THE MANAGEMENT OF SINDH MADRESSATUL ISLAM UNIVERSITY

R E P O R T
O N
GEOTECHNICAL INVESTIGATION
FOR
SINDH MADRESSATUL ISLAM UNIVERSITY
EDUCATION CITY PHASE-1
MALIR, KARACHI

AUGUST, 2018

Consultants:
EA Consulting (Pvt) Limited

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A P P E N D I X

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1. INTRODUCTION:

The Management of Sindh Madressatul Islam University has embarked on the development of SMIU, Education City Phase-1, Malir, Karachi. This report deals with the geotechnical investigation on proposed University Campus.

M/s EA Consulting (Pvt.) Limited are providing consultancy services for the project

In order to obtain geotechnical information for the design of foundations, it was considered necessary to carry out subsoil investigation at the project site. '*Geotechnical Services*' were assigned the job of subsoil investigation. The report was prepared in August, 2018.

The program of investigation comprised of drilling twenty one boreholes varying in depth from 10-25 m. In addition to boreholes, six test pits were manually excavated 0.30-1.20 m depth.

In order to ascertain the degree of compactness / consistency of substrata, standard penetration tests (SPTs) were performed at various depth horizon wherever found feasible. Moreover core samples were extracted using double tube core barrel.

Selected soil samples were sent to the laboratory of 'Geotechnical Services' Karachi, for the evaluation of geo-engineering characteristics.

This report presents a review of subsoil investigation performed at the project site. The field and laboratory test data has been analyzed for the evaluation of allowable bearing pressure. The recommendations regarding the type and bearing capacity of foundations are incorporated in the report. The report also presents CBR values for the design of road pavements.

The report also incorporates borehole and testpit location plan, borelogs, pitlogs, field/laboratory test results and photographs.

2. PROGRAM OF INVESTIGATION:

2.1 Detail of Boreholes:

The program of subsurface investigation at the project site consisted of drilling twenty one boreholes.

Following table present detail of borehole:

Table 2.1

Detail of Boreholes

Boring No.	Location	Depth (m)
BH-1	Banks / Public Relation Office / Admission DESK (External Development)	10.0
BH-2	Faculty Block-1 Management Business Administration & Commerce	10.0
BH-3	-do-	15.0
BH-4	-do-	10.0
BH-5	Faculty Block-2 Computer Sciences	10.0
BH-6	-do-	25.0
BH-7	-do-	10.0
BH-8	Main Library Common Facilities	15.0
BH-9	-do-	10.0
BH-10	Administration Building	10.0
BH-11	Students Welfare Centre	10.0
BH-12	VC House	10.0
BH-13	Faculty & Staff Apartment	15.0
BH-14	-do-	10.0
BH-15	-do-	10.0
BH-16	Staff Houses	10.0
BH-17	-do-	15.0
BH-18	Faculty Hostel Female	10.0
BH-19	Faculty Hostel Male	15.0
BH-20	Students Hostel Female	15.0
BH-21	Students Hostel Male	10.0

The locations of these boreholes are shown on borehole location plan appended to this report.

2.2 Drilling:

The boring was accomplished by rotary/wash method. Rock core drilling was carried out using double tube core barrel in conjunction with tungsten carbide bit. After each run of the core barrel, percent core recovery and rock quality designation (RQD) were determined. The cores were stored in wooden core boxes. Wooden markers indicating depth and run numbers were inserted between each core run. The core boxes were, then, transported to the laboratory for testing. Some of the cores were sealed with molten wax and treated as undisturbed samples.

2.3 Standard Penetration Test:

Standard penetration tests (SPTs) were performed at various depth horizons wherever found feasible. These tests were performed in accordance with ASTM Designation D-1586. This test gives indication of degree of compactness/consistency of granular/cohesive substrata. The 'N'-values are shown on borelogs appended to this report.

Disturbed samples were obtained through split spoon sampler used in the standard penetration tests. These samples were carefully examined to identify the soil types at various depths. The samples were placed in plastic containers, marked with borehole number, depth and subsequently, dispatched to the laboratory.

2.4 Testpits:

In addition to boreholes, six test pits were manually excavated upto 0.30-1.20 m depth. Bulk samples were collected from testpits. Field density tests (AASHTO T-191) were performed in each testpit.

It must be noted that TP-2, TP-3, TP-4, TP-9 & TP-11 have not been excavated due to presence of hard limestone deposit at top.

2.5 Laboratory Testing:

In order to arrive at a rational evaluation of the geotechnical properties of the substrata, a program of laboratory testing was undertaken in the laboratory of Geotechnical Services.

Following physical and chemical tests were performed on representative soil samples:

- Grain size analysis
- Atterberg Limits
- Moisture Content
- Unconfined Compression
- Bulk Density
- Swell Potential
- Total Salts
- Sulphate content
- Chloride content
- pH value

Following laboratory tests was performed on bulk samples extracted from testpits.

• Sieve Analysis	AASHTO T-80
• Liquid Limit, Plastic Limit	AASHTO T-90
• Moisture-Density Relationship (Modified AASHTO	AASHTO T-180
• Three Point CBR (Soaked)	AASHTO T-193

The results of laboratory tests are appended to this report.

3. SUBSURFACE CHARACTERISTICS:

The stratigraphy and the subsurface conditions have been evaluated on the basis of boring logs supported by field and laboratory test results. The subsurface investigation has revealed that, to some extent, there is variation in stratification both in the horizontal and vertical directions. Subsurface characteristics have been discussed separately.

In some boreholes, subsurface investigation has revealed that top 2.0-6.0m consist of hard LIMESTONE / calcareous SANDSTONE. This is underlain by hard, sandy SHALE and very dense, silty SAND / sandy SILT that extends upto the investigated depth of 25.0 m.

In boreholes BH-13, BH-14, BH-19, BH-20 & BH-21, study of these borelogs show that that top substrata comprise of very stiff to hard, clayey SILT / sandy SHALE. Swell potential tests show that the cohesive deposits (silty CLAY / SHALE) possess low to medium swell potential. This is followed by hard, LIMESTONE and very dense, silty SAND that continues upto the depth of 15.0 m.

Major subsurface deposits can be described as follows:

- Brown, medium to dense, medium to coarse SAND, some silt
- Yellowish brown, hard, LIMESTONE pieces
- Brown, very stiff, sandy CLAY / clayey SAND
- Brown, stiff to hard, clayey SILT
- Brown, friable, SANDSTONE

The exact sequence of occurrence of these deposits is shown on boreholes appended to this report.

Ground water table was not encountered upto the investigated depth of 25.0 m below existing ground level.

4. FOUNDATION RECOMMENDATIONS:

4.1 General:

Foundation is a structural member that supports the loads of a structure and distributes them over the substrata on which it rests. In order to be satisfactory, the foundation should satisfy the following requirements:

a) The foundation must be safe against the possibility of shear failure

b) The foundation must not undergo excessive differential settlement

Calculations have been made to check allowable soil pressure for both the shear and settlement criteria.

Keeping in view the stratigraphy of the area and field and laboratory test results, the allowable pressures have been computed.

4.2 Foundation Type:

The choice about the foundation type has been made on the basis of geotechnical properties of the substrata, type of structure and anticipated loading conditions.

Taking into account the subsoil condition and structural loads, it is recommended that proposed structures be supported on **isolated footing**.

4.3 Allowable Bearing Capacity

Following Table presents allowable bearing capacity of isolated footing for each structure separately.

Allowable Bearing Capacity of Isolated Footing

Structure	Borehole No.	Depth (m)	Bearing Stratum	Allowable Bearing Capacity (tsf)
Banks / Public Relation Office / Admission DESK (External Development)	BH-1	1.0	LIMESTONE	3.0
Faculty Block-1 Management Business Administration & Commerce	BH-2, 3, 4	1.0	LIMESTONE	3.0
Faculty Block-2 Computer Sciences	BH-5, 6, 7	1.0	LIMESTONE	3.0
Main Library Common Facilities	BH-8, 9	1.0	LIMESTONE	3.0
Administration Building	BH-10	1.0	LIMESTONE	3.0
Students Welfare Centre	BH-11	1.0	LIMESTONE	3.0
VC House	BH-12	1.0	LIMESTONE	3.0
Faculty & Staff Apartment	BH-13, 14, 15	1.50	Sandy SHALE*	2.0
Staff Houses	BH-16, 17	1.0	LIMESTONE	3.0
Faculty Hostel Female	BH-18	1.0	LIMESTONE	3.0
Faculty Hostel Male	BH-19	1.50	Sandy SHALE*	2.0
Students Hostel Female	BH-20	1.50	Sandy SHALE*	2.0
Students Hostel Male	BH-21	1.50	Sandy SHALE*	2.0

*** The swell potential results demonstrate that shale deposit possesses low to medium swell potential. Hence, certain precautions must be adopted against the possibility of volume changes in the soil. These precautions have been discussed in paras 4.4 & 4.5 of the report**

It is important to note that before placing foundation concrete the excavations should be carefully inspected to ensure that foundations are being placed in competent soil. This precaution is necessary to guard against localized fills and inhomogenities

4.4 Minimum Foundation Pressure:

In boreholes BH-13, BH-14, BH-19, BH-20 & BH-21, study of these borelogs show that that top substrata comprise of very stiff to hard, clayey SILT / sandy SHALE. This SHALE deposit possesses low to medium swell potential.

Hence, while proportioning footings, it must be ensured that minimum foundation pressure resulting from dead load should not be less than 1.25 ton/ft^2. This can be achieved by increasing spans where found necessary. This precaution is necessary to neutralize uplift due to swelling action of shale.

4.5 Further Precautions Against Swelling:

1. In order to protect the walls from damage due to swelling action of shale, plinth beams should be kept 4" clear of the ground and should be supported on columns. The space between plinth beam and the ground should be filled with collapsible formwork of cardboard or some other similar material upon which the concrete could be formed but which crushes at loads only slightly greater than the weight of wet concrete.

2. Surface drainage should be carefully designed. It should be ensured that water does not accumulate in the vicinity of the structure and is disposed off promptly through the drains.

4.6 Seismic Coefficients:

According to the Uniform Building Code (1997), the soil profile falls in 'S_C' category corresponding to 'very dense, soil & soft rock'.

Following table gives seismic zone, seismic zone factor, soil profile type and seismic coefficients.

Seismic zone	Zone factor 'z'	Soil profile Type	Seismic Coefficient 'Ca'	Seismic Coefficient 'Cv'
2B	0.20	' S_C'	0.24	0.32

4.7 Cement Type:

American Concrete Institute (ACI) gives the requirements for concrete exposed to sulphate (SO_4) containing solutions. The ACI standards are given below:

Sulphate Exposure	Water Soluble Sulphate in Soil (%)	Sulphate in Water (mg/lit)	Cement Type
Negligible	0.00-0.10	0-150	OPC
Moderate	0.10-0.20	150-1500	Type II
Severe	0.20-2.00	1500-10000	Type V
Very Severe	Over 2.00	Over 10000	Type V plus pozzolan

Sulphate content in subsoil has been found to be negligible. It is therefore recommended that Ordinary Portland Cement (OPC) be used in concrete in contact with soil.

5. TESTPITS INVESTIGATION:

5.1 Details of Testpits

The program of investigation at the road site consisted of manually excavated six test pits. Testpit were excavated upto 0.30-1.20 m depth below existing ground level

Table 5.1 gives details of test pits:

T A B L E 5.1
DETAILS OF TEST PITS

Pit No	Co-ordinates		Investigated Depth (m)
TP-1	E=338902	N=2765320	0.30
TP-2*	E=339167	N=2765569	-
TP-3*	E=339430	N=2765995	-
TP-4*	E=339505	N=2765755	-
TP-5	E=339463	N=2765557	1.00
TP-6	E=339251	N=2765262	0.70
TP-7	E=339025	N=2765063	1.20
TP-8	E=339211	N=2765063	0.60
TP-9*	E=339281	N=2764966	-
TP-10	E=339349	N=2765019	0.95
TP-11*	E=339663	N=2765314	-

***It must be noted that TP-2, TP-3, TP-4, TP-9 & TP-11 have not been excavated due to presence of hard limestone deposit at top.**

Bulk samples were collected from testpits. Field density test was performed in testpits varying in depth from 0.3 -1.20 m. This test was performed using the sand replacement method as per AASHTO T-191. Bulk samples were extracted from tests pits for performing classification, compaction and CBR tests. These samples were transported to the laboratory of Geotechnical Services, Karachi.

Following laboratory tests was performed on bulk samples.

- Sieve Analysis AASHTO T-80
- Liquid Limit, Plastic Limit AASHTO T-90
- Moisture-Density Relationship (Modified AASHTO AASHTO T-180
- Three Point CBR (Soaked) AASHTO T-193

The results of laboratory tests are appended to this report.

5.2 Classification:

These comprised the performance of particle size analysis and Atterberg limits (liquid & plastic limits) on subgrade samples.

Table 5.2 gives classification of subgrade as per AASHTO on the basis of particle size analysis and Atterberg limits.

T A B L E 5.2

CLASSIFICATION OF SUBGRADE

Pit No	Description	AASHTO Classification
TP-1	Brown, sandy GRAVEL / gravelly SAND	A-1-b
TP-5	Brown, sandy GRAVEL	A-2-4
TP-6	Brown, silty, fine to medium, SAND	A-4
TP-7	Brown, silty / clayey, fine SAND	A-4
TP-8	Brown, silty fine SAND	A-4
TP-10	Brown, sandy GRAVEL	A-2-4

5.3 Field Density & Compaction:

Field density tests were conducted on subgrade material as per AASHTO T-191. Table 5.3 gives summary of field density and moisture-density test results along with in-situ degree of compaction as compared to maximum dry density. It is seen that the degree of compaction varies from 76.88 to 85.20 %.

T A B L E 5.3

FIELD DENSITY & COMPACTION

Pit No	Depth (m)	Field Dry Density (gm/cc)	Maximum Dry Density (gm/cc)	In Situ Degree of Compaction (%)
TP-1	0.0-0.30	1.689	2.088	80.89
TP-5	0.0-1.00	1.686	2.080	81.06
TP-6	0.0-0.70	1.743	2.080	83.80
TP-7	0.0-1.20	1.721	2.020	85.20
TP-8	0.0-0.60	1.711	2.020	84.70
TP-10	0.0-0.95	1.476	1.920	76.88

5.4 California Bearing Ratio (CBR):

Three point soaked CBR tests were performed on the 06 subgrade bulk samples. Table 5.4 gives details of compaction and CBR tests. The CBR values are being presented for 95% maximum dry density range between 14.12 and 45.38 %.

T A B L E 5.4

COMPACTION / CBR TEST RESULTS

Pit No	Classification	Max Dry Density (gm/cc)	CBR @ 95% MDD (%)	CBR @ 98% MDD (%)
TP-1	A-1-b	2.088	45.38	47.46
TP-5	A-2-4	2.080	33.92	35.62
TP-6	A-4	2.080	14.12	14.84
TP-7	A-4	2.020	21.72	22.68
TP-8	A-4	2.020	16.15	16.66
TP-10	A-2-4	1.920	29.85	31.45

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For GEOTECHNICAL SERVICES

SAIF AHMED SAEED, P.E.
B.E. (Civil), M.Engg. (AIT)
AMASCE, MIE Consult/882

C E R T I F I C A T E

This is to certify that I, Saif Ahmed Saeed, am submitting the soil investigation report for Sindh Madressatul Islam University (SMIU), Education City Phase-1, Malir, Karachi which has been carried out under my guidance and supervision. The recommended bearing capacity is given on page 6 and summarized below:

Allowable Bearing Capacity of Isolated Footing

Structure	Borehole No.	Depth (m)	Bearing Stratum	Allowable Bearing Capacity, tsf
Banks / Public Relation Office / Admission DESK (External Development)	BH-1	1.0	LIMESTONE	3.0
Faculty Block-1 Management Business Administration & Commerce	BH-2, 3, 4	1.0	LIMESTONE	3.0
Faculty Block-2 Computer Sciences	BH-5, 6, 7	1.0	LIMESTONE	3.0
Main Library Common Facilities	BH-8, 9	1.0	LIMESTONE	3.0
Administration Building	BH-10	1.0	LIMESTONE	3.0
Students Welfare Centre	BH-11	1.0	LIMESTONE	3.0
VC House	BH-12	1.0	LIMESTONE	3.0
Faculty & Staff Apartment	BH-13, 14, 15	1.50	Sandy SHALE	2.0
Staff Houses	BH-16, 17	1.0	LIMESTONE	3.0
Faculty Hostel Female	BH-18	1.0	LIMESTONE	3.0
Faculty Hostel Male	BH-19	1.50	Sandy SHALE	2.0
Students Hostel Female	BH-20	1.50	Sandy SHALE	2.0
Students Hostel Male	BH-21	1.50	Sandy SHALE	2.0

I certify that following conditions have been observed while performing the entire soil investigation:

1. I was present at site from 06.07.18 to 17.07.18 when field work of the subsoil investigation was in progress on above site.
2. The representative of subsoil testing laboratory Mr. Jam Miral was present at site to obtain the soil samples for laboratory testing purposes.
3. Books and references considered while giving the final recommendations are listed in the appendix of the report.
4. The borelog results are in conformity with and correlated to laboratory results.

SAIF AHMED SAEED
GEOTECHNICAL ENGINEER
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