Assessment Of Variation In Soil Parameters, For Design Of Lightly Loaded Structural Foundations

Muhammad Usman Arshid [1], Faisal Shabbir [1], Jawad Hussain [1],Ayub Elahi [1], Afaq Ahmed [1], Imran Khan Tahir [2]

[1] Department of Civil Engineering, University of Engineering and Technology Taxila, Pakistan.
[2]Assistant Manager, Telenor Pakistan Pvt. Ltd.

ABSTRACT: Assessment of variation in soil parameter is required to proceed for structural design of foundations. This study aims to develop the zoning of the project area on the bases of extensive experimental work in laboratory and field tests performed at the number of locations of the project area. The zones are developed based on similar characteristics of different soil parameters. The data points have been marked on the base map of the study area along with the boundaries of the zones. The experimental data of the study area has shown potential for development of three zones. The subsurface soils in zone A consist of low plastic fill material up to 2.0 m depth overlaying low plastic clay from 2.0 m to 4.0 m and low plastic clay/clayey silt beyond 4.0 m depth. Zone B consists of low plastic clay and clayey silt up to the depth of 4. meter overlaying clayey silt to silt with sand material from 4.0 m to 6 m depths and gravel with sand beyond 6.0 meter depth. In zone C, low plastic clay/clayey silt is found up to 2.0 m depth overlaying silty sand up to 4.0 m depth and gravel with sand beyond 4.0 m depth. Number of blows (N Value) of standard penetration test (SPT) for Zone A is less than 8, for Zone B, it ranges from 8-15 and for Zone C, N value is greater than 15. The resultant data can be helpful during planning stage of the project and during feasibility study of mega projects. The research work is extendable to develop the geotechnical zoning map of any specific area and it can be part of building code.

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KEYWORDS: Soil parameters, Geotechnical zoning, Structural design, Standard penetration tests

1. INTRODUCTION

The study area lies between 72°45′ and 73°30′ Easting and 33°30′ and 33°50′ Northing in the foot of Margalla hills. The region has historically been a part of the crossroads of Punjab and Khyber Pakhtunkhwa with the Margalla Pass acting as the gateway between the two regions. Rapid growth of population in the study area has made ever-increasing demands on natural resources and Potential problems for administration authorities are i) conversion of forest to residential areas ii) draw down of ground water table iii) improper solid waste disposal iv) availability of geological materials for construction v) instability of slopes vi) environmental and surface water pollution and potential subsidence of building foundations caused by instability of loess. The development of Geotechnical maps is a relatively new concept but it has gained considerable recognition within short period of its introduction. Integration of geotechnical database with the Geographical information systems has boosted its recognition.

The resultant data can be helpful during planning stage of the project and during feasibility study of mega projects. The research work is extendable to develop the geotechnical zoning map of any specific area and it can be part of building code.

Geology

The study area has wide variation in terrain; the elevation difference reaches upto 1175 m, as the plain area is surrounded by mountains of Margalla hills, Kala Chitta, outer and lower Himalayas ranges. There are many ridges reaching height of 1600 m containing complexly thrusted, folded shales and Eocene limestones these are generally overturned.

The process of collision initiated 20 million years ago approximately; between the Eurasian and Pak-India tectonic plates; is the key factor of the geology of the study area. The complex stratigraphy and geological structure produced due the said collision, has attracted many of the international and local geologists to study the behavior of the terrain. Geological Survey of Pakistan has done extensive work to produce geological maps of the region. The map showing the geological features of the study area, extracted from the Geological map developed by geological survey of Pakistan is shown in Figure 1.

Seismicity

The study area has gone through frequent folding, faulting, series of earthquakes in the past; hence there has been considerable tectonic activity during the recent geologic era. Deformed quaternary deposits are found in the study area due to the extensive tectonic activity. In A.D. 25, an earthquake estimated of intensity IX destroyed the ancient city of

Taxila, 25 km from the study area. More recently, a Richter magnitude 5.8 earthquake on February 14, 1977, centered 7 km northeast of Rawalpindi, caused damage indicating Modified Mercalli intensity VII near the epicenter (Adhami and others, 1980) and on October 8,2005, a massive earthquake jolted the northern part of Pakistan and Azad Jammu and Kashmir, this earth also caused the collapse of a residential plaza in the study area.

For sensitive structures, site-specific designs are required that take into account the strength of the underlying soil and bedrock and the distance from probable earthquake sources (Adhami and others, 1980, p. 137).

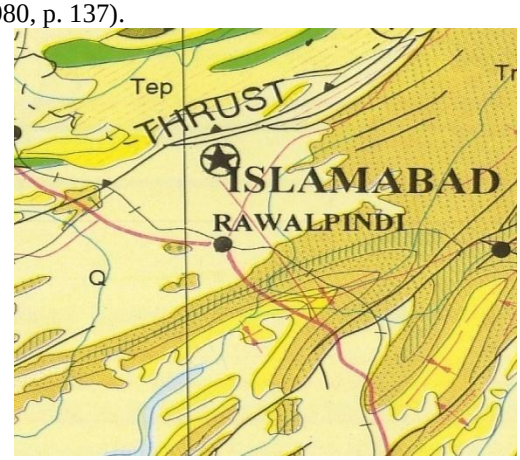


Figure 1: Geology of study Area

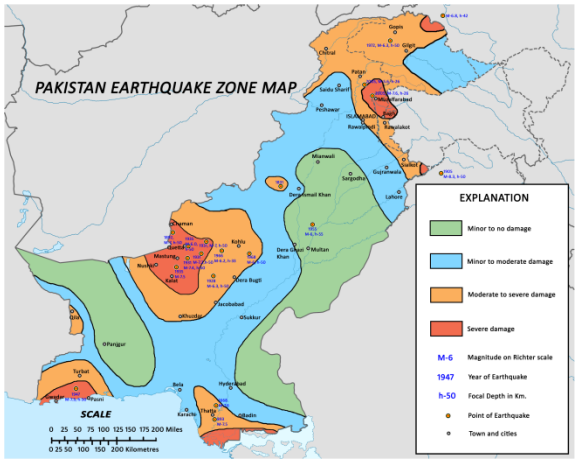


Figure 2: Seismicity of Study Area

According to the Seismic Zoning Map of Pakistan, the project sites falls in Zone 2A, consequently the structures should be designed in accordance with the requirement of seismic design after due consideration to other structural design parameters.

Geotechnical Mapping

The resultant data can be helpful during planning stage of the project and during feasibility study of mega projects. The research work is extendable to develop the geotechnical zoning map of any specific area and it can be part of building code.

The development of Geotechnical maps is a relatively new concept but it has gained considerable recognition within short period of its introduction. Integration of geotechnical database with the Geographical information systems has boosted its recognition. These maps are very helpful in the field of civil engineering providing readily available data for planning and feasibility study of projects, saving lots of time and effort and preliminary judgment of engineering characteristics of soils, to be encountered during the execution of proposed projects. In the developed countries [CEGM-IAEGC, 1976] the geotechnical maps are being included in the local building codes and the number of geotechnical maps has been already introduced in South Africa [Kleinhan I, 2003], Australia [Bui et al. 1998] and Palestine [Isam Jardaneh, 2007]. In Pakistan such effort has also been made for the cities of Lahore and Faisalabad.

2. METHODOLOGY OF RESEARCH

Soil Exploration and Sampling

Keeping in mind the requirement of the research project, a soil exploration program was induced and the process was completed in the following order.

- Boring of test hole up to the 10 m depth that is the range of subsurface investigations generally required for lightly load structures.
- Performing Standard Penetration Test at 1.0 meter interval or change of strata which ever occurred earlier.
- Collection of soil samples for laboratory testing
- Performance of Laboratory test required for establishment of Design parameters
- Engineering analysis of field data and laboratory test results.

Data Collection

Geotechnical data from 34 sites at scattered locations throughout the study area was collected. The collected data from these locations contained, standard penetration test N values, soil classification, soil stratigraphy, sub-soil characteristics of top 3-meter soil.

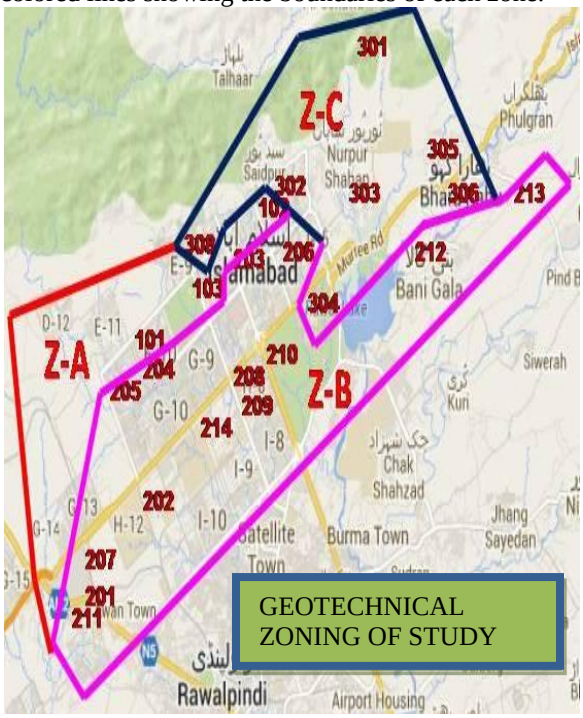
Geotechnical Zoning

The study area shown potential for creation of three zones on the basis of SPT bore hole log, for the 3.0 meter of overburden soils. Three Zones are developed on the basis of experimental data, namely zone A, B & C; the stratigraphy developed for these zones has been shown in Figure 2. Zoning dissection has been done keeping in view the Terzaghi's work to border line the SPT N values for soft, medium and hard consistency soils [7]. Table-1 shows the ranges of N values for the developed Zones.

Table 1: SPT-N values

Sr. No	Zone	Range of N values
1.	Zone-A	1-8
2.	Zone-B	9-15
3.	Zone-C	Above 15

Geotechnical zoning map based on SPT has been developed and has been shown in Figure 3, with colored lines showing the boundaries of each zone.



3.0 Discussion and Results

The subsurface soils in zone A consist of low plastic fill material up to 2.0 m depth overlaying low plastic clay from 2.0 m to 4.0 m and low plastic clay/clayey silt beyond 4.0 m depth. Zone B consists of low plastic clay and clayey silt up to the depth of 4.0 meter depth overlaying clayey silt to silt with sand material from 4.0 m to 6 m depths and gravel with sand beyond 6.0 meter depth. In zone C, low plastic clay/clayey silt is found up to 2.0 m depth overlaying silty sand up to 4.0 m depth and gravel with sand beyond 4.0 m depth.

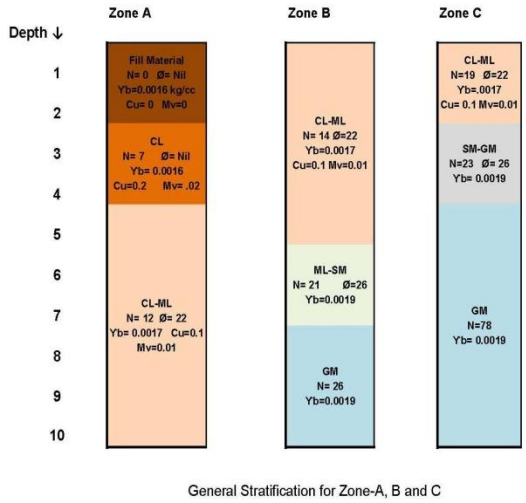


Figure 2: Geotechnical Zoning Map Developed

Experiments and Interpretation of Results

The data points shown in Fiqure-1 are the sites of Standard Penetration tests and collection of soil samples for laboratory testing. It is evident the extensive experimental work has been done and test station are scattered throughout the study area. On the basis of Field testing and laboratory analysis the soil parameters for foundation design have been worked out. The results are shown in Table 2, 3 and 4 for the zone A, B and C respectively. These tables includes experimental test results including the depth, bulk density, untrained cohesion, co efficient of compressibility and angle of internal friction for the three zones.

Table 2: Zone-A, Foundation Design Parameters

Soil Classification	Depth (m)		Bulk Density (g/cm^3)	Undrained Cohesion (kg/cm^2)	Coefficient of compressibility (cm^2/kg)	Angle of Internal Friction (Degree)
	From	To				
Fill Material	0	2	1.6	-	-	-
Clay Low Plastic (CL)	2	4	1.6	0.2	0.02	-
Clayey Silt (CL-ML)	4	10.0	1.7	0.1	0.01	22

Table 3: Zone-B, Foundation Design Parameters

Soil Identification	Depth (m)		Bulk Density (g/cm^3)	Undrained Cohesion (kg/cm^2)	Coefficient of compressibility (cm^2/kg)	Angle of Internal Friction (Degree)
	From	To				
Clayey Silt (CL-ML)	0	5	1.7	0.1	0.01	22
Clayey Silt/Silt with Sand (ML-SM)	5.0	7.0	1.9	-	-	26
Gravel with Silt (GM	7.0	10.0	1.9	-	-	-

Table 4: Zone-C, Foundation Design Parameters

Soil Identification	Depth (m)		Bulk Density (g/cm^3)	Undrained Cohesion (kg/cm^2)	Coefficient of compressibility (cm^2/kg)	Angle of Internal Friction (Degree)
	From	To				
Clayey Silt (CL-ML)	0	5	1.7	0.1	0.01	22
Clayey Silt/Silt with Sand (ML-SM)	5.0	7.0	1.9	-	-	26
Silt with Sand/Silt with Gravel (SM-GM)	7.0	10.0	1.9	-	-	-

Salient features from the tables presented above are summarized as following.

- The subsurface soils in zone A consist of thin layer of low plastic fill material that is overlaying low plastic clay in Zone A and Low plastic clay/clayey silt in Zone B and C. that is found in varying thickness as shown in the stratigraphy of the all zones.
- Silt with gravel is encountered at variable depth in Zone B and C.
- Silt with sand mixed with gravel is present at shallow depth in Zone C.
- In Zone A Fill Material and Low Plastic Clay in loose condition is found, that require proper consideration during foundation design computations.
- The borderlines of Zones have been plotted on the administrative map of study area to produce geotechnical map of the study area.

Terzaghi's (1943) equation for bearing capacity computation, modified by meyerhof (1963), hansen (1970) and vesic (1973,1975) was further adjusted by Bowls in 1996 for layered soils, can be used for computation of bearing capacities and the foundation design curves for the varying width of foundations using soil parameters presented as above.

4. CONCLUSIONS & RECOMMENDATIONS

On the Basis of criteria of SPT N values, the three Zones have been developed having the Values of N, SPT ≤ 8; $8 >$SPT < 15; SPT >15 for zone A, B and C respectively. The Soil parameters are worked out for foundation design requirement of each zone. The stratigraphy has shown the presence of fill material upto 2.0 m depth in Zone A, and generally the subsurface soils consist of Low Plastic Clay/ Clayey silt and Gravels with silt found at varying depths. The resultant data can be helpful during planning stage of the project and during feasibility study of mega projects. Zone A require soil improvements for construction of even lightly loaded structures. In Zone B Construction of single/double story dwellings can be proposed without soil improvements Zone C is suitable for multistory structures and commercial buildings.

5. RECOMMENDATIONS

This study can be used as guide line and a way forward to develop the Geotechnical maps on regional or provincial levels. The research work can be further extended by using artificial intelligence techniques to draw the precise boundary lines.

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