Analysing some geotechnical properties of soils to predict the swelling potential in the left side of Mosul city using GIS methods

Dr. Suhail Idrees Abdulqader Khattab, Dr. Rasheed Saleem Abed and Bashar M. A. Abdullah Al-Imam

Abstract **---**The use of new technologies and programs in geotechnical analysis is emphasized in this paper . Soil properties in the left side of Mosul city (approximate area of 131 km^2) were correlated with swelling behavior . The results of tests of more than 300 boreholes in the study area were collected from different resources . Statistical and geospatial analysis were using geographic information systems GIS programs . The out-put identified the most risk areas . Field visits show evidence of swelling effects on some buildings.

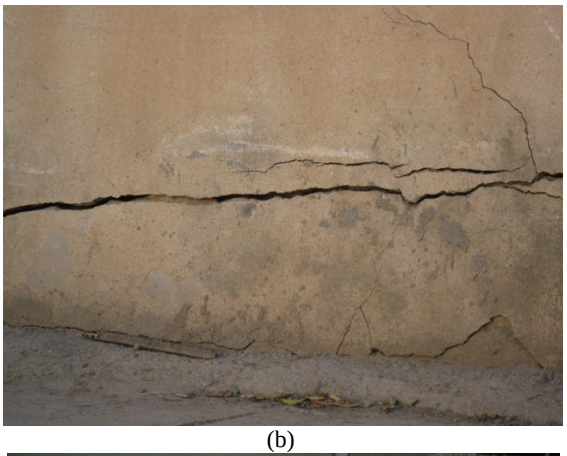
Keywords**--** swelling, water content, dry density , GIS.

I. INTRODUCTION

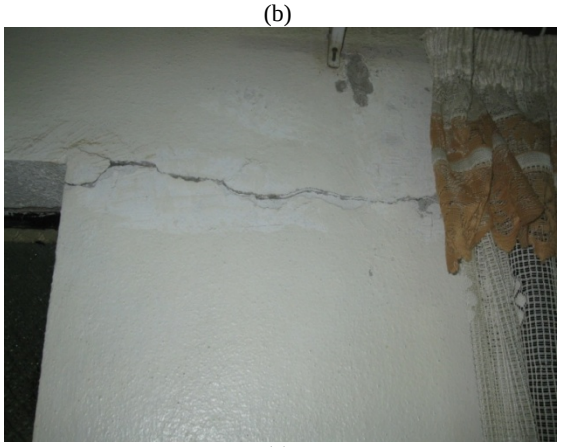
SOME buildings in the Mosul city Suffer from cracks related to the presence of problematic soils as expansive soils [13] as shown in fig. (1).

The geological age of the left side of Mosul city is dated between lower Miocene and quaternary . The lower Miocene consists of lower Fares (Fatha) and upper Fares (Injana) . The quaternary consists of alluvium deposit and river terraces so it contains sands , clays and gravel which deposited by the river and the weathering of Injana . The geological map of left side of Mosul city shown in fig (2) [1].

(a)



(b)



(c)

Fig 1. Shows the cracks in districts (17) for the left side of Mosul city

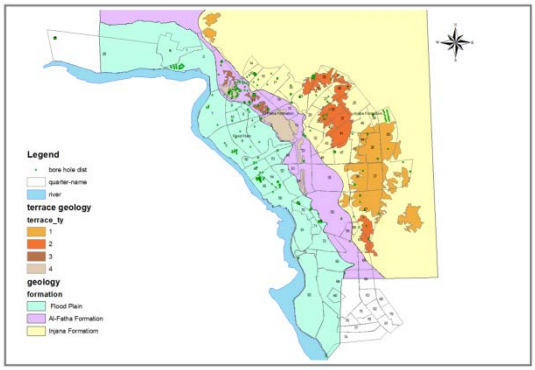


Fig 2 Geological map of the left side of Mosul city. Numbers indicate districts.

Dr. Suhail Idrees Abdulqader Khattab is Professor at Coll. Of Engg. / Civil Dept., University of Mosul.
Dr. Rasheed Saleem Abed is Lecturer at Center of Remote Sensing, University of Mosul.
Bashar M. A. Abdullah Al-Imam is Master Student at Coll. Of Engg. / Civil Dept., University of Mosul. Email: jo_ba_er@yahoo.com

Expansive soils are clayey soils which exhibit significant volume change related to soil moisture variation [6] . The presence of expansive soils greatly affects the construction activities in many parts of the world [11] . Foundations constructed on these clays are subjected to large uplift forces caused by swelling which induce heave cracking and breaking of foundations , slabs , and walls [6] .

Many investigations were carried out to analyze the factors affecting the swelling of clayey soils as initial water content (Fig. 3)[7] and (Fig. 4)[10] , initial dry density (Fig. 5) [8] , (Fig. 6) [10] liquid limit (table 1) [2,3] , Plasticity index (table 2) [2,3,9] , Clay content [14] , Passing # 200 [5] and Swelling index [13] .

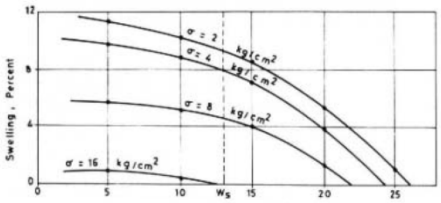


Fig. 3 Effect of initial water content on swelling (After El-Sohby and Rabba, 1981)

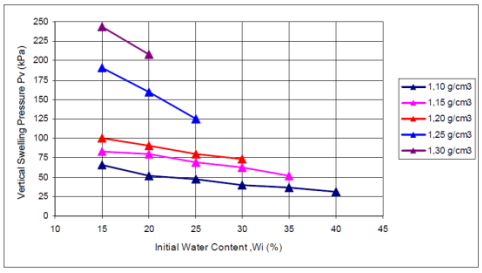


Fig. 4 Relation between the vertical swelling pressure and the initial water content for different initial dry densities (After Burak , 2004).

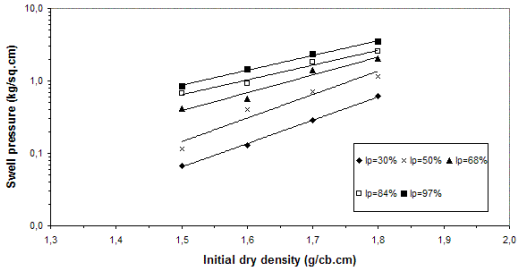


Fig 5 Relation between the vertical swelling pressure and the initial water content for different initial dry densities (After Erol, 2004).

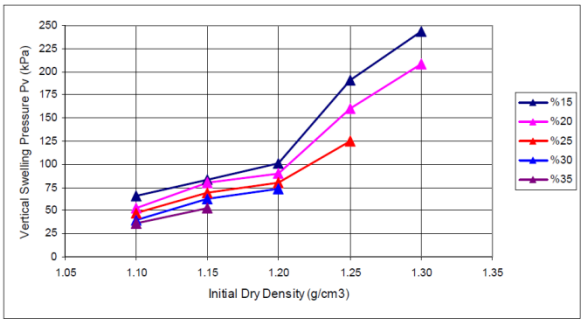


Fig 6 Relation between the vertical swelling pressure and the initial dry density for different initial water content . (After Supaz, 2004)

TABLE 1 SOIL EXPANSIVITY PREDICTION BY LIQUID LIMIT .

Degree of expansion	Water content %	
	Chen [3]	1498IS [2]
Low	< 30	20 - 35
Medium	30 - 40	35 - 50
High	40 - 60	50 - 70
Very high	> 60	70 - 90

TABLE 2 SOIL EXPANSIVITY PREDICTION BY PLASTICITY INDEX .

Degree of expansion	Plasticity Index %		
	Holtz and Gibbs[9]	Chen[3]	IS 1498[2]
Low	< 20	0 - 15	< 12
Medium	12 - 34	10 -35	12 - 23
High	23 - 45	20 -55	23 - 32
Very high	> 32	> 35	> 32

In the past, results of soil tests and swelling properties were documented on point locations and stored in the form of tables , curves and reports on paper media .

The new spatial techniques of GIS within (ArcGIS 9.3) can connect among several locations and use the borehole attributes to perform interpolation and fill gaps.

The aim of this study is to prepare a geotechnical digital map for soil properties that affect on the swelling potential in the left side of Mosul city . The studied soil properties include initial water content, initial dry density, liquid limit, plasticity index … etc. The prepared maps will help in predicting swelling soil location of potential swelling and identify most risk areas.

II. EXPERIMENTAL WORKS & MATERIALS

This works was performed according to the following headlines :

1- Collect of borehole test results from various concerned organizations such as government laboratories , schools, health centers …etc . Other data were found in research topics performed in the past .
2- Georeferencing areal photo and city map using GIS functions .
3- Locating the GPS coordinates of various points and fed into the GIS program (Fig.7)
4- Preparing the tables of test result in a suitable way is readable by the GIS software .
5- Spatial and statistical analysis .

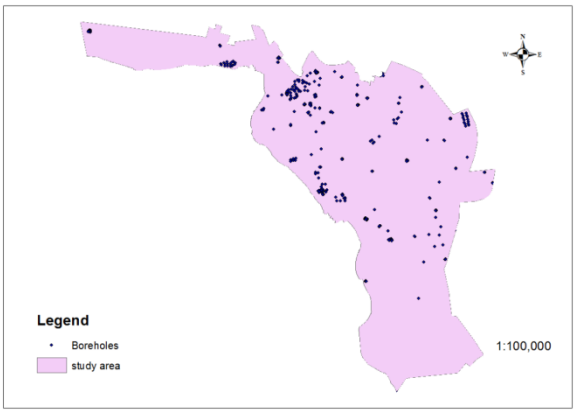


Fig. 7 Represent the study area and the borehole distribution

III. RESULTS & DISCUSSION

Various soil properties have been studied carefully in the study area. Limiting criteria of each have been imposed to mark the effect on swelling behavior.

According to Chen, Gibbs , IS1498 , Sapaz and Erol.,..etc. The following criteria to is used:

Accordingly, related plans were fig. (8) shows the case of liquid limit criteria while figures 9,10,11,12,13 and 14 show the criteria of plasticity index , initial water content , initial dry density , clay content , passing # 200 , activity and swelling index .

On figure (15), the results of actual tests on swelling potential are shown those more than 4.4 t/m^2.

This collection of maps shows diverse location within the city. Overlay analysis was that satisfies all the above mentioned criteria. The result can be seen in figures (16-22).

Visual comparison overlay figures (16-22) shows a great match of the risk areas having higher swelling potential.

V. CONCLUSION

The prepared maps show that higher swelling pressure is generally located in four zones , (A,B,C,D) . This finding was obtained by overlay analysis with eight basic soil property contributors .

The results were comparable with other researchers conclusions and verified by field visits to sample locations.

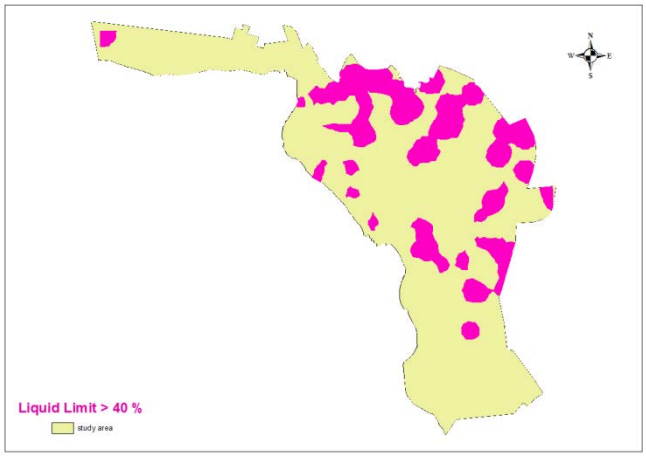


Fig. 8 Showing highly expansive soils based on L.L.(larger than 40 %)

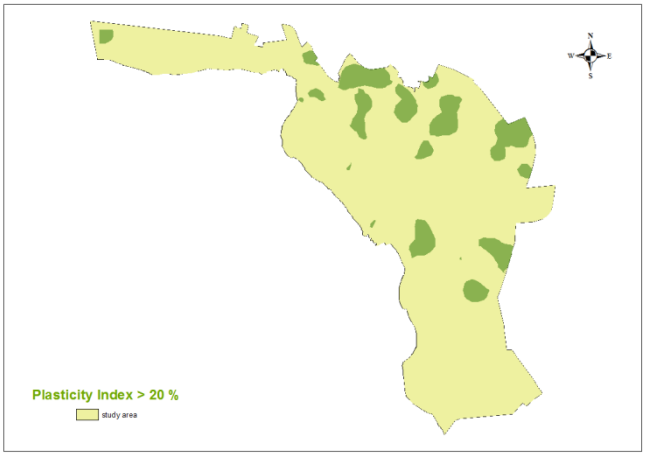


Fig. 9 Showing highly expansive soils based on P.I.(larger than 20 %) .

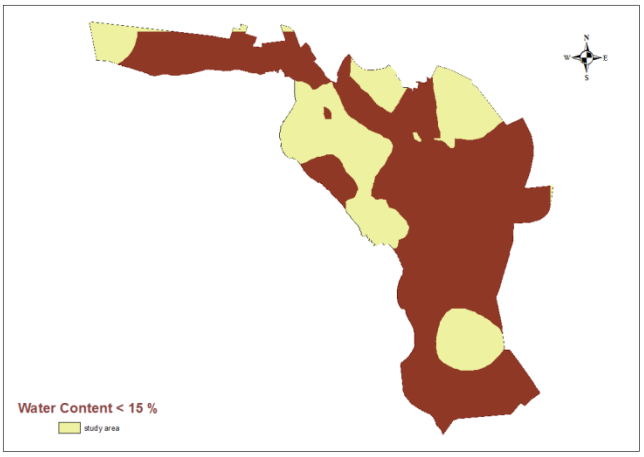


Fig. 10 Showing highly expansive soils based on Initial water content (less than 15%).

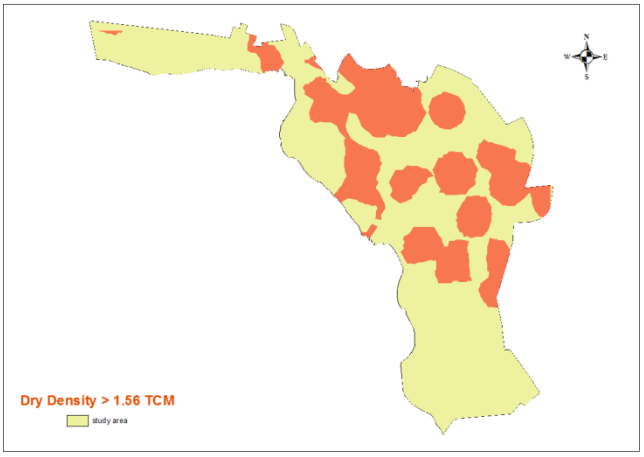


Fig. 11 Showing highly expansive soils based on Initial dry density (greater than 1.56 T/M^3).

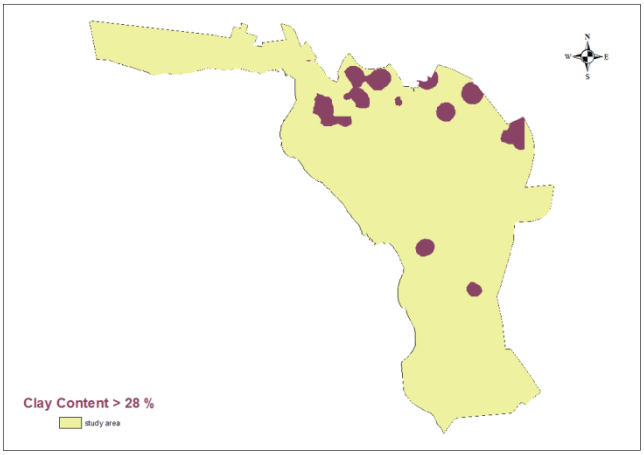


Fig. 12 Showing highly expansive soils based on clay content (greater than 28 %) .

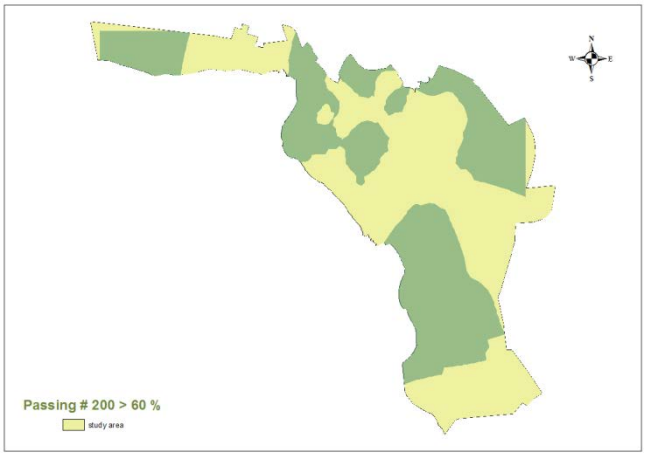


Fig. 13 Showing highly expansive soils based on passing # 200 (greater than 60 %) .

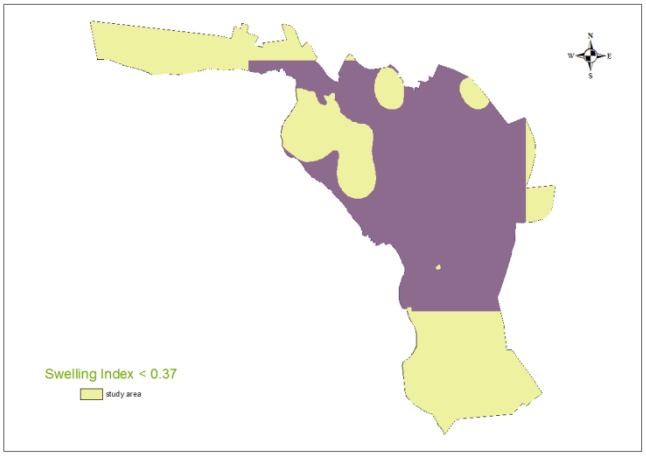


Fig. 14 Showing highly expansive soils based on swelling index (less than 0.37).

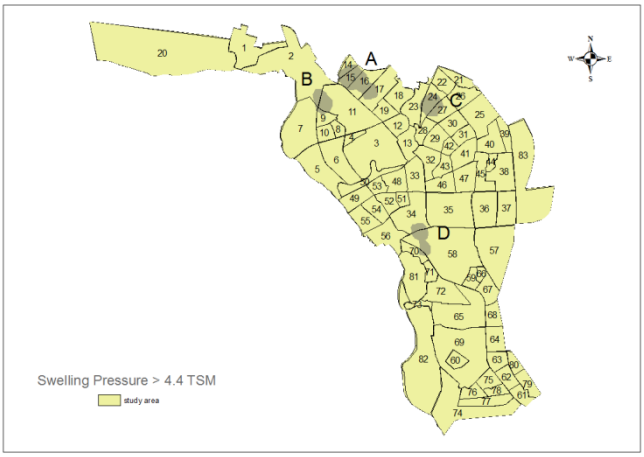


Fig. 15 Swelling pressure larger than 4.4 T/M^2 . Numbers indicate districts .

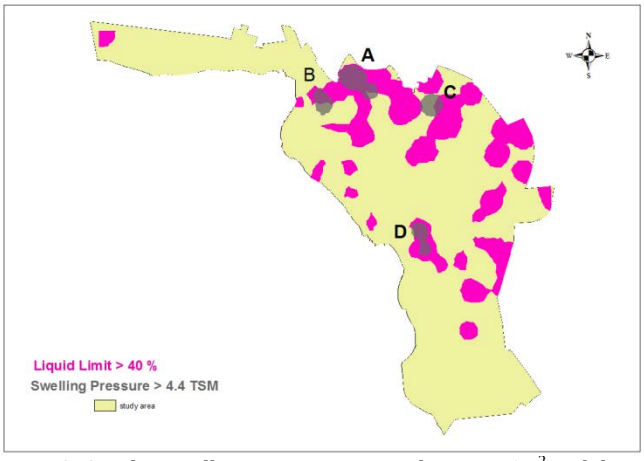


Fig. 16 Overlay swelling pressure greater than 4.4 T/M^2 with liquid limit greater than 40% .

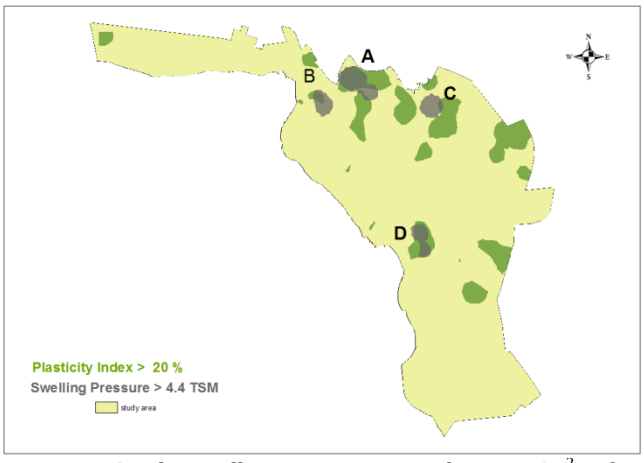


Fig. 17 Overlay swelling pressure greater than 4.4 T/M^2 with plasticity index greater than 20 % .

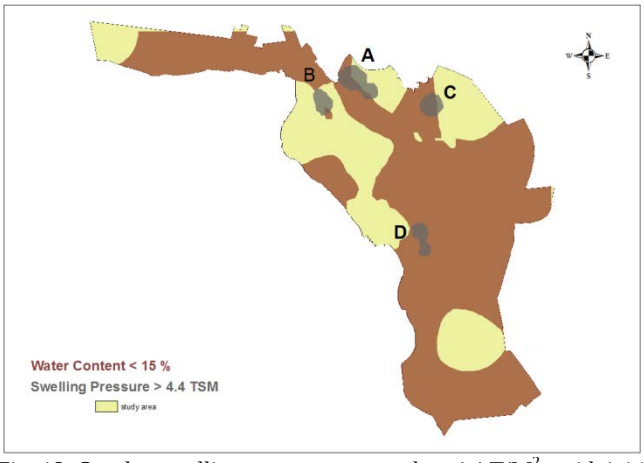


Fig. 18 Overlay swelling pressure greater than 4.4 T/M^2 with initial water content less than 15 % .

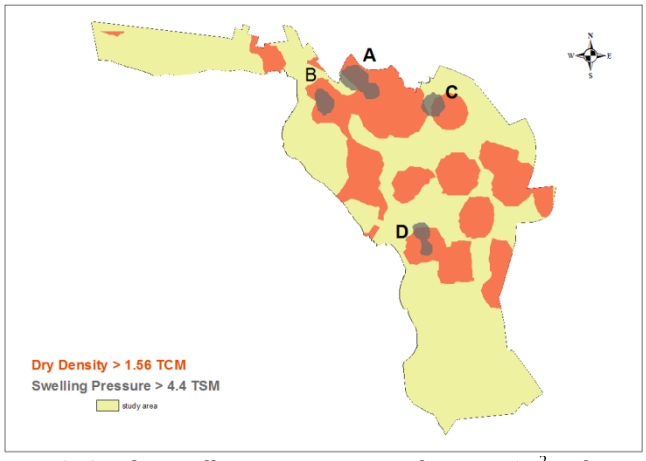


Fig. 19 Overlay swelling pressure greater than 4.4 T/M^2 with initial dry density greater than 1.56 T/M^3 .

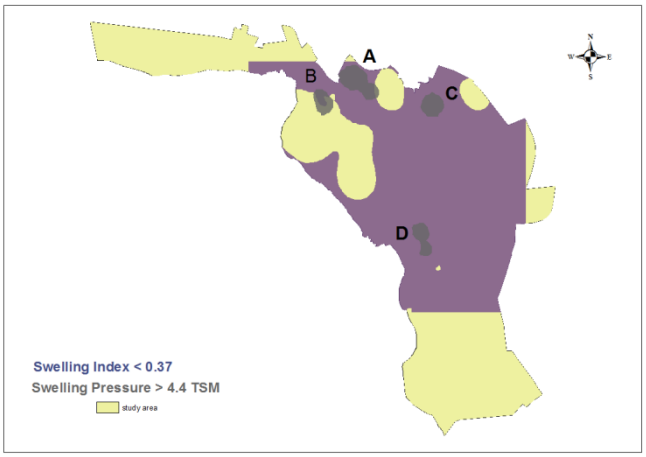


Fig. 20 Overlay swelling pressure greater than 4.4 T/M^2 with swelling index less than 0.37.

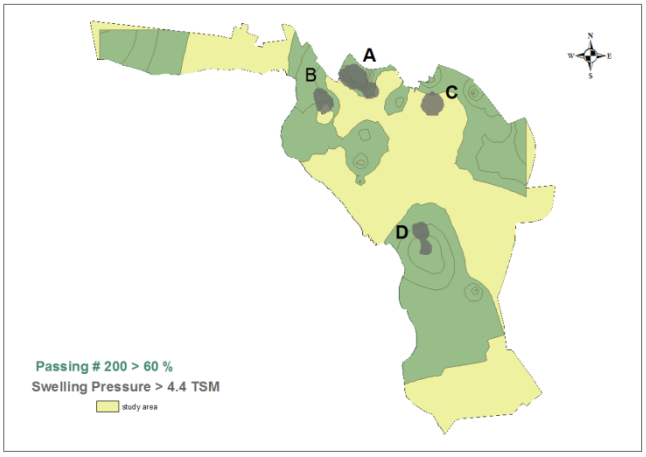


Fig. 21 Overlay swelling pressure greater than 4.4 T/M^2 with passing # 200 greater than 60 % .

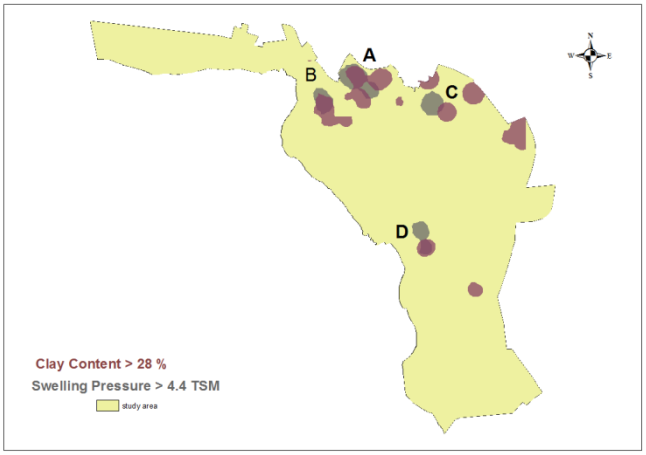


Fig. 22 Overlay swelling pressure greater than 4.4 T/M^2 with clay content greater than 28 % .

REFERENCES

[1] Al-jburiy M. A. , 1988 , "Geology of Mosul area east Tigris River" ,unpub., (in Arabic) , M. sc. Thesis ,Mosul University .

[2] Bureau of Indian Standards." Indian standard classification and identification of soils for general engineering purposes". BIS , New Delhi, 1970, IS 1498 .

[3] Chen, F.H. , 1975"Foundations on expansive soils ",.Elsevier , Amst-erdam.

[4] Chen, F.H. 1988,"Foundation on expansive soils", 2d ed., Elsevier, New York, NY, 463 pp.

[5] Chen, Fu Hua, , 1965 "The use of piers to prevent the uplifting of lightly loaded structures founded on expansive soils", Engineering Effects of Moisture Change in soils (Concluding Proceedings of the International research and Engineering Conference on Expansive Clay soils), Texas A&M University, pp. 152-171.

[6] Dhowian A., Orhan Erol, and Abdulfattah, Y., 1988. "Evaluation of expansive soils and foundation methodology in the kingdom of Saudi Arabia", King Abdula-ziz City for Science and Technology, Riyad .

[7] El-Sohby, M.A., and Rabba, E.A., 1981 , "Some factors affecting swelling of clayey soils", Geote-chnical Engineering, Vol. 12, pp. 19-39.

[8] Erol, O., 2004, "Correlations for Quickpredivtion of swell pressure" , EJGE.

[9] Holtz, W.G., and Gibbs, H.J. ,1956. "Engineering properties of expansive clays". Transactions of ASCE, 121, 641-663.

[10] Sapaz, B. , 2004, "Lateral versus vertical swell pressures in expansive soils" , Msc thesis unpub, Middle east technical university.

[11] Sridharan A., Parkash K. , 2000" Classification procedures for expansive soils Institute of civil engineers, 143 , Oct., 235-240 .

[12] Thabit K.M. , Alkhashab M. N. , Khattab S. I., Mahmood M.N., 1989 " Cases of settlement of buildings in old Mosul", (in Arabic) journal of education and science, Mosul University , Vol. 6.

[13] Vijayvergiya, A., and Skullivan, R.A., 1973"Simple Technique for identifying Heave potential" , Proceedings of a workshop on expansive Clays and Shales in Highway Design and Construction ,D.R. Lamb and S.J. Hanna, editor, May, pp.275-294.

[14] Williams A.B. & Donaldson G.W. (1980). "Develop-ments relating to building on expansive soils in south Africa:1973-1980".Proc. of the 4th Int. Conf. on Exp. Soils, Denver, Vol.22 pp.834-844.