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PEAT CHARACTERISTICS AND DISTRIBUTION AT THE NORTH OF DELTA NILE

(Kafr El-Sheikh governorate)

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الملخص

يعتبر البيت احدى انواع التربة ذات المشاكل حيث تتكون من جذور النباتات المتفحمة جزئيا وتوجد بشكل منفرد أو مختلطة بالمواد العضوية وتكون على شكل الياف وتنتشر فى المناطق الاستوائية بمناطق البرك والمستنقعات التى تنحسر عنها المياه فيحدث تحلل لجذور واوراق النباتات ،ويصنف البيت على اساس نسبة ما يحتوية من مواد عضوية والياف ورماد وعادة ما يكون لونه بني داكن الى أسود. التعريف الدقيق للبيت عبارة عن تربة عضوية ذات محتوى عضوي يزيد عن 75٪ ويعتمد التعريف الهندسى للبيت على خصائصة الفيزيقية والميكانيكية ،وتنتشر فى مصر فى منطقة وسط وشمال الدلتا حيث توجد على شكل طبقات يتراوح سمكها من متر الى ثلاثة امتار واحيانا تكون متداخلة مع تكوينات الطين اللين ويختلف عمقها من مكان الى اخر حيث توجد قريبة من سطح الارض كما فى كفر سعد اوعلى اعماق كبيرة كما فى رشيد.

ومن خصائصها إرتفاع نسبة المحتوى المائى لها ، عدم تحملها للاحمال الواقعة عليها وذلك لأنضغاطيتها العالية تحت تأثير الاحمال وإعادة التشكل بسهولة عند رفع الحمل عنها وكذلك ضعف مقاومتها لقوى القص . مما يجعلها لا تصلح للتأسيس المباشر عليها.

ويهدف هذا البحث الى تحديد اماكن انتشار واعماق البيت فى محافظة كفرالشيخ وتحديد خصائصة الميكانيكية والفيزيقية بناء على عينات تم تجميعها من خلال مجموعة من الجسات المنفذة بواسطة المركز القومى لبحوث الاسكان والبناء بمحافظة كفر الشيخ

ABSTRACT

Peat is considered extremely soft, wet unconsolidated superficial deposits. It can also be described as a naturally occurring highly organic substance derived primarily from plant materials. It is very spongy, highly compressible and combustible. Peat is classified based on its fiber, organic ash content, and is usually dark brown or black color. The precise definition of peat is soil with organic content of more than 75%. The engineering definition is essentially based on the mechanical properties of soil. Peat is a problematic soil known for low shear strength and high compressibility characteristics. Therefore, it is definitely needed to expand our knowledge on the characterization of geotechnical properties and the mechanical behavior of this soil type, in other words, the behavior in terms of shear strength, stability, and settlement, its physio-chemo and mechanically coupled process. Peat is found in many countries throughout the world, that is in areas with excess rainfall and poorly drained ground and in absence of microbial activity. In Egypt, deposits of peat can be found as a 1 m thick layer near the around surface at north-east the Nile Delta and change in altitude and thickness towards the middle and north of the Delta. The aim of this paper is to explain the distribution of the peat in Kafr El-Sheikh governorate at north Nile delta and the geological formation of the study area. The data used are collected from samples taken from north of Nile delta by Housing and Building Research Center, (HBRC). The physical, chemical and mechanical property of the peat are discussed.

Keywords: peat, physical property, chemical property, mechanical property.

1- INTRODUCTION

- Peat has certain characteristics that sets it apart from most mineral soils and requires special considerations for construction over them. These special characteristics include high natural moisture content, high compressibility, low shear strength, potential for further decomposition as a result of changing environmental conditions, high permeability and high specific area. Engineers have recognized that peat land or peat is a problematic soil that is to be avoided as far as possible. Peat or organic soils represent the extreme form of soft soil, they are subjected to instabilities, such as localized sinking and slip failure, massive primary, long-term secondary and even tertiary settlements when subjected to even moderate load increasement. These materials may also chemically and biologically change with time. It is obvious that the mechanical properties of peat are very different from those of the mineral soils (silt and clay) that are familiar to engineering graduates throughout the world. Thus, it is needed to fully understand the characteristic of peat such as high-water content, lack of topographic relief and dynamics in their soil properties, that set them apart from mineral soils. Criteria based on mineral soils cannot be generally applied to peat conditions. Egypt is not considered from peatlands in the world, where it covers 0.005 % of Egyptian land (Yuanqiao Wu,2017). There are Three examples from Egypt those show the effects of peat under one side of foundation building as shown in fig (1). The first from Minyat Sandub, Dakahlia, its 36 meters high with raft foundation and leaned at angle of 1.353^{o} at 10m depth can found 2m thick layer of peat lay under the tilted side, the second from Faraskur, Damietta, its 12 meters high with shallow foundation. The building was tilted by 1.67^{o}, 1 m thick layer of peat lay under the tilted side at depth of 4m. The third example from Kafr Saad, Damietta with shallow foundation of 1.5m of depth, the building consists of a ground floor and 4 floors (height of 15m) and tilled by 1.53^{o}. The peat layer under the foundation by 1 m under the tilted side. From these three examples, the engineer is unaware of this type of soil and its property. The target of this paper is to explain the physical, mechanical and chemical properties of peat and its distribution at Kafr El-Sheikh governorate, north of delta Egypt. Where the housing and building national research center, implemented 150 boring at Kafr El-Sheikh governorate to review the social housing in the study area as illustrated in fig.2. The study area is approximately 3748 km^2 at north of Nile delta.

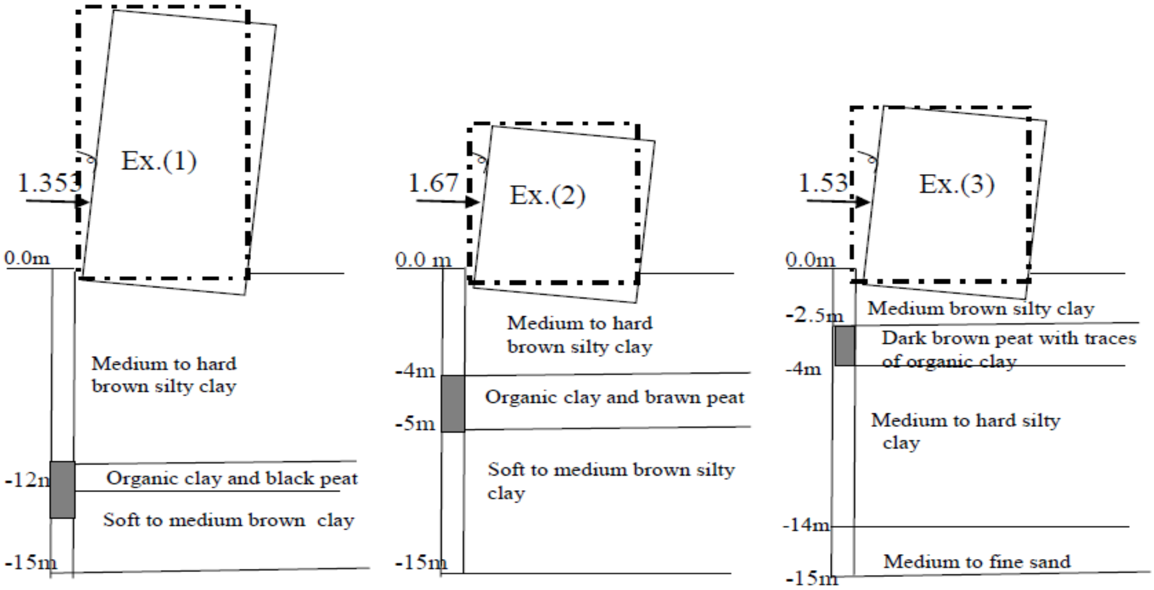

Fig.1 Three examples from Egypt those show the effects of peat under one side of foundation

2- <u>THE GEOLOGICAL STUDY</u>

The center and south of the study area are cover by the deposits of the modern geologic era (the Holocene era), the structures of first layer consists of clay deposits, clay and sandstone. These sediments are deposited above the ancient marine (sub-delta formations) dating back to the Pleistocene period, consisting of coarse sand, soft gravel and gravel which contains quartz or igneous rocks. Ismail (1984). The study area consists of three formation zone fig.3 the first is Sidi Salem formation and its mainly composed of green-grey clays with a few interbeds of dolomitic marls, and rare occurrences of quartzes sandstones with calcareous cement and siltstones, the second is Kafr El-Sheikh formation is composed of soft clays with a few interbeds of poorly consolidated sands with a clayey matrix. The development of this series appears to be rather constant over the entire Delta area. Its upper boundary is marked by the first appearance of the El-Wastani sands which have a typical littoral fauna. The Kafr El Sheikh is dated as Early to Middle Pliocene age, according to paleontological evidence and the third is Baltim formation mainly composed of green-grey clays with a few interbeds of dolomitic marls, and rare occurrences of quartzes sandstones with calcareous cement and siltstones (Barakat, 1982).

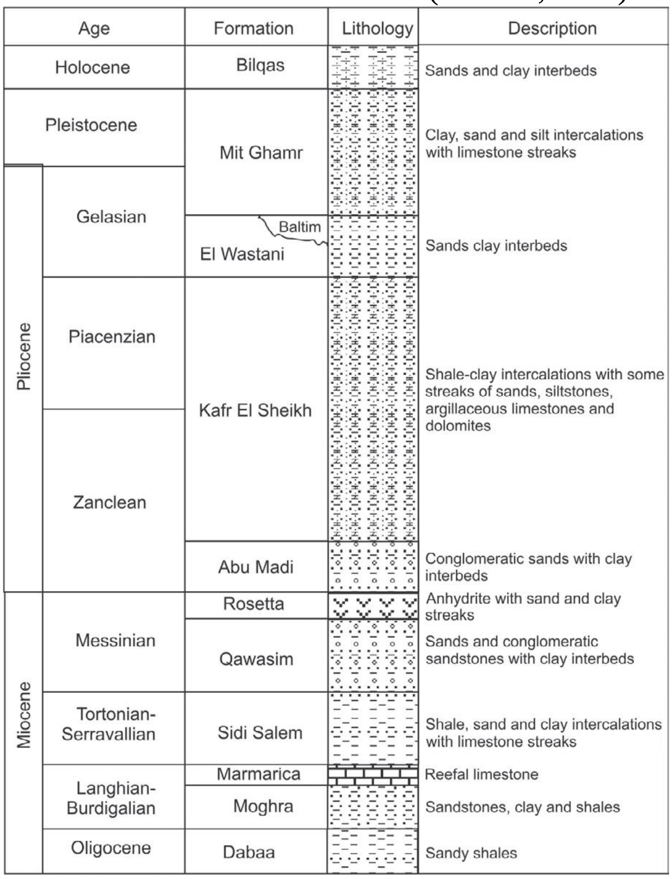

Fig. 3 The Generalized subsurface stratigraphic column of the Nile Delta region. After Ahmed A. Ismail et.al .(2010)

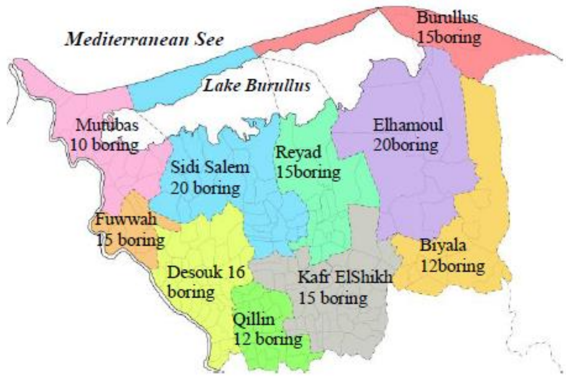

Fig.2 explain the distribution of the boring in the study area (HBRC).

3- THE GEOTECHNICAL STUDY

To determine the locations and characteristics of peat in the study area, the coordinates of the borings Those were implemented in the different sites were determined, from the boring profile can find the position and level of the peat were determined.

3-1 Peat Classification and property

3-1-1 Peat Classification

The American Society for Testing Materials (ASTM) D2487 classifies soils according to the Unified Soil Classification System based on particle size distribution and the Atterberg limits (Liquid Limit, w_L; Plastic Limit, w_P, and Plasticity Index, PI) and in ASTM, D4427 peats are classified on the basis of fiber content, ash content, acidity, absorbency and botanical composition. Based on fiber content peats are classified either as fibric (more than 67% fibers), hemic (33% to 67% fiber content), and sapric (less than 33% fibers). The standard notes that the fiber content may be related to the degree of humification (H) developed by von Post scale (1924), (fibric corresponds approximately to H1-H3; hemic corresponds to H4-H6; and sapric corresponds to H7-H10). Peats are divided into 3 categories based on the ash content (i.e. the material remaining after drying in a furnace): low ash (less than 5% ash), medium ash (5% to 15% ash), and high ash (ash content greater than 15%). Peats can also be classified based on the acidity, as measured by the pH. There are 4 categories: highly acidic (pH less than 4.5); moderately acidic (pH between 4.5 and 5.5); slightly acidic (pH between 5.5 and 7.0), and finally basic (pH greater than or equal to 7.0). Classification of the peat based on the absorbency relies on the water holding capacity of the peat as measured by Test Methods D 2980. The peat can be extremely absorbent (water holding capacity greater than 1500%); highly absorbent (water holding capacity between 800 and 1500%); moderately absorbent (water holding capacity greater between 300% and 800%); and slightly absorbent (water holding capacity less than or equal to 300%).

3-1-2 .SOIL MINERALOGY

To determine the mineral composition of the soil sample, two basic tests were carried out, the first is X- ray Powder Diffraction (XRD) and the second is Scanning Electron Micrographs (SEM). XRD is a rapid analytical technique primarily used for phase identification of a crystalline material as example minerals and inorganic compounds, so the XRD system didn’t identify the organic material or the fiber but explain the basic minerals of the sample. The (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens, and it gives information about the sample including external morphology (texture). Fig.4 explain the mineralogy of the sample which consists of illite, silicon at peak point and Fig. 5 explain the texture of the sample which explain the fiber, organic matter and clay mineralogy distribution. Illite consists of a gibbsite sheet bonded to two silica sheets, one at the top and another at the bottom. It is sometimes called clay mica. Das (2014). From fig. 4&5, the mineral composition of the sample according to XRD is illite and silica which appears as clay mica in SEM and the fiber that appears in SEM explains the ash content of the peat.

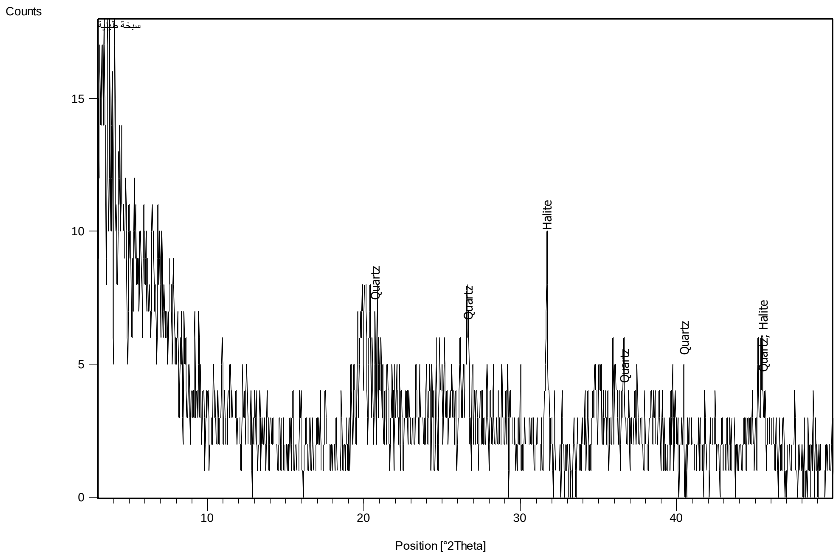

Fig. 4 The XRD of the peat sample

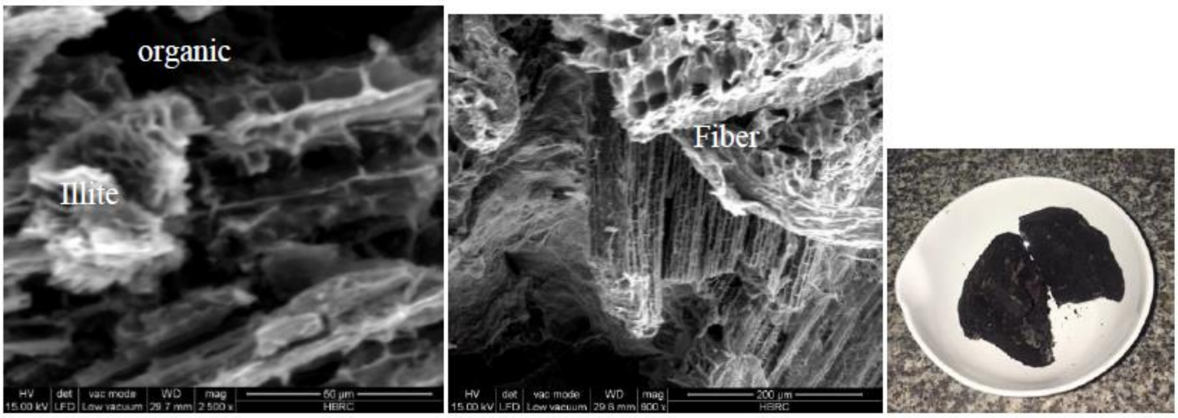

Fig.5 The SEM of peat sample

3-2 EXPERIMENTAL WORK, PEAT CHARACTERIZATION

The experimental work divided into three group. The first group was for the physical properties of the peat, Atterberg limits according to ASTM, D4318, water content according to ASTM, D2216, the Specific gravity according to D854**,** Bulk Density according to ASTM, D4531. The second group was for the chemical properties of the peat, the percentage of organic matter and ash content according to ASTM, D2974 then the fiber content according to ASTM, D1997, and the pH according to ASTM, D2980. The third group was for the mechanical property of peat, compressibility tested according to ASTM,D2453 and as shown in fig (8) explain the consolidation test and the different result are listed in table (1) and by comparing between the test's results and the results at table (2) can observed a similarity in the result with (Azzouz, 1976), which the relationship verify gave a relation between (Wc) and Cc for organic soil and peat, (Cc = 0.0115 *W)* gives result 2.08 and from consolidation curve Cc = 2.07.

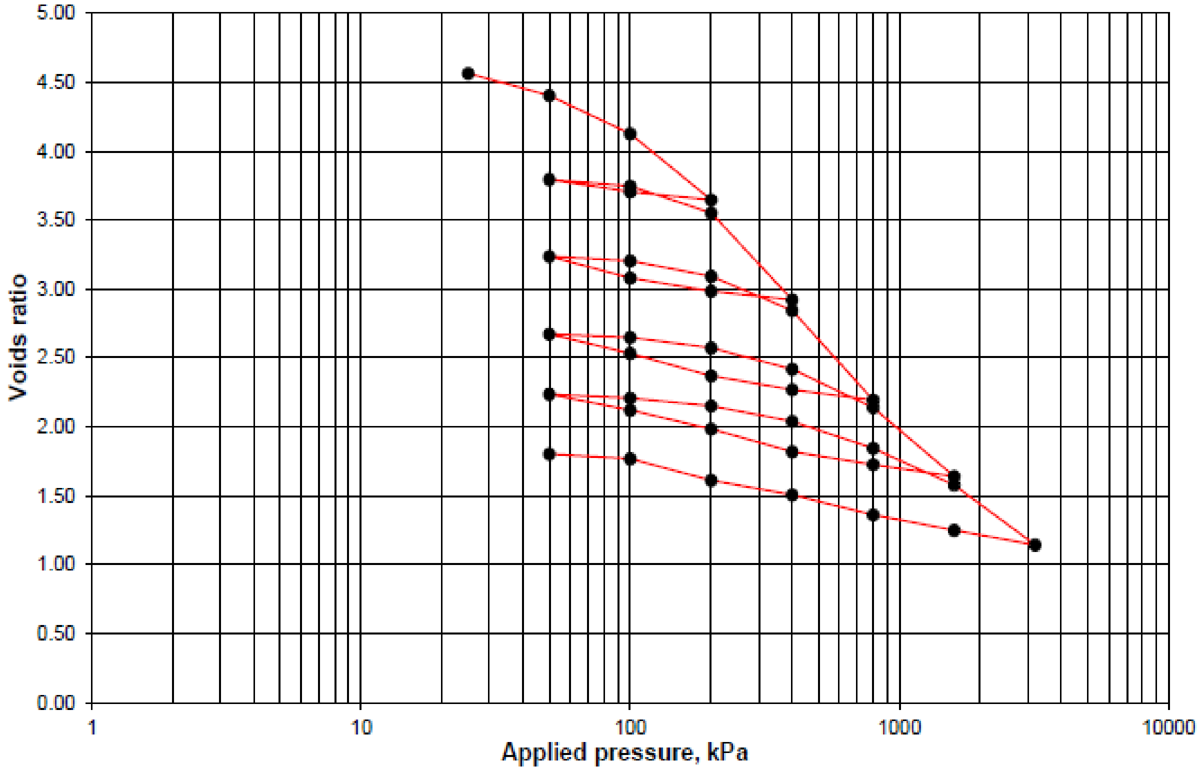

Fig.8 explain the consolidation test

Table 1, The result of the experimental work

test	**Result**	**test**	**result**
Water content	110-180%	organic matter	20-40 %
Liquid limit	140- 230%	pH	5.04 - 5.7
Plastic limit	50-80%	Cc	2.07
Specific gravity	1.51-1.57	Void Ratio	4.71
Bulk Density	0.3 - 0.5 Mg/m^3	Degree of Saturation	70-95%
ash content	10 - 40 %		

Table 2, Physical and chemical properties of peat, (Kazemian et al. ,2011)

Peat type	Natural water content (w, %)	Bulk density (Mg/m³)	Specific gravity (G_s)	Acidity (pH)	Ash content (%)	Reference
Fibrous-woody	484-909	-	-	-	17	Colley (1950)
Fibrous	850	0.95-1.03	1.1-1.8	-	-	Hanrahan (1954), Asadi et al., 2009, 2010
Peat	520	-	-	-	-	Lewis (1956)
	500-1500	0.88-1.22	1.5-1.6	-	-	Lea and Browner (1963)
Amorphous and fibrous	200-600	-	1.62	4.8-6.3	12.2-22.5	Adams (1965)
	355-425	-	1.73	6.7	15.9	
Amorphous to fibrous	850	-	1.5	-	14	Keene and Zawodniak (1968)
Fibrous	605-1290	0.87-1.04	1.41-1.7	-	4.6-15.8	Samson and LaRochell (1972), Moayedi et al.(2011a, b)
Coarse fibrous	613-886	1.04	1.5	4.1	9.4	Berry and Vickers (1975)
Fibrous sedge	350	-	-	4.3	4.8	Levesque et al. (1980)
Fibrous sphagnum	778	-	-	3.3	1	
Coarse fibrous	202-1159	1.05	1.5	4.17	14.3	Berry (1983)
Fine fibrous	660	1.05	1.58	6.9	23.9	NG and Eischen (1983)
Fine fibrous	418	1.05	1.73	6.9	9.4	
Amorphous granular	336	1.05	1.72	7.3	19.5	
Peat portage	600	0.96	1.72	7.3	19.5	Edil and Mochtar (1984)
Peat waupaca	460	0.96	1.68	6.2	15	
Fibrous peat (Middleton)	510	0.91	1.41	7	12	
Fibrous peat (Noblesville)	173-757	0.84	1.56	6.4	6.9-8.4	
Fibrous	660-1590	-	1.53-1.68	-	0.1-32.0	Lefebvre et al. (1984)
Fibrous peat	660-890	0.94-1.15	-	-	-	Olson and Mesri (1970)
Amorphous peat	200-875	1.04-1.23	-	-	-	
Peat	125-375	0	1.55-1.63	5-7	22-45	Yamaguchi et al. (1985)
Peat	419	1	1.61	-	22-45	Jones et al. (1986)
Peat	490-1250	-	1.45	-	20-33	Yamaguchi et al. (1987)
Peat	630-1200	-	1.58-1.71	-	22-35	Nakayama et al. (1990)
Peat	400-1100	0.99-1.1	1.47	4.2	5-15	Yamaguchi 1990
Fibrous	700-800	~1.00	-	-	-	Hansbo (1991)
Peat (Netherlands)	669	0.97	1.52	-	20.8	Termatt and Topolnicki (1994)
Fibrous (Middleton)	510-850	0.99-1.1	1.47-1.64	4.2	5-7	Ajlouni (2000)
Fibrous (James Bay)	1000-1340	0.85-1.02	1.37-1.55	5.3	4.1	

4- <u>PEAT DISTRIBUTION AT THE STUDY AREA.</u>

The peat covers about 70% of Kafr El-Sheikh governorate, it is distributed around the lake and extended to the south of the study area as shown in fig (9), with depth ranges from 8 to 10 m and sometimes deepen to 12 ~ 14 m from the ground surface. This layer of peat appears through soft to medium silty clay layer, where the geological formation of this area is a reason for the soil deposits. In case of it is found near the ground surface, the layer is removed and replaced by granular replacement.
the peat layer is a problem for buildings with high stress which raises the cost of their foundations to be of raft-pile system or grouting the peat layer by improving material.

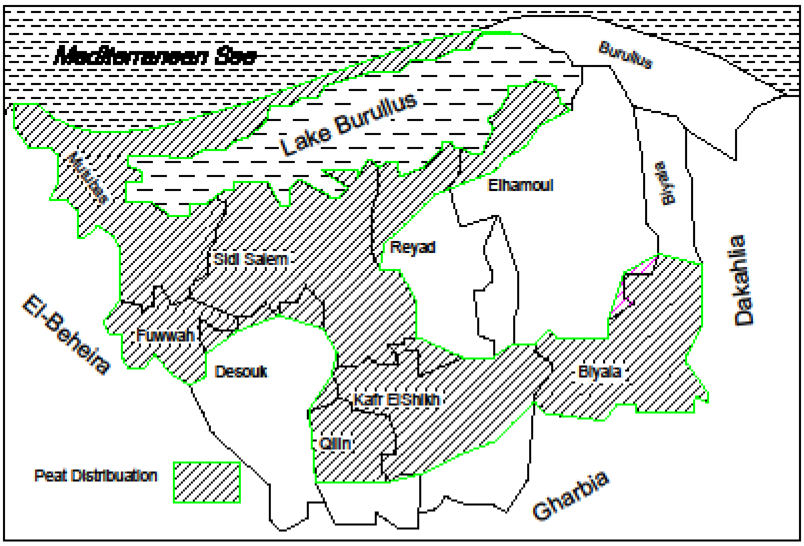

Fig.9 explain peat distribution at study area

5- CONCLUSION.

- The peat appears in Egypt at the mid and north of Delta Nile.
- The peat covers about 70% of Kafr El-Sheikh governorate's area, at depth between 8 to 10 m and sometimes between 12 to 14 m from the ground surface.
- The percentage of ash content 20-40 % and that explain the value of void ratio.
- The physical and mechanical properties of peat dependeds on the percentage of organic matters.
- The XRD system didn't identify the organic material or the fiber.
- The depth of peat layer is between 8 to 14 m which is a problem for buildings with high stress distribution which raises the cost of their foundations
- Unconventional solutions should be developed to reduce construction costs on this type of soil.

REFERENCE.

Ahmed A. Ismail, Mohamed Boukhary and Ahmed I. Abdel Naby," Subsurface stratigraphy and micropaleontology of the Neogene rocks, Nile Delta, Egypt, Geologia Croatica, Zagreb, 2010.

Azzouz, A.S., Krizek,R.J.and Corotis,R.B. (1976) Regression analysis of soil compressibility. Soil and Foundation,16(2),19-29

Barakat, M. G. (1982): "General Review of the Petroliferous Provinces of Egypt with Special Emphasis on their Geological Setting and Oil Potentialities". Research Project on the Resource Development and Policy in Egypt, Petroleum and Natural Gas, Cairo, Egypt, pp. 19-33.

Braja m. Das, Khaled Sobhan," Principles of Geotechnical Engineering, Eighth Edition, SI" Library of Congress Control Number: 2012952059,2014, PP 39-46

Ismail, A.A. (1984): Quantitative well logging analysis on some subsurface, Successions in the Nile Delta area. MS.C. Thesis, Geology Department, Faculty of Science, Ain Shams University, Cairo, Egypt, 214 p.

Kazemian, S., Prasad, A., Huat, B. B. K. and Barghchi,M, M. 2011. A state of art review of peat: Geotechnical engineering perspective. International Journal of Physical Sciences, 6(8), pp.1974–1981.

Yuanqiao Wu, Ed Chan, Joe R. Melton, and Diana L. Verseghy**,** A map of global peatland distribution created using machine learning for use in terrestrial ecosystem and earth system models, Geoscientific Model Development, Journal of the European Geosciences Union,2017-152

Von Post L.،. The Genetic System of Organogenic Formations in Sweden. Comm.Intern. Pedol., 1924 ، 22: 287-304