the pressure that brings the sample back to its initial height (i.e. at 0% vertical swell). (Al-Mhaidib 1998).

Table (1). Properties of the three sits of soil used in the study

Properties	Sample No 1	Sample No 2	Sample No 3	Sample No 4	Sample No 5	Sample No 6
Specific Gravity, Gs	2.65	2.71	2.67	2.68	2.72	2.64
% of Gravel	0	0	0	0	0	0
% of Sand	30	33	35	34	32	35
% of Silt and Clay	70	67	65	66	68	65
Liquid Limit	57	38	48	50	52	55
Plastic Limit	25	27	29	30	26	22
Plasticity Index	31	35	33	38	32	30
Swelling pressure Kpa	40	47	52	62	65	71
Swell percent	0.2	0.1	0.4	0.3	0.1	0.2
Shrinkage limit %	23	24	25	21	24	22
Max. dry density gm/cc	1.654	1.685	1.701	1.7024	1.625	1.634
USCS	CL	CL	CL	CL	CL	CL
AASHTO	A-3	A-3	A-3	A-3	A-3	A-3

A- Free swell in the oedometer:

The swell pressure of soil is determined through the one-dimensional restrained swell test by utilizing the oedometer apparatus. The undisturbed soil specimen is cut at its in-situ moisture content, put in an odometer, saturated and brought to equilibrium under a surcharge of about 1 kPa. The load on the specimen is increased periodically until the height of the specimen returns to origin. For each increment of load, the specimen is allowed to consolidate fully before the application of the next load. The amount of swell is recorded with the dial gauge and the maximum vertical stress necessary to attain original height of sample is the swelling pressure. A graph can be obtained of height or void ratio against stress Fig. (5). This test has the advantage that only one sample is required and apart from free swell, the consolidation characteristics can be determined. The obtained results of the Free swell of the studied soil are mostly coincide with their optimum moisture content values. The highest value of Free swell is detected at sample no. 5 (71 KPa), while the lowest value is detected in sample no. 1 (41 kpa (Table 2)

Table (2): Results of unrestrained swell and compression test in oedometer.

Pressure (kPa)	1	25	50	100	200
Initial reading (mm)	4.14	4.42	4.33	4.09	3.6

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Final reading (mm)	4.42	4.33	4.09	3.6	3.07
Change in Height (mm)	0.28	0.09	0.24	0.49	0.53

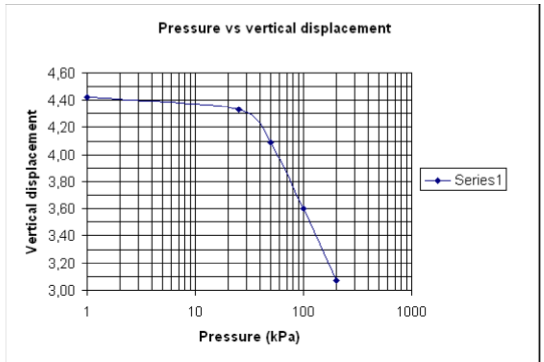

Fig. (5): Relationship between the pressure and vertical displacement in study site no 1.

6- X - Ray Diffraction Test Results:

Identification of the presence of expanding clay minerals in soil is carried out by using different methods such as x-ray diffraction and electronic microscopy Fig. (6). In the x-ray diffraction test, x-rays are collimated and directed onto the sample, which has been ground to a fine powder (normally less than 10 microns).

The common radiations used in x-ray crystallography are produced by Cu, Co, Fe and Cr tubes. Powder prepared samples from Sharorah were tested. The diffractometer records are shown on Fig. (6). The calculated d-spacing can be obtained to a reliable accuracy. The diffractometer profiles show several overlapping in the zone $2\theta = 4^o$ to $2\theta = 8^o$. In this zone we can observe the smectite group or montmorillonite where d = 15 A^o. Other minerals may be present in this area. These include but not limited to; Vermiculite (d = 14 A^o), Cholrite, (d = 14 A^o) and Illite and Mica (d = 10 A^o). From the X-ray diffraction results it can be confirmed that expanding minerals belonging to smectite groups are present in all four Saudi clays under study. Peak intensities indicate that mineral proportions are different but detailed quantitative study is beyond the scope of work for this research.

Classification of potential swell based on plasticity table

The change in moisture contents (Atterberg limits) of a soil sample can be used to indicate the degree for potential swell as presented in Table 3. A soil sample with liquid limit exceeding 70% and plastic index greater than 35% is judged to have a very high potential swell. In the present study the liquid limit is commonly less than 70% and plastic index is less than 35% is judged to have a medium potential swell.

Table (3): Classification of potential swell based on plasticity (Holtz and Gibbs, 1956).

Classification of potential swell	Liquid limit (LL), %	Plasticity index (PI), %	Shrinkage limit (SL), %
Low	20-35	Less than 18	More than 15
Medium	35-50	15-28	10-15
High	50-70	25-41	7-12
Very high	More than 70	More than 35	Less than 11

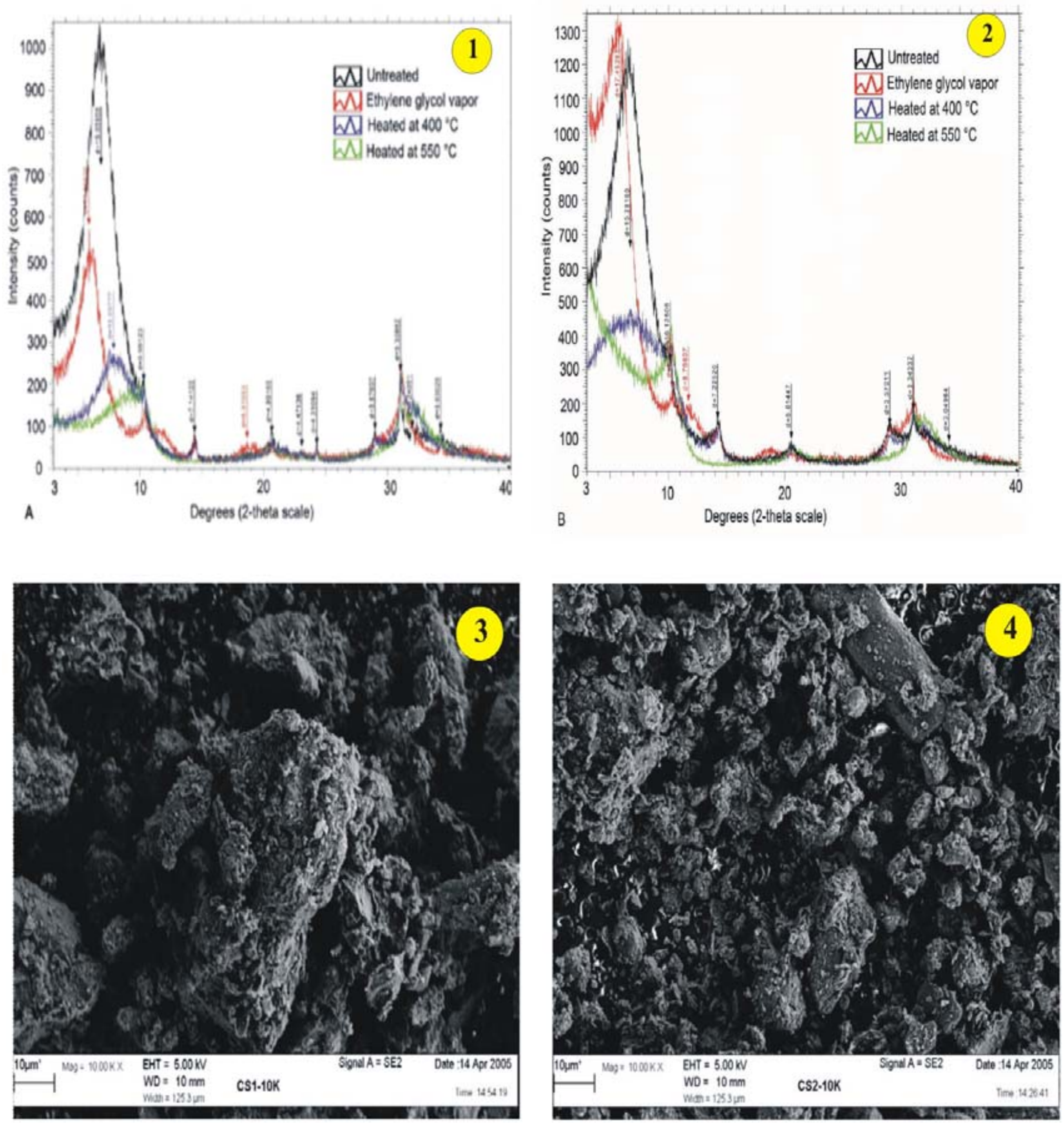

Fig. (6): X-ray diffractograms of a soil sample and SEM images at site 1 and 2.

Recommendations and Treatment of Expansive Soil

For the study at hand, the recommendations summarized here below have been single out based on the results of visual observations and field and laboratory investigations:

1- Control the shrink-swell behavior through the following alternatives;

• Replace existing expansive soil with non-expansive soil or mixing. Madhyannapu et al., (2010) provide details of quality control when stabilizing expansive sub-soils using deep soil mixing, demonstrating the use of non-destructive tests based on seismic methods.

• Maintain a constant moisture content.

• Improve the expansive soils by stabilization or compaction.

Soil stabilization can improve the properties of expansive soils considerably. Possible materials for the stabilization could include lime, pozzolana, lime-pozzolana mixture, cement, resins or fly ash. The choice of a material or a combination of materials depends on the size and importance of the building (risk/damage acceptable) and economic consideration of the client. However, the need to strike a proper balance between quality and cost should not be overlooked. Chemical stabilization can be used to provide a cushion immediately below foundation placed on expansive soils, e.g. pavements and sand (Hudyma and Avar, 2006) or granulated tire rubber (Patil et al., 2011and Sabat, 2012) (Fig. 7).

• Hydration before the start of pre-construction. The disadvantages of this method it takes time up to several Months.

• Strengthening structures and design elements of origin of the tiles, walls, columns, foundations to bear the puffiness and the resulting pressure.

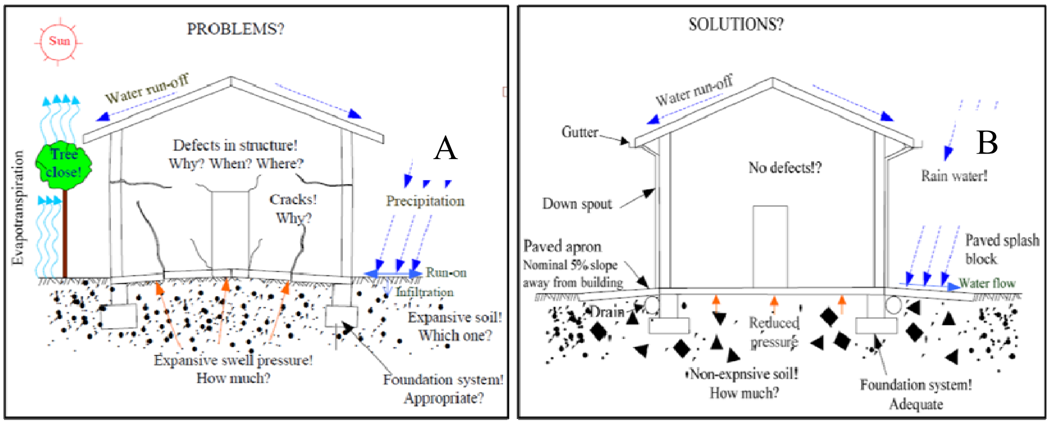

Fig. (7): A- Idealized building with problems, B-Hypothesized solutions to the problems.

• Using deep foundation (Piles) to transfer the lodes from the weak expansive soil to strong non- expansive one.

• Make a water drainage system in a location far away from the building so as to prevent the accumulation of water in the expansive soil.

• Repair the Cracked Walls.

•Tolerate the Damage

Conclusions

Sharorah is located to the south of the kingdom of Saudi Arabia at the border to Yemen. Geotechnical studies carried out for some projects indicated reddish clay of medium to high plasticity.

Expansive soils are one of the most significant ground related hazards found globally, contributing billions of pounds annually. Expansive soils are found throughout the world and are commonly found in arid/semi arid regions where their high suctions and potential for large water content changes on exposure/deficient with water can cause significant volume changes. In humid regions such as the Sharorah problematical expansive behavior is generally occurs in clays of high Ip. Either way, expansive soils have the potential to demonstrate significant volume change in direct response to changes in water content. To understand and hence engineer expansive soils in an effective way it is necessary to understand soil properties, suction/water conditions, water content variations stiffness of foundations and associated structures

The present study is aimed to characterize the soils collected samples from Sharorah regions of Saudi Arabia by evaluating their relative expansive nature. Gradation test depicted that. samples have high percentages of clay an average 70 % . Since the amount of moisture dictates the severity of swell; these tests were conducted at two different moisture content conditions. In this study, the USCS system (Unified soil classification system) and AASHTO is used to classify the soil sample. According to USCS the soil sample are commonly CL type. According to AASHTO, the soil are A-3 type.). This study also introduce a new soil classification based on field observation, lithologic character, dedifferentiation in color and hardness, clay content and stander penetration test (SPT), the Quaternary sediments in Sharorah region can be subdivided into three units, from top to base are;

1- Loss to medium dens yellow silty sand with SPT 24/50 2- Medium dens dark brown silty sand with SPT 40/50 3- High dens dark brown silty sand with SPT 15.

In the present study the liquid limit is commonly less than 70% and plastic index is less than 35% is judged to have a medium potential swell. The highest percentage of liquid limit is recorded at the sample no.1 by about (57%), but the lowest percentage of liquid limit is detected in sample no. 5 (33 %). The Swelling index of the studied soil samples is varied, the highest percentage of Swelling index is noticed at the sample no. 2 by about (0.1 %). The lowest percentage of Swelling index is detected in sample no. 3 (0.4 %). The Plastic limit of the different types of soil at the study area is varied, in the range (22 to 30 %).

XRD profile of Sharorah shows the presence of clay minerals corresponding to smectite, illite and kaolinite. The presence of these mineral fractions explains the typical expansive behavior exhibited by these soils.

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المشاكل الهندسية المتعلقة بالتربة القابلة للانتفاخ بمنطقة شرورة –المملكة العربية السعودية.

دكتور/ احمد خلف عبد العال

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ملخص البحث .تغطي التربة القابلة للانتفاخ مساحات شاسعة من أراضي المملكة العربية السعودية، حيث توجد مناطق عديدة بالمملكة من اهم هذه المناطق منطقة شروره. وقد تسببت هذه التربة في ظهور العديد من التصدعات والتشققات في المباني، وكذلك حدوث ارتفاعات و نتوءات كبيرة في الأرصفة والطرق المقامة على هذه التربة .كما رصدت بعض الانهيارات والخسائر الكبيرة التي كلفت ملايين الريالات في بعض مناطق المملكة العربية السعودية .ولا يوجد حتى الآن أرقام دقيقة تبين مدى التلف الناتج من انتفاخ التربة على المستوى المحلي في المملكة العربية السعودية ولكنه يقدر بملايين الريالات في السنة . وتعتبر التربة القابلة للانتفاخ بمنطقة شرورة من الصخور الرسوبية وهي التي تشمل الصخر الصفحي، والأحجار الطينية والطميية، وهذا النوع يمتد على طول الخط المقابل للحد الغربي من الدرع العربي ويوجد أيضا في مناطق الغاط و تيماء وتبوك والجوف.

وتقدم هذه الورقة نبذة عن التربة القابلة للانتفاخ وتوزيعها في العالم، وأهم العوامل المؤثرة في مقدار الانتفاخ .كما تعرض الورقة أهم الطرق المستخدمة لتصنيف هذه التربة وكذلك طرق قياس مقدار الانتفاخ المتوقع .وتبين الورقة أماكن وجود التربة القابلة للانتفاخ في المملكة العربية السعودية والخصائص الجيوتكنيكية والتكوين المعدني لتربة كل منطقة، وتصنيف قابلية الانتفاخ للتربة في كل منطقة .وفي الختام تعرض الورقة أهم طرق معالجة التربة القابلة للانتفاخ وطرق التأسيس عليها والتي من اهمها:

١ .استبدال التربة القابلة للانتفاخ بتربة جيدة، وذلك عندما تكون التربة القابلة للانتفاخ قريبة من سطح الأرض وذات سمك قليل حيث يمكن استبدالها بتربة أفضل منها ويتم دمك هذه التربة الجديدة جيدًا.

٢ .تغيير طبيعة التربة القابلة للانتفاخ وخواصها الهندسية، ويتم ذلك بعدة طرق من أهمها: الدمك المنتظم لطبقات التربة وذلك بإشباع التربة بالماء والسماح لها بالانتفاخ قبل بدء الإنشاء ومن عيوب هذه الطريقة أنها تستغرق وقتًا طوياً قد يصل إلى عدة شهور.

٣ .منع تسرب المياه للتربة القابلة للانتفاخ المقام عليها المنشأ ة وذلك باستخدام عوازل للرطوبة مثل بعض الألواح المعدنية أو الحواجز المائية لتقليل تسرب الماء للتربة وبالتالي تقليل مقدار الانتفاخ .وقد تكون هذه العوازل أفقية لمنع تسرب المياه من سطح الأرض، أو تكون عمودية تحيط بالمنشأة وتمنع تسرب المياه بشكل أفقي.

4 .معالجة التربة القابلة للانتفاخ كيميائيًا بالمثبتات الكيميائية مثل الجير أو الأسمنت بين فراغات التربة حيث تساعد على تقليل حد السيولة ومعيار اللدونة وبالتالي تقليل مقدار الانتفاخ.

5. تقوية المنشآت وذلك بتصميم عناصر المنشأ من بلاطات، وجدران، وأعمدة، وأساسات لتتحمل الانتفاخ والضغط الناتج عنه.

6. عمل نظام تصريف للمياه في الموقع بعيد عن المنشآت بحيث يمنع تجمع المياه وبالتالي تسربها للتربة القابلة للانتفاخ.