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Effect of Soil Settlement on Wall Cracks and Failures in the City of Shari, Saudi Arabia, Case Study

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ABSTRACT. This paper describes a case study for the causes of cracks and ruptures that emerged in the houses of the City of Shari, AlQassim region. The structures of this city built using the load wall bearings system. Loads of bearing masonry buildings usually have walls arranged at a fairly uniform spacing to carry gravity loads to the foundation without addition of columns. This study is divided to two parts; the first part discusses the field geotechnical investigation of the construction site. The second part presents the results of a parametric study for the effect of soil settlement as well as the positions and sizes of the wall openings on the existence of the wall cracks. The results showed that, the construction of houses almost at or very near to the ground surface with no rigid tie-beams under the walls which could help in resisting the differential settlement affects their safety. The opening definitely reduces the stiffness of the wall and subsequently reduces the failure load and increases deflection at the same load level. The finite difference-based code FLAC and the finite element-based code, ANSYS were used in the analysis.

Keywords- Settlement Cracks, Wall Bearing Structures, ANSYS

1. Introduction

The city of Shari is located in the Al-Qassim region and is bordered on the north of the city of Buraidah about 124 kilometers. In the city of Shari, Housing built on wall bearings system and cracks appeared in many houses, these cracks threaten these houses by failure at any moment and without warning.

This study aims to study the causes of cracks and ruptures that emerged in the houses of the City of Shari, AlQassim region. The behavior of the structures built using the load wall bearings system in general and the factors that affect their design, execution and structural analysis are examined. The study also aims to study the expected behavior of the wall bearing structural system in case any architectural modifications are to be done in the building in order to avoid these cracks and ruptures. The objectives of this study are:

1. To investigate the soil/foundation conditions in the site.

2. Identifying the probable causes of cracks and ruptures that have emerged in the Shari's structures.

3. To conduct a parametric study for the soil effect on the safety of structures namely;

a. Existence of the wall openings, their positions and sizes.

b. Effect of changing the dimensions and reinforcement of the wall openings' doorsteps.

2. Literature Review

There are numerous existing wall bearing buildings in the Kingdom of Saudi Arabia and in many places around the world. Loads of bearing masonry buildings usually have walls arranged at a fairly uniform spacing to carry gravity loads to the foundation without addition of frames or columns. Masonry walls are widely used as interior partitions in skeleton buildings. Composite masonry walls supported on reinforced concrete beam are commonly used in traditional buildings either as load-bearing walls stiffened by beams.

Many researchers investigated the behavior of masonry walls under different loading. In (1961), Rosenhaupt and Bulletin [1] studied the elastic analysis of composite walls. A general theoretical investigation of the composite beam-wall action and its application to the particular case of the foundation beam have shown that the wall behaves like a deep beam, with tension concentrating in the beam which acts as a tension tie and compression being distributed along the height of the wall. The structural behavior between masonry walls and supporting beams is represented by a triangular load diagram with zero ordinates at supports and maximum loading at mid-span. The rest of the wall load may be assumed to be transmitted to the support points by arching action.

Wood and Simms [2] investigated the composite action of heavily loaded brick walls supported on reinforced concrete beams and found that the axial force in the lower beam is approximately 30% of the vertical load. The failure was characterized by crushing of the masonry near the supports accompanied with slip at the interface between wall and the beam under the effect of combined bending and axial forces. The behavior of the system is largely influenced by the relative stiffness of the wall and the beam. While S. R. Davies and A. F. Ahmed [3]; studied the analysis of composite wall-beams. They concluded that with increasing the beam stiffness relative to the infill wall increases the length of contact between the beam and the wall and increases the bending moment in the beam and reduces the wall stresses.

Behavior of the masonry structures with openings had been extensively investigated. Dawe and Seah [4] studied the effect of openings in masonry infill in steel frames. They indicated that; the openings greatly reduced stiffness and load carrying capacity compared to infill walls without opening. Failure was initiated by separation of the wall from the frame on each side of the opening. Khalid Mosalam et al. [5] discussed the static response of in-filled frames. They concluded that; the openings in in-filled walls lead to a more ductile behavior and reduced the stiffness values by about 40% when compared with in-filled frames without openings (solid infilled frames) for lateral loads below the cracking load level. Solid in-filled frames cause the behavior to be brittle (sudden drop of load on crack initiation).

Stephen Schnider et al. [6] investigated the behavior of steel frames with brick masonry infill having large window openings. They illustrated that; the ductility of these tested masonry infill depended on the opening width. Narrow width of opening tended to be more ductile than walls with wider opening. Y.Chiou et al. [7] studied experimentally and analytically masonry in-filled frames. They concluded that; the structural behavior and stress distributions of the framed masonry wall are highly influenced by the failure of mortar. In addition, the filled masonry wall affects dominantly the behavior of the framed masonry structure. The completely filled masonry wall increase the stiffness of the structure and the adjacent column fails in the configuration of nearly uniform cracks.

For masonry walls, it is specified by the masonry standards joints committee code (1999) [8] and Egyptian code of Building 204-2005 [9], requirements for masonry structures and masonry society that the beam deflection not exceed the span/600, nor 7.60 mm whichever is less.

3. Methodology

The researchers visited the site in order to identify the nature of the area and structures utilizing the wall bearing system. In order to achieve the objectives of the study, the following methodology was implemented:

1.Examine the existing cracks and ruptures and their extent and their probable causes.

2.Execute boreholes and open bits, if possible, around structures to identify the nature of soil and foundation conditions.

3.Establish numerical models to investigate the effect of soil nature on the wall openings and to investigate the wall baring system and its structural analysis.

4.Examine and consider several cases of walls with different architectural configurations to study their behavior.

5.Analyze the behavior of walls which was determined through the results of the numerical study compared to the behavior resulting from a previous laboratory study.

4. Field Investigations

The research team conduted several field trips to the considered site, City of Shari, AlQassim which lies 124 km northwest of the city of Buraidah, Figure (1) shows a Google Earth photo for the city location. The site visits showed the following:

- The cracking lies in an area that is highly inhibited with people and passes through their houses.
- The existence of the ground surface cracking that reaches more than 10 cm in width and up to 10 cm in depth and varies in length and may reach up to 30 m in length, Figure (2).
- The houses in the area are built with wall bearing systems founded on weak strip plain concrete footings.
- The strip footings are constructed on or at very near level to the ground surface.
- The houses roofs are supported by steel-sections posts which in turn are held against the walls.
- The cracks and ruptures appeared anchored in the fences and walls of some buildings especially around the wall openings (windows and doors), as shown in Figure (3).

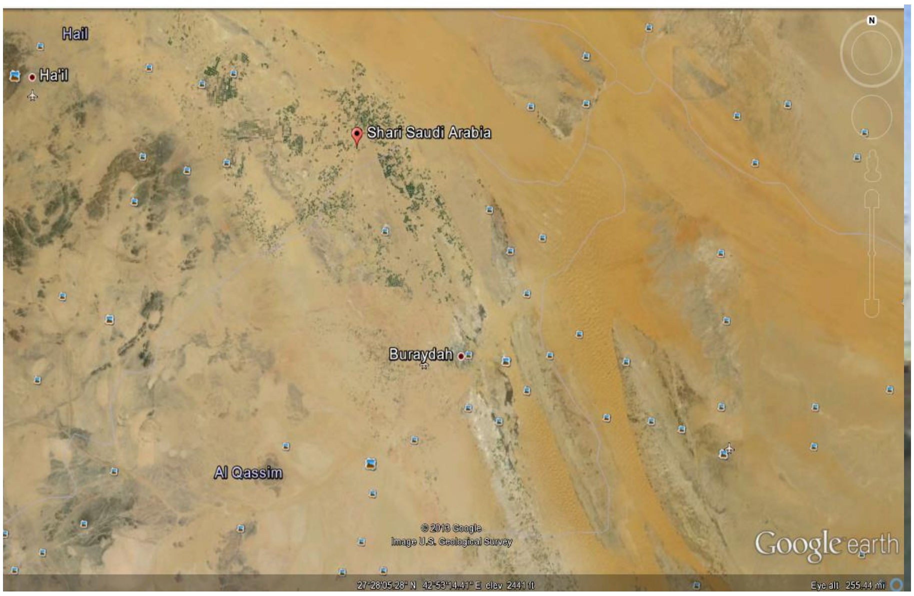

Fig. (1). City of Shari, AlQassim

Fig. (2). Ground surface cracking

Fig. (3). Cracks in the fences surrounding the houses

4.1 Geophysical/Geotechnical Site Investigations

A complete geophysical/geotechnical study was conducted at the site which included the following tasks:

- Drilling four (4) boreholes to a maximum depth of 15.0 meter below existing ground level under the supervision of a geologist.
- Soil samples were extracted, arranged, numbered, packed and sent to the lab for classification, testing and preparing the factual report about the site soil profile.
- Standard Penetration Tests (SPT) was performed in accordance with ASTM D1586 for measuring either the field relative density of cohesionless soils or the field consistency of cohesive soils and the results of the shear parameters of these soils, (ϕ) and (c).
- Establish the soil profile at the boreholes locations including groundwater observation.
- Perform a laboratory testing program to estimate the geotechnical properties of the underlying subsurface soil.
- Prepare a factual report about the subsoil condition at the proposed site.

Laboratory tests were performed on selected soil samples recovered from the boreholes to determine pertinent engineering, classification, and chemical properties. The field work was carried out in accordance with ASTM D1586 & D2113.

5. Results and Discussion

5.1 Results of Site Investigations

The geophysical investigation showed that Al-Qassim is devided into two geological units; the Arabian Shield and the Arabian Shelf (the sedimentary sector). The separation line between them extends between southeast and northwest of the AlQassim region. The Arabian Shield consists of igneous and metamorphic rocks that formed the foundations, around which the sediments coalesced. The Arabian Shelf formations are sedimentary which returns back to more recent geological ages. The sedimentary rocks often consist of limestone and sandstone, with layers of shell usually separating between them.

5.2 Site Conditions

Based on the boreholes information, the laboratory test results, general description of the different types of materials encountered during the investigation are presented below:

- Generally the surface layer on the site consists of brown to reddish brown, non to high plastic silty sand and/or poorly graded sand/gravel with varying percentage of silt and gravel.
- According to Standard Penetration Test (SPT) results, as a field test, the counted numbers of blows (N) required to drive the standard split-spoon 30 cm into the soil at different depths were ranging between 14 and larger than 50. Such high values of (N) indicated that the penetrated soil was in medium dense to very dense state. This soil was observed at depths ranging between 0.40 to 2.00 m below the existing ground level.
- The following layer is limestone which consists of yellowish brown and ceramic yellow, moderately hard, highly weathered, intensely fractured interbedded with thin layer of shale or sandstone. Total Rock Core Recovery (TCR) values are ranging between 15 and 32%, while Rock Quality Designation (RQD) values are observed between zero and 6%, showing very poor condition. This layer extended to the depth ranging between 3.50m and 5.50m in BH-2, BH-3, and BH-4.
- Layers of shale were encountered in all boreholes. These layers was observed at depths ranging between 2.00m to 6.00 m below the existing ground level, and extended up to a maximum explored depth. The shale was generally brownish grey to reddish brown in colour, low to high plastic, recovered as sandy elastic silt/sandy silt/silty clayey sand/silty sand with clay interbedded with thin layer of sandstone at some places. The shale encountered in the boreholes is generally hard consistency. Rock encountered in the borehole is generally strong.
- The measured fines content for selected samples ranged from 7.81 to 84.8% with an average of 54.9%. The results of Atterberg limits testing had Liquid Limits ranging from 35.5% to 63.0% and Plasticity Indexes ranging from 10.3% to 30.0%, indicating that the fine grained material is predominantly medium to high plasticity silt & clay.

- Free swelling test is performed on cohesive soil layer in case of no groundwater occurs at these layers.

- The collapsing tests showed that the collapsing potential is moderate.

- The mineralogical examination showed that the soil and groundwater samples contain high concentrations of calcite, gypsum, and calcium carbonate. The soil samples also contain iron oxides which work as cementing agent for soil particles causing potential failure upon exposing to water.

- The hierological examination also showed that the soil samples are free of the clay minerals that have high potential for swelling (Kaolinite) which is in agreement with the results of the free swelling test results.

- Groundwater was encountered at depth ranging between 5.00 m and 5.20 m below the existing ground level. The groundwater depths reported do not necessarily indicate seasonal perched or static groundwater levels, which may vary due to variations in precipitation, irrigation, groundwater withdrawal or injection, and other factors.

- Chemical analysis consisting of pH, sulfate, and calcium chloride content determinations was performed on twelve (12) soil sample in accordance with the British Standard (BS1377). The tested soil sample registered a pH value of 7.65 to 7.88, sulfate (SO_3) 0.088% to 0.248% and chloride (Cl) 0.024% to 0.152%. One sample of groundwater collected from the site was analyzed to determine pH, sulfate, total dissolved solids and chloride, in accordance with the British Standard (BS 812). It registered a pH value of 8.18, sulfate (SO_3) 1440 ppm, chloride (Cl) 2324 ppm and total dissolved solids (TDS) 6100 ppm.

5.3 Effect of Soil Profile and Construction Techniques on the Surface Cracking of Structures

The study for the soil profile at the site showed that increasing the moisture in the collapsible soil, due to rainfalls and the surrounding huge farms, led to soil layers collapsing and consequently the emerging of the ground surface cracking and ruptures. The size and rate of these crakes depend on the applied loads on the soil from the superstructures constructed on it which increase as the surface loading and stress increase.

Therefore, it could be concluded that the probable cause of these cracks are the collapsible nature of the soil, the presence of high concentrations of calcite, gypsum, calcium carbonate, and iron oxides which are all soluble agents causing potential failure upon exposing to water. In addition to these factors, the fluctuation in the movement of the groundwater levels in the area due to wells operation and rainfall led to the emerging of the ground surface cracking and rupture.

Since it is noticed that the damaged houses are constructed almost on or at very near to the ground surface with no rigid tie-beams under the walls which could help in resisting the differential settlement. Moreover, the surface load concentration due to the existence of the steel-sections posts which are used to support the houses roofs increased the surface stresses. Therefore, these damages in the village houses may be attributed to the nature of collapsible soil in the site, surface load concentrations, and the absence of tie-beams contribute to the sever damage in the walls of these houses.

5.4 Parametric Study

The study is divided into two parts; the first one is to show the effect of soil settlement on the existence of the wall openings utilizing the soil properties collected from the site. An explicit finite difference FLAC program that performs a Lagrangian analysis for numerical modeling is used in this study. The finite difference method can be considered one of the oldest numerical techniques used for the solution of differential equations by knowing initial values and/or initial boundary conditions. [10]. The second part of the study covers the positions and sizes of the wall openings and the effect of changing their dimensions and positions, using the FEM-based software package "ANSYS". The part of the study regarding the investigation of the effect of strengthening the vicinity of the wall openings using reinforcement was omitted due to lake financial support to do more lab structural testing.

5.4.1 Effect of Soil Constitutive Models

Two types of soil models are used in this study to cover the soil conditions in the site:

1- Null material model is used to represent material that is removed or excavated. It is an easy way to represent a gap or voids in FLAC

2- Elastic, isotropic model offers the simplest picture of material behavior. It is valid for homogeneous, isotropic, continuous materials that show linear stress-strain behavior with no hysteresis on unloading. This model is also useful in representing the concrete material.

3- Mohr-Coulomb model is the traditional model used to represent shear failure in site soil [11]. The failure envelope for this model relates to a Mohr-Coulomb criterion (shear yield function) with tension limit (tensile yield function). The shear flow rule is non-related and the tensile flow rule is related. This model is appropriate to use for the surface soil layers of silty sand soils. The shear strength parameters of this soil were utilized in the input data for FLAC software.

The mesh used is 0.1m x 0.1m, total width = 17m total height = 7m. The dimension of the opening is 3m x 3m, top beam is 1m thick, foundation level is -1.5m with foundation thickness = 0.5m, columns are 1m thick. Ground beam is 2.0 m thick. The main soil properties are shown in Table 1, a problematic soil with a certain dimension 30 cm x 3 m is shown in Figure 4, and a parametric study was done for three set of properties for the problematic soil.

Table (1). Materials Properties

	Concrete	Main Soil	Soil A	Soil B	Soil C
Density, Kg/m^3	2400	1700	1700	1700	1700
Elastic Modulus, Pa	2E10	50E7	50E6	50E6	50E6
Poisson Ratio	0.2	0.3	0.3	0.3	0.3
Cohesion, Pa	-	10000	1	1	1
Friction, Degree	-	35	30	20	10

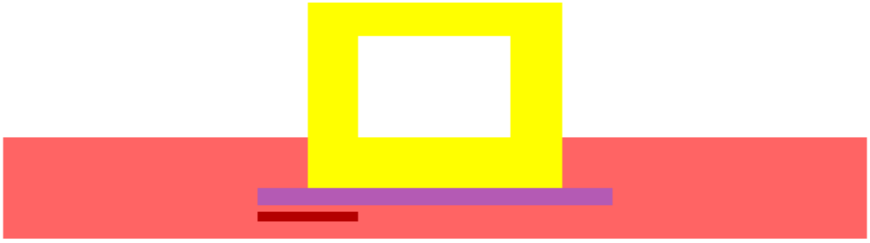

Fig. (4). Regions used in the Study

Exaggerated grid distortions for the three cases are shown in figures 5, 6, and 7. Maximum displacements are 0.2751mm, 0.2833mm, and 0.3031 for the three cases A, B, C respectively. It is clear as the soil properties deteriorate the displacement increases. For all cases a tilt appears for the structure indicating the effect of the problematic soil.

Fig. (5). Grid distortion, Soil A

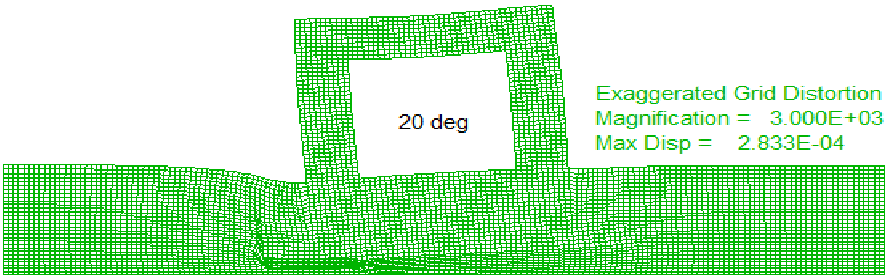

Fig. (6). Grid distortion, Soil B

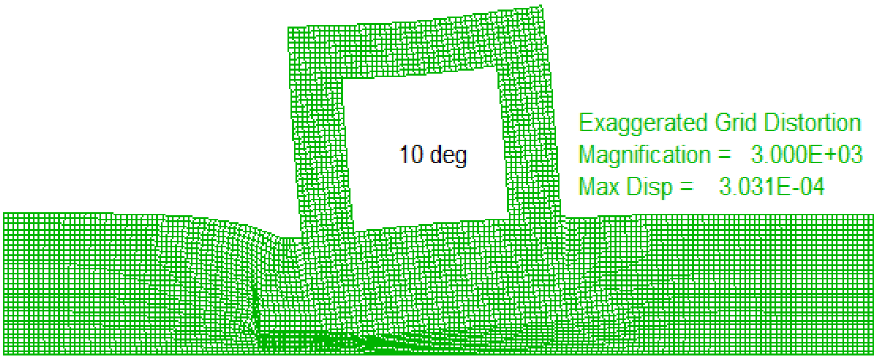

Fig. (7). Grid distortion, Soil C

Vertical (Y) displacement contours for the three cases are shown in Figures 8, 9, and 10. Maximum displacements are on the left hand side of the structures for all cases. It is clear as the soil properties deteriorate the vertical displacement increases as can be seen from the increase of the pink area on the left hand side of the structure indicating the effect of the problematic soil. Table 2 shows the vertical displacement at the top left hand side point of the structure for the three cases.

Table (2). Selected Y Displacements

Item	Soil A – 30 Deg	Soil B – 20 Deg	Soil C- 10 deg
Y disp m (61,70) x10^--4	-2.483	-2.530	-2.669

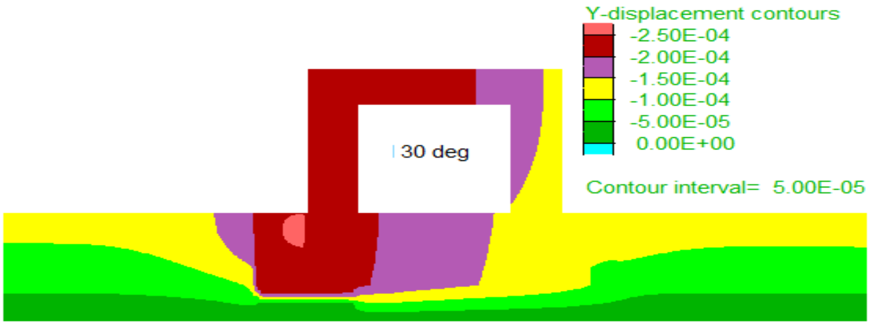

Fig. (8). Vertical displacement, Soil A

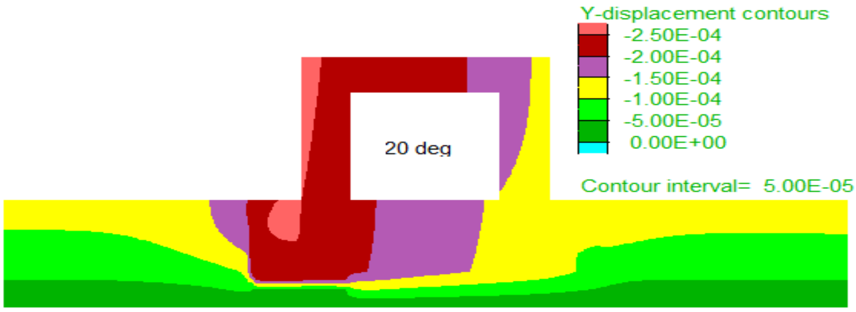

Fig. (9). Vertical displacement, Soil B

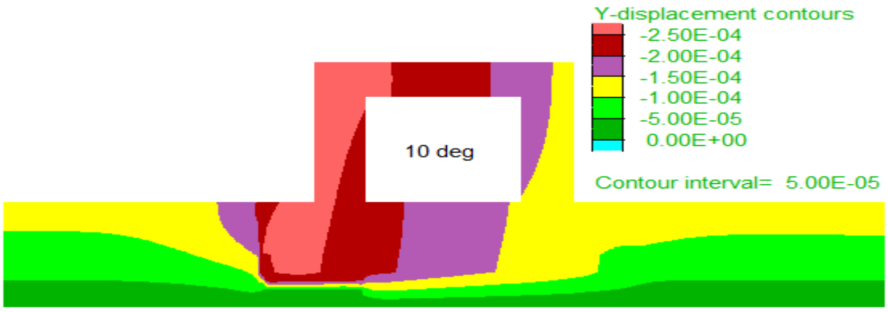

Fig. (10). Vertical displacement, Soil C

Horizontal (X) displacement contours for the three cases are shown in figures 11, 12, and 13. Negative values indicate the movement towards the left hand side of the structures for all cases. It is clear as the soil properties deteriorate the horizontal displacement increases as can be seen from the increase of the pink area on the upper right hand side of the structure indicating the effect of the problematic soil. Table 3 shows the horizontal displacement at the top right hand side point of the structure for the three cases.

Table (3). Selected X Displacements

Item	Soil A – 30 Deg	Soil B – 20 Deg	Soil C- 10 deg
X disp m (110,70) x10^-4	-1.286	-1.360	-1.536

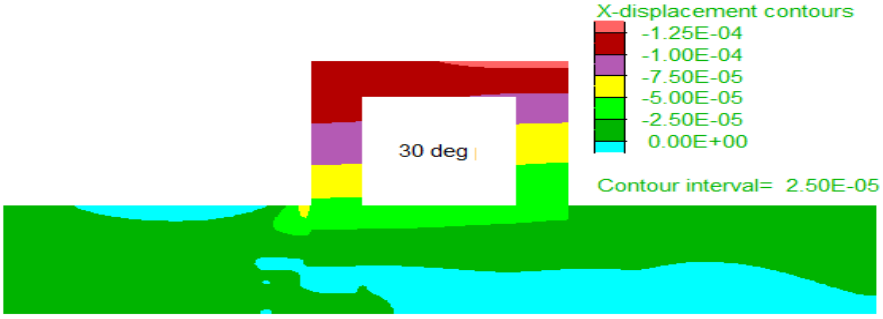

Fig. (11). Horizontal displacement, Soil A

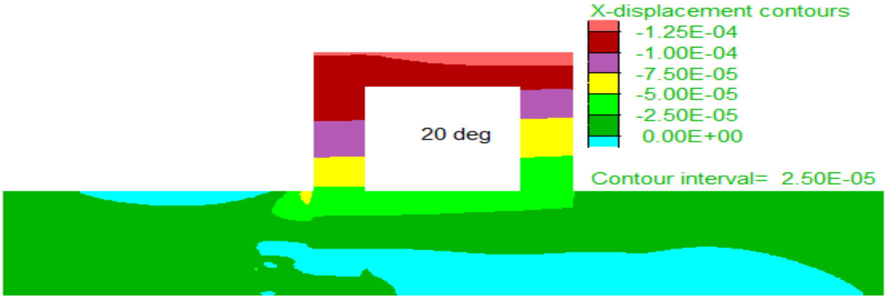

Fig. (12). Horizontal displacement, Soil B

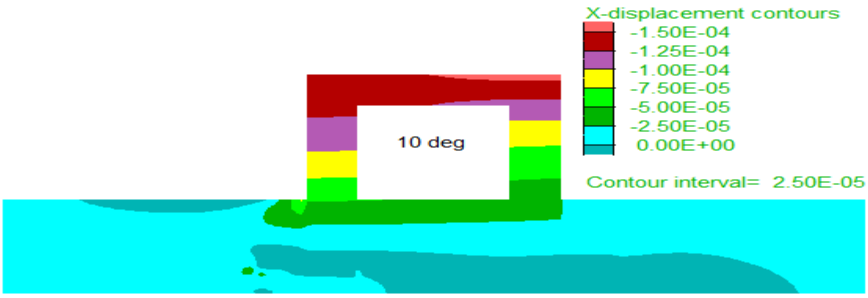

Fig. (13). Horizontal displacement, Soil C

Horizontal (X) stress contours for the three cases are shown in Figures 14, 15, and 16. Negative values indicate compression, and positive values indicate tension. Table 5 shows the horizontal stresses at the middle lower fibers of the top beam (point 85, 61) and at the lower right hand side fibers of the left column (point 70, 31) for the three cases. It is clear as the soil properties deteriorate the horizontal stresses increases as can be seen from table 4 indicating the effect of the problematic soil.

Table (4). Selected Horizontal Stresses

Item	Soil A – 30 Deg	Soil B – 20 Deg	Soil C- 10 Deg
Sxx Pa (85,61) x10^5	1.301	1.309	1.328
Sxx Pa (71,31) x10^5	-33.37	-33.59	34.35

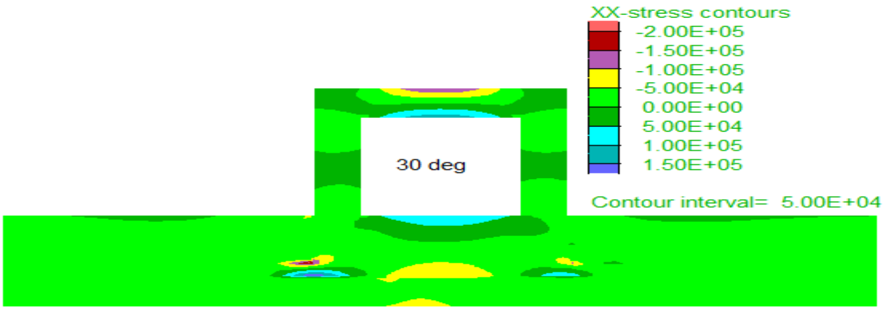

Fig. (14). Horizontal stresses, Soil A

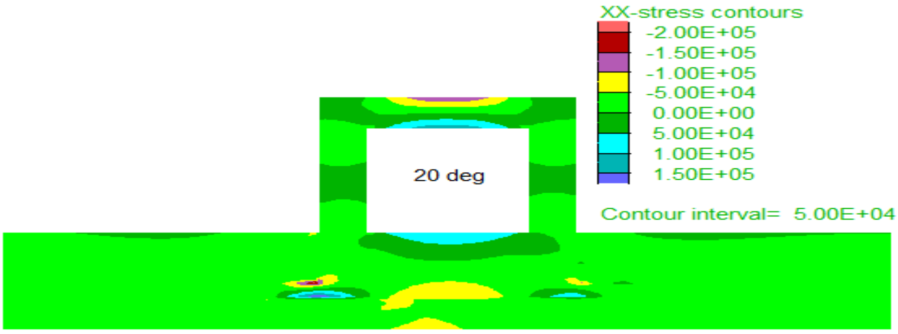

Fig. (15). Horizontal stresses, Soil B

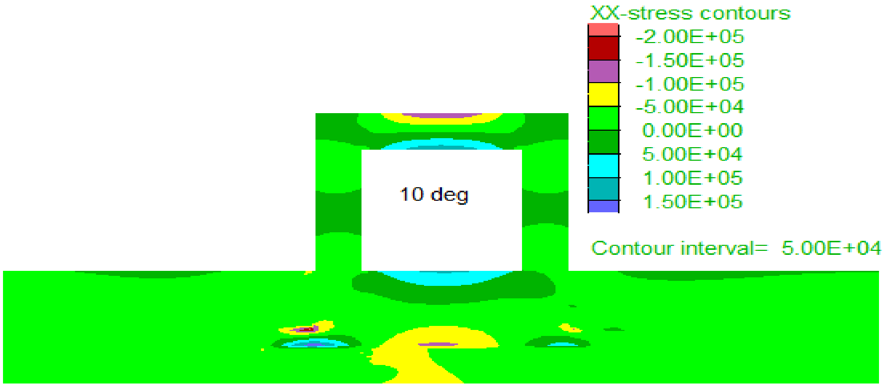

Fig. (16). Horizontal stresses, Soil C

Vertical (Y) stress contours for the three cases are shown in figures 17, 18, and 19. Negative values indicate compression, and positive values indicate tension. Table 6 shows the vertical stresses at the lower right hand side fibers of the left column (point 70, 31) for the three cases. It is clear as the soil properties deteriorate the horizontal stresses increases as can be seen from table 4 indicating the effect of the problematic soil.

Table (6). Selected Vertical Stresses

Item	Soil A – 30 Deg	Soil B – 20 Deg	Soil C- 10 deg
Syy Pa(70,31) x10^5	-1.997	-2.030	2.102

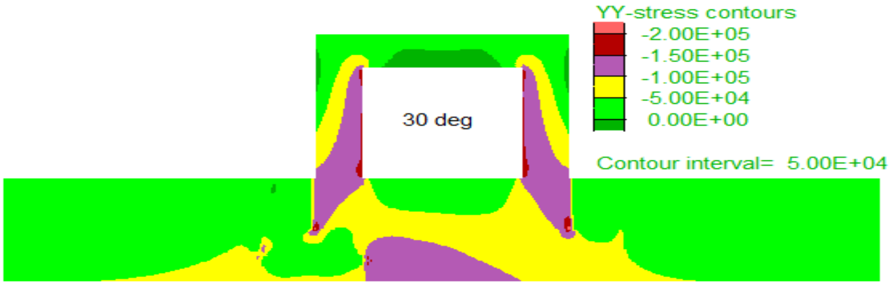

Fig. (17). Vertical stresses, Soil A

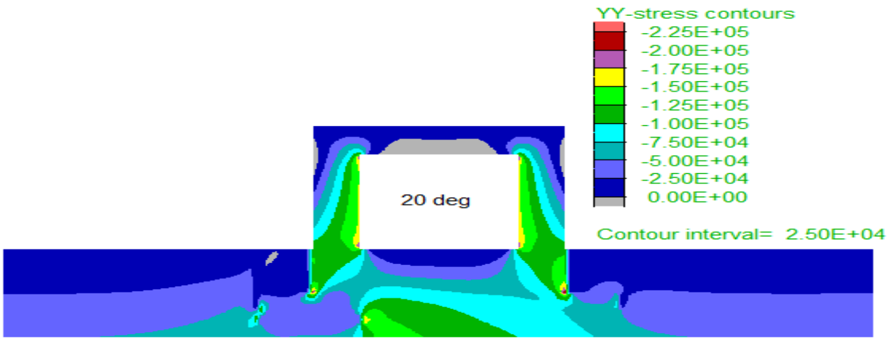

Fig. (18). Vertical Stresses, Soil B

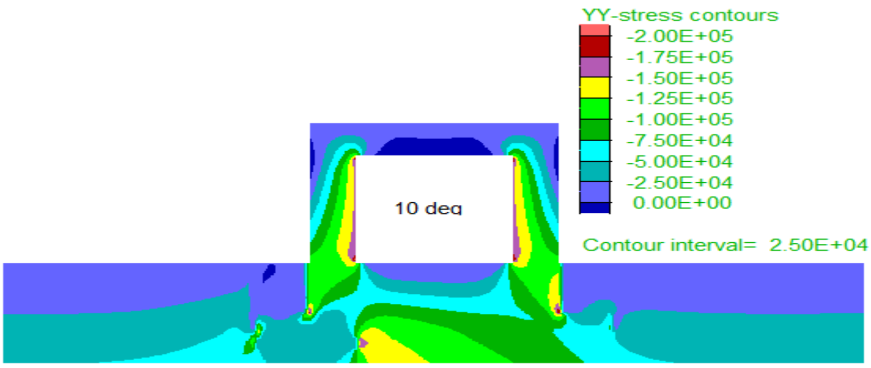

Fig. (19). Vertical stresses, Soil C

5.4.2 Effect of the Size of Opening

In this parameter, an investigation of the effects of opening existence in masonry wall and the effect of the size opening in the horizontal direction, (increase in width of the opening) and the effect of the size of opening in vertical direction, (increase in height of opening). The openings are placed in wall at center of the model. The models are loaded under the effect vertical load increased up to failure occurred.

In case of increase in width of the opening, three analytical models (W1, W2, and W3) are investigated. Model W1 has an opening 400×300 mm, model W2 has an opening 600×300 mm and model W3 has an opening 800×300 mm, respectively. While in case of increase in height of opening, three analytical models (V1, V2, and V3) are studied. Model V1 has an opening 400×450 mm while model V2 has an opening 400×600 mm and model V3 has an opening 400×750 mm.

The analytical results are found that: the presence of the opening in the wall influenced on the resistance the walls for the loads and reduces the stiffness of the wall. The increase of the height opening in vertical direction (opening height) has little influence on the ultimate load with comparison the increased the width opening in horizontal direction.

5.4.3 Behavior of Models with Opening in Light of Mode of Failure

The behavior of models with central opening (increase in the height of opening) was observed that nearly have the same trend as models without opening; because the opening size was not intersecting the load path. Load path of these models were kept similar as load path observed for models without opening. The failure happened at the supports of model and propagated diagonally towards the loading points.

For models with opening increase in the width direction, the load path was deviated around the opening. The failure of these models occurred at the bearing regions of the lintel. The cracks increased around the lintel of the opening and propagated towards the loading points and supports of the model. Figure (20) and (21) demonstrates the internal stresses trajectories for models at 75% from the failure load.

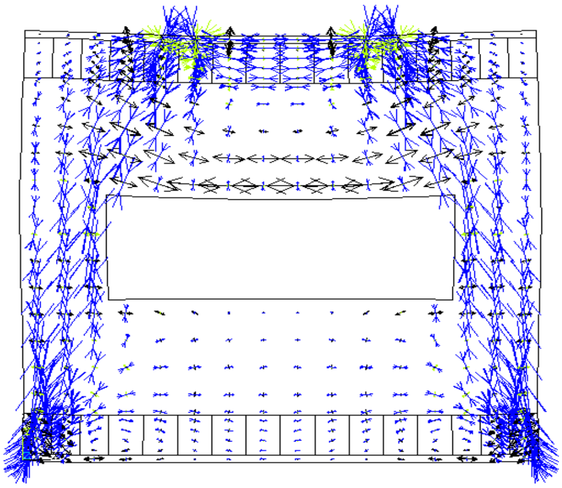

Fig. (20). Internal stresses trajectories for model W3

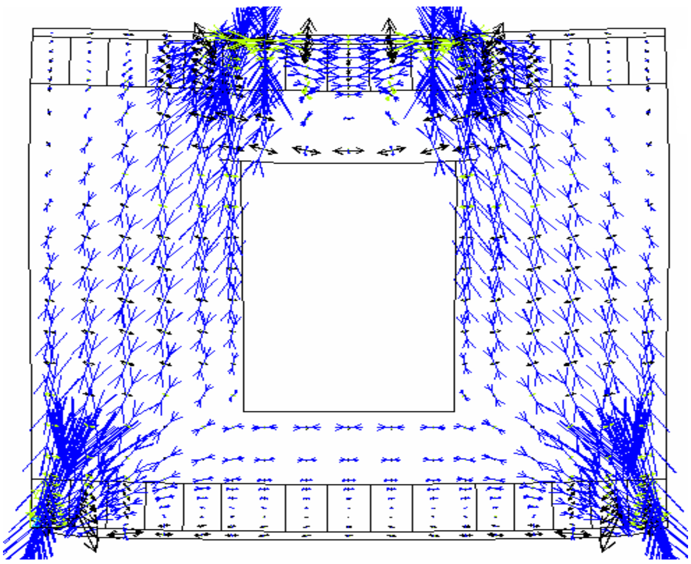

Fig. (21). Internal stresses trajectories for model V2

6. Conclusion

- The collapsible nature of the soil in the field, the presence of high concentrations of calcite, gypsum, calcium carbonate, and iron oxides which are all soluble agents causing potential failure upon exposing to water.

- The fluctuation in the movement of the groundwater levels in the area due to wells operation and rainfall led to the emerging of the ground surface cracking and rupture.

- The surface load concentration due to the existence of the steel-sections posts which are used to support the houses roofs increased the surface stresses.

- The presence of the opening in the wall influenced on the resistance the walls for the loads. The opening definitely reduces the stiffness of the wall and subsequently reduces the failure load and increases deflection at the same load level. Also; it may be said that the increase of the opening size reduces the strain capacity of the wall loading to earlier failure.

- The failure load reduced with the increase in the height of opening and the deflection of the lower beam reduced with the increase in the opening height.

- The increase of the height opening in vertical direction (opening height) has little influence on the ultimate load with comparison the increased the width opening in horizontal direction.

7. References

[1] Rosenhaupt, J. and Bulletin, T., "Elastic Analysis of Composite Walls, A Gernal Theory," *Journal of Structural Engineering*, Vol. 10, No. 1, (1961).

[2] Wood, R.H. and Simms, L.G., "A Tentative Design Method for the Composite Action of Heavily Loaded Brick Walls Supported on Reinforced Concrete Beams," *BRS CP 26/69 Building Research station*, Watford, Herts, (1969).

[3] Davies, S.R. and Ahmed, A. F., "An Approximate Method for Analyzing Composite Wall Beams," *Proceedings of the British Ceramic Society*, NO. 27, (1978), pp. 305-320.

[4] Dawe, J. L. and Seah, C-K., "Behavior of Masonry Infill Steel Frames," Canadian Journal of Civil of Engineering, Vol. 16, No. 2, (1989), pp. 865-876.

[5] Mosalam, K. M., White, R. N., and Gergely, P, "Static Response of Infilled Frames Using Quasi-Static Experimentation", *Journal of Structural Engineering*, Vol.123, (1997), pp 1462-1469.

[6] Schneider, S. P., Zagers, B. R., and Abrams, D. P., "Lateral Strength of Steel Frames With Masonry Infills Having Large Openings", *Journal of Structural Engineering*, Vol.124, (1998), pp. 896-904.

[7] Chiou, Y-J, Tzeng, J-C, and Liou, Y-W, "Experimental and Analytical of Masonry Infilled Frames," *Journal of Structural Engineering*, Vol.125, (1999), pp. 1109-1117.

[8] The Masonry Standards Joints Committee, "Building Code Requirements for Concrete Masonry Structures," ACI 530/ASCE 5/TMS 402, *American Concrete Institute, American Society of Civil Engineers and the Masonry Society, Detroit, New York and Boulder*, (1999).

[9] Egyptian Code of Practice (ECP 204-2005), "Design and Construction of Building Structures", (2005).

[10] Desai, C. S., and Christian, J. T., Numerical Methods in Geomechanics, New York: McGraw-Hill, (1977).

[11] Vermeer, P. A., and Borst, R. De., "Non-Associated Plasticity for Soils, Concrete and Rock," *Heron*, Vol. 29, No. 3, (1984), pp. 3-64.

تأثير هبوط التربة على تصدعات الحوائط والانهيارات في محافظة "شيرى" – المملكة العربية السعودية – دراسة حالة

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ملخص البحث. تصف هذه الورقة دراسة حالة لأسباب الشقوق وتصدعات المباني التي ظهرت في بيوت محافظة "شرى" بمنطقة القصيم . بناء هياكل هذه المدينة تم باستخدام نظام الحوائط الحاملة. الأحمال في هذا النظام تنتقل عادة بطريقة الجدران مرتبة في تباعد منظم يؤدى إلى تحمل أحمال المنشأة دون إضافة الأعمدة. وتنقسم هذه الدراسة إلى قسمين؛ الجزء الأول يناقش دراسة ميدانية جيوتقنية لطبيعة التربة في موقع البناء. الجزء الثاني يعرض نتائج دراسة لتأثير هبوط التربة وكذلك أماكن ومقاسات الفتحات في الحوائط على الشقوق والتصدعات في المباني. أظهرت النتائج أن بناء المنازل تقريبا في مستوى أو بالقرب جدا من مستوى سطح الأرض مع عدم وجود كمرات ربط جاسئة تحت الجدران بحيث يمكن أن تساعد في مقاومة الهبوط المختلف يؤثر على سلامتها. وجود الفتحات في الجدار بالتأكيد يقلل من صلابة الجدار و بعد ذلك يقلل من الحمل المسبب للانهيار ويزيد من الازاحة الرأسية عند نفس مستوى الحمل. تم استخدام حزمة البرامج FLAC المبنية على طريقة الفروق المحدود وحزمة البرامج ANSYS المبنية على طريقة العناصر المحدودة في التحليل.