BRCORP
TECHNOLOGY | INNOVATION | INDUSTRY

International Journal of
Advanced Structures and Geotechnical Engineering
ISSN 2319-5347, Vol. 03, No. 04, October 2014

Foundation system adopted to construct building in and around KUET campus of the Bangladesh

MD. ASSADUZZAMAN, MD. RAFIZUL ISLAM AND MUHAMMED ALAMGIR
Department of Civil Engineering, Khulna University of Engineering and Technology (KUET), Bangladesh
Email: asad_kuet06@yahoo.com, imrafizul@yahoo.com, alamgir63@yahoo.com

Abstract: The subsoil of southwest region of bangladesh, especially in the surrounding of kuet campus that is situated in lowland topography with a very thick soft fine grained and organic soil deposits up to great depth. This paper describe the case studies of different foundation system adopted for the construction of some building in and around kuet campus. The building in this region are experienced very large amount of total and differential settlement. While constructed conventional shallow foundation, as a result constructed infrastructure lost their utility and abandoned in some cases. Geotechnical engineers have been facing such difficulties for the last few decades and rate of the construction of civil infrastructure have been increased in the recent years. Based on the field experiences and to ensure the foundation stability, different types of foundation have been practiced in kuet campus such as the construction of amar ekushy hall, rokeya hall and new academic building. Based on the reveled subsoil conditions of the study area, a general soil profile is adopted in this study. The adopted foundation system ranges from continuous brick footing to pile foundation. Considering the engineering soundness, safety of building and the cost, a foundation system associated with ground improvement using sand compaction piles and mat foundation over a compacted sand layer is proposed. Based on study, the soil is very soft and there is organic layer between two clayey layers. Sand cushion with mat foundation and another sand compaction pile with single column foundation is suitable. Normally pile foundation is suitable but pile length is high so cost is higher than other foundation. Brick foundation is not suitable for this campus and around of this campus. Special attention is needed to take care for design foundation

Keywords: *Foundation, Stabilization, Compressive Strength, Laboratory, Additives and Capacity*

1. Introduction:

Three mighty rivers the Gangas, the Brahamaputra and the Meghna and their associated tributaries contributed very much in the formation of sub soil profiles of Bangladesh which is situated in the in Bengal Basin. The South- West costal region of Bangladesh contains fine grain soil deposits with the presence of organic soil deposits with the presence of organics is due to the fact that vast of these coast regions were part of the Sundarbans, the world largest mangrove forest extends over an area 5,77,285 hactares as recorded (Razzaque and Alamgir 1999). During the geological changes in the past, some part of the Sundarbans were submerged by the weathered and sediment deposits resulting in the present peat deposits in these region. In this region peat soil is found in different layer and in different depth. Also this soil has low bearing capacity below the peat layer. For that purpose all infrastructure are settled by large amount. Due to this inherent limitation the foundation system for the construction of civil infrastructure is designed special consideration and very carefully, which leads to high cost for the preparation of sub structure in this region of Bangladesh.Bangladesh is a deltaic land, which is formed by the lower reaches of the Brahamaputra, the eastern channel of the Ganges, the Meghna and their associated tributaries. **K**hulna University of Engineering & Technology (KUET), located in the south western region of Bangladesh. The campus situated in a lowland topography with a very thick soft and organic soil deposits up to great depth. Many years ago it was the part of the biggest mangrove forest Sundarban. In course of time some part of Sundarban were submerged by sediment deposits resulting in the present peat layer in this region. Several new building have been and or are being constructed such a New Academic Building , Amar Ekushy Hall , Rokeya Hall in which different types of foundation system are considered based on the sub soil profiles , building types , purpose and the consultant preference. The selected ten constructed building of the region depicts that four different types foundation are used such that Mat foundation, Pile foundation, wall footing, Single column footing.

The performance of the constructed buildings are evaluated and hence discussed in this paper.Bore logs and soil profile are parts of sub soil exploration, based on which the foundation is designed. To know the nature of soil below the proposed building exactly and specially with their entire physical, chemical, and engineering properties, the sub soil exploration is done on the site. Such an exploration program is done after gathering all preliminary information such that available information, Reconnaissance, Building code requirements and Preliminary design data. Then a tentative exploration program is worked out and samples are collected at different layer so that the samples can be tested at laboratory to get different parameter.

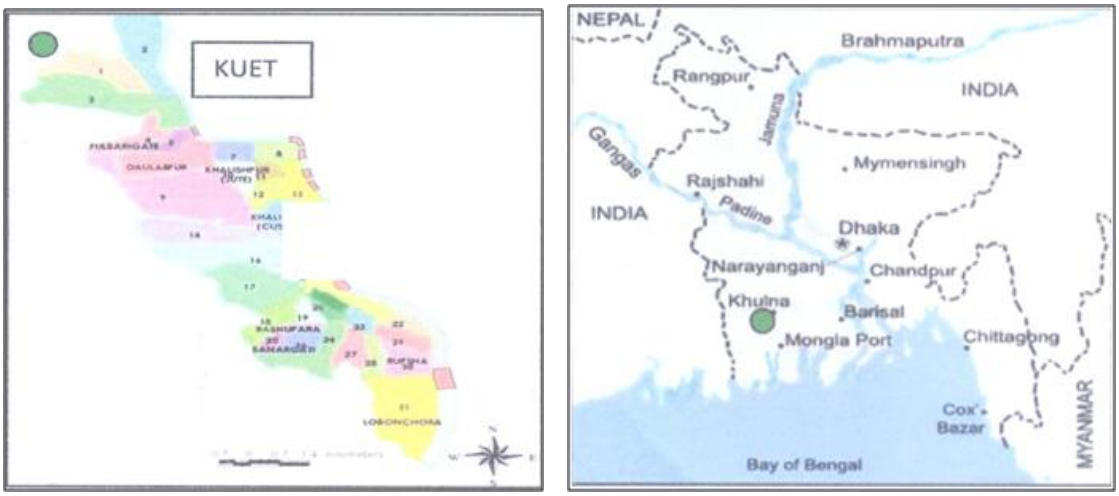


Figure 1: Location of Khulna University of Engineering & Technology (KUET) campus in Bangladesh map and the map of Khulna City

On the soil profile, the ground water table, existing construction, and the proposed structure should be also be indicated. It also be helpful if the essential engineering data, such as the standard penetration resistance, unconfined compressive strength. The arrangement of various soil layer can be best shown in the form of a geologic profile or soil profile. A geologic profile is a graphical representation of underground condition along a given line on the ground surface. In order to clearly show the various soil layers, the vertical scale is usually made large than horizontal scale. A soil profile is simple to construct.

First all boring along the profile are represented along vertical lines, with the spacing of boring drawn to conventional horizontal scale. Along each boring, the separate soil layers are shown at the correct elevations and are clearly identified. The boundaries between identical soil layers are connected to indicate the most likely at stratification. The reliability of a geologic profile as compared to the actual soil condition depends upon the nature of the ground and spacing of the boring. If the soil conditions are erratic, the arrangement of various layers between the boring may differ considerably from the interpolation. On the soil profile, the ground water level, existing construction proposed construction should also be indicated. It also helpful, if the essential engineering data, such as the standard penetration test value, unconfined compressive strength, etc are indicated profile. The main focus of this study formulated as, (1) To Know the foundation system adopted in different building; (2) To know the sub soil condition on which the building are constructed; (3) To prepare a general soil profile of our study site; (4) To justify the suitability of the foundation which could be used in different site; (5) To make the settlement calculation; (6) To analysis the foundation based on cost benefit ratio.

2. Materials and methodology:

To these attempts, 10 Nos. different types building that are situated in and outside of KUET campus are selected in this study. Soil boring are performed to know the classification of soil, N-value at different layer and Engineering properties such as unconfined compressive strength (q_u), liquid limit value(W_L), plastic limit value(W_P) and Cc value. In this study 10 different building is consider as a study materials that diagram and position are shown in Figure.2

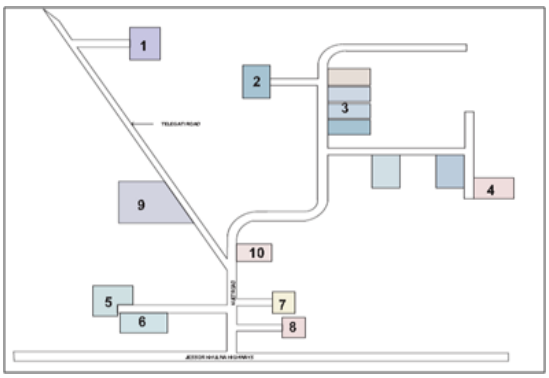


Figure 2: Building location in our study

1. Mohilla TTC
2. Amar Ehushey Hall
3. New Academic Building
4. Rokeya Hall
5. Teacher's Building
6. Moittre Naursing home
7. Fresh Clinic
8. Adjacent building of fresh clinic
9. Building beyond khan jahan ali Hall
10. Suktara Building

Four types of foundation are used in ten different building that are mat foundation, pile foundation, wall footing and single column footing. Mat foundation are used in Amar Ekushey Hall, Sand pile are used in new Academic Building, Rokeya Hall, Moitre Nursing Home, Fresh clinic and building near Fresh Clinic, Mohila Training center and wall footing are used in suktara and bulding behind Khan Jahan Ali Hall. On the basis of soil boring, a soil profile are formed at different preselected building that are given below.

2.1 Soil profile of new academic building, KUET

The profile shows the soil characteristics up to 15m depth. The three storied building is use a academic purpose of KUET.

Table 1: Typical soil profile of New Academic Building, KUET

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Gray clay with organic	5	C_c= 0.16, Gs= 2.68, q_u=67kPa, W= 51%, W_L=48% & W_P= 42%
3-6	3		Dark gray clay with trace organic	6	q_u=28kPa, W= 66%, W_L=59% & W_p= 57%
6-15	9		Dark gray with silty clay	9	W= 53%, W_L=57% & W_p= 73%

2.2 Soil profile of Rokeya hall, KUET

The profile shows the soil characteristics up to 15m depth. The three storied building is use as a student's Hall.

Table 2: Typical soil profile of Rokeya Hall, KUET

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Gray clay with organic	4	q_u=28kPa, W=53%, W_L=58% & W_P= 42%
3-6	3		Dark gray clay with trace organic	8	q_u=29kPa, W= 53%, W_L=47% & W_p= 59%
6-15	9		Dark gray with silty clay	9	W= 53%, W_L=54% & W_p= 72%

2.3 Soil profile of amar ekushya hall, KUET

The profile shows the soil characteristics up to 15m depth. The five storied building is use as a student's Hall

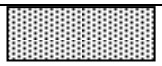
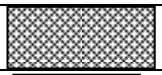
Table 3: Typical soil profile of Amar Ekushya Hall, KUET

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		rganic clay , dark gray	5	C_c= 0.16, Gs= 2.72,q_u=67kPa, W=58%, W_L=50% & W_P= 42%
3-6	3		lty clay with composed timber, dark Gray	7	W_p= 61%
6-15	9		Dark gray with silty clay	9	W= 52%, W_L=57% & W_p= 67%

2.4 Soil profile of mohilla technical training center

The profile shows the soil characteristics up to 15m depth. The three storied building is use as a office and classroom.

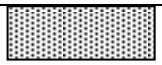
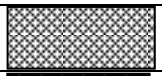
Table 4: Typical soil profile Mohilla Technical Training Center

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Clay silt with gray	5	C_c= 0.15, Gs= 2.71, q_u=55kPa W=38%, W_L=42% & W_P= 30%
3-6	3		Organic clay with dark gray	8	Gs= 2.69, W=63%, q_u=36kPa W_L=49% & W_p= 64%
6-15	9		Silty clay with gray	9	C_c=0.24,Gs=2.67,q_u=79kPa, W= 53%, W_L=45% & W_p= 77%

2.5 Soil profile of maitre nursing home, Fulbarigate:

The profile shows the soil characteristics up to 15m depth. The three storied building is use as a hospital.

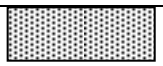
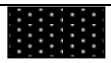
Table 5: Typical soil profile Maitre Nursing Home, Fulbarigate

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Clay silt with gray	5	C_c= 0.15, Gs= 2.71, q_u=55kPa W=48%, W_L=62% & W_P= 45%
3-6	3		Organic clay with dark gray	8	Gs= 2.72, W=64%, q_u=37kPa, W_L=55% & W_p= 55%
6-15	9		Silty clay with gray	9	C_c=0.17,Gs=2.67,q_u=75kPa, W= 60% & W_L=58%

2.6 Soil profile of near maitre nursing home, Fulbarigate

The profile shows the soil characteristics up to 15m depth. The four storied building is use as a residential building.

Table 6: Typical soil profile near maitre nursing home, Fulbarigate

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Dark gray with silty clay	5	C_c= 0.168, Gs= 2.67, q_u=67kPa, W=46%, W_L=55% & W_P= 45%
3-6	3		Dark gray with organic	6	Gs= 2.68, W=59%, W_L=55% & W_p= 74%
6-15	9		Dark gray with silty clay	5	Gs= 2.67,W= 58% & W_p= 70%

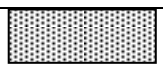
2.7 Soil profile of fresh clinic, fulbarigate

The profile shows the soil characteristics up to 15m depth. The five storied building is use as a clinic

2.8 Soil profile of adjacent building fresh clinic, Fulbarigate :

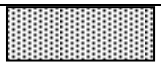
The profile shows the soil characteristics up to 15m depth. The five storied building is use as a residential building

Table 8: Typical soil profile of adjacent building of fresh clinic, Fulbarigate

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Clay silt with gray	4	Gs= 2.71, q_u=55kPa, W=52%, W_L=59% & W_P= 60%
3-6	3		Organic black	6	C_c= 0.51, Gs= 2.72, W=64%, q_u=39kPa, W_L=64% & W_p= 65%
6-15	9		Clayey silt with gray	7	C_c=0.19,Gs=2.71,q_u=87kPa, W= 57%, W_L=52% & W_p= 61%

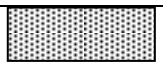
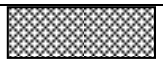
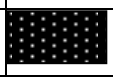
2.9 Soil profile of building behind khan jahan ali hall :
The profile shows the soil characteristics up to 15m depth. The for storied building is use as a residential building

Table 9: Typical soil profile of building behind khan jahan ali hall

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Clay silt with trace	4	C_c= 0.12, Gs= 2.68, q_u=61kPa W=47%, W_L=56% & W_P= 60%
3-6	3		Organic black	7	C_c= 0.52, Gs= 2.68, W=56%, q_u=39kPa, W_L=64% & W_p= 57%
6-15	9		Silty clay with gray	9	C_c=0.11,Gs=2.67,q_u=86kPa, W= 52%, W_L=58% & W_p= 79%

2.10 Soil profile of building suktara near khan jahan ali hall :
The profile shows the soil characteristics up to 15m depth. The four storied building is use as a residential building.

Table 10: Typical soil profile of building suktara near khan jahan ali hall

Depth (m)	Thickness (m)	Strata	Classification of soil	N-Value	Engineering Properties
0-3	3		Dark gray with silty clay	5	C_c= 0.168, Gs= 2.68,W=52%, W_L=58% & W_P= 48%
3-6	3		Dark gray with silty clay	8	Gs= 2.69, W=63%, W_L=49% & W_p= 64%
6-15	9		Dark gray with silty clay	9	C_c=0.168,Gs=2.66,W= 60%, W_L=58% & W_p= 74%

3. Result and discussions:
In south –West region of Bangladesh, civil infrastructure suffers for very large amount differential settlement. In general soil profile, it is seen that there is an organic layer between two clay layers. The organic layers is very much compressed and eventually contributes in large settlement secondary consolidation. If mat foundation is used then excessive settlement occure. In this case pile may be used. But due to the presence of organic layer, there is a possibility of negative skin friction. To reduce this negative skin friction, it is necessary to increase the diameter and length of pile foundation. Which requires excessive cost, so ground improvement can be a good alternative to solve geotechnical engineering problem. Sand compaction pile with a granular soil layer over it can be simplest ground improvement techniques. So after ground improvement mat foundation may be provided to get the best service. Although use of pile foundation is safe for the super structure but other type of foundation were used for low cost. Sometimes ground improvement was done to improve the geotechnical engineering properties of the soil. In this case geo-textile method was used to improve the ground condition. Pile foundation is used when the super structure with the water even with large number of piles neither the necessary compression nor sufficient friction can be obtained and farmer layers exists only at a depth which is unreachable , a heavy building can safely founded by sinking it partly into the ground so that it actually float.

4. Conclusions:
- Large settlement occurs at the building while Mat foundation is used without soil improvement
- In our study site, the soil is very soft and there is organic layer between two clayey layers
- Two type of foundation is recommended for the study site. One is sand cushion with mat foundation and another is sand compaction pile with single column footing.
- Normally pile foundation is suitable because it is less or zero settlement. But it pile length is high so cost is higher to the other foundation
- Brick foundation is not suitable for this campus
- Special attention to take care for design of foundation in South-West region of the Bangladesh

References:
[1] Bureue of research, testing and consultancy (BRTC). (1988). "Soil investigation and constructing building foundation report of proposed Khulna University of selected Gollamary Area". Department of Civil Engineering, Bangladesh University of

Engineering and Technology.Associates limited, (1992). "Consultants reports about the design and construction of academic building - 1 at Khulna University". Khulna, Bangladesh

[2] Shaheedullah Associate Limited, (1992). "Consultants reports about the design and construction of academic building -1 at Khulna University". Khulna, Bangladesh

[3] Mukherjee, B.B.(1992). "Quaternary pollen analysis as a possible indicator of prehistoric agriculture in the deltaic part of west bangle". J. Playnol, Vol. 8: 144-151

[4] Sen, P. and Bananerjee, M. (1984). "On the occurrence of reptilian remnants in the peat bed of Barrackpore. 24-Parganas, West Bengal" Paleobot. Soc. Ind. Vol.29:47-51

[5] Vishnu Mitre and Gupta, H. P. (1972). "Pollen analysis study of quaternary deposit in the Bangla" Basin. Paleobotanist. vol.19: 297-306

[6] Razzaque, M.A and Alamgir, M. (1999). "Long term settlement observation of a building in a peat deposits of Bangladesh" International Conference on Civil & Environmental Engineering- New Frontiers and Challenges. Bangkok. Vol.2: III-85 to IV-94