The Zonation of Static Shallow Foundation Bearing Capacity on Educational Area of Padjadjaran University, Sumedang District, West Java, Indonesia

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Abstract

Research area is included in the zones of Undifferentiated Young Volcanic Products of Mount Tangkubanparahu and Lake Deposits of Bandung Ancient Lake. The study was conducted in the educational area of Padjadjaran University. The object of the research is basic and mechanical properties of soil. Administratively, the research area is included in the district of Jatinangor, Sumedang Regency, West Java Province, Indonesia. This study aims to investigate the mechanical and physical properties of soil with undisturbed sample depth less than 1 meter. Afterwards, the samples through the triaxial UU test to find out the mechanical and the physical properties of the soils. The value of c (cohesion), ϕ (angle of internal friction), and ɣ (unit weight) converted to be the value of bearing capacity by using the formula which is introduced by Terzaghi. Based on calculations for shallow foundation in general shear condition and local shear condition indicates that the highest value in allowable bearing capacity (q_a) was in square foundation in one meter depth. The zonations of bearing capacity data is divided into five zones, they are; less than 3 tons/m^2 zone, 3 – 4 tons/m^2 zone, 4 – 5 tons/m^2 zone, 5 – 6 tons/m^2 zone, and more than 6 tons/m^2 zone. The foundation type suggested in the research area is square foundation with one meter wide and one meter depth.

Keywords: Bearing Capacity, Soil Mechanics, Foundation Type, Zonation of Bearing Capacity

1. Introduction

The research area is included in the district of Jatinangor, Sumedang Regency, West Java Province, Indonesia (figure 1). Jatinangor district is a district that belonging to the rapidly infrastructure growing sector. It is directly proportional to the level of developing land use. 3 units of apartments and some educational buildings already built within a period of four years. This is done to meet the needs of educational and residency sector.

Soil as the foundation plays an important role in determining the safety factors level of an infrastructure that will be built on it. The study of engineering geology is necessary to help us determine the safety factor of the area that will be used to develop an infrastructure. The physical properties and mechanical properties of soil and rock can be used as a base of consideration in decision making for the implementers and regional development planners.

[Figure 1]

2. Geological Background

Based on Silitonga (1973), the stratigraphy of Jatinangor area from the oldest to the youngest as follows (figure 2) :

1. Undifferentiated Young Volcanic Products (Qyu) in the form of tuffaceous sand, lapili, lava, agglomerate mostly from Mt. Tangkubanparahu and Mt. Tampomas. Between Bandung and Sumedang this unit expressed as a flat or low hill area covered by yellowish gray to reddish gray soil,
2. Lava of Young Volcanic Products (Qyl) in the form of lava,
3. Lake Deposits (Ql) in the form of tuffaceous sand, sandstone, gravel and conglomerate. Locally form horizontal layers. Contains limestone concretions, plant remains, fresh water molluscs, and bones of vertebrates. Locally also intercalated by breccia.

In the field, the outcrop condition already highly weathered.

[Figure 2]

3. Methods

The research is done by using guide based on engineering geological mapping, basic properties test, triaxial test and mechanical properties calculation using Terzaghi formula to determine the bearing capacity of soil.

As the definition by Dearman (1991), engineering geological mapping is one of geology applied discipline to civil engineering. What should be shown on an engineering geological map depends on its purpose. The basic map information is needed to assess the feasibility of a proposed engineering construction. Map type that used in this research is lithological type (LT). Typically the scale of such mapping is 1 : 5000 to 1 : 10.000. Engineering geological mapping aimed to obtain information on the deployment of soil based on the characteristics of Unified Soil Classification System (USCS). This mapping can be tentative or provisional because the field description of soil dominated by subjective approaches. The correction will be obtained by conducting laboratory tests on undisturbed samples. All methods of undisturbed soil sampling adapted from ASTM D 1452.

Types of laboratory tests conducted to determine the physical properties of soil including the moisture content test, unit weight test, specific gravity test, the liquid limit test, plastic limit test, hydrometer analysis and sieve analysis. And the type of laboratory tests conducted to know the mechanical properties of the soil is a triaxial UU test. All laboratory tests adapted from ASTM (American Standard Testing and Materials).

Ater that the mechanical properties parameters of soil (c, φ, and ɣ) processed to obtain the value of soil bearing capacity using this following Terzaghi formula :

$$\mathbf{q_a = q_{ult} / F} \qquad (1)$$

Where q_a is the allowable bearing capacity value, q_{ult} is ultimate bearing capacity value, and F is factor of safety.

Factor of safety that used in this research is 3. The foundation built above the seepage. The general shear failure of continuous footing simulation used to determine the bearing capacity because this simulation produce the lowest bearing capacity value, which has the following formula :

$$\mathbf{q_{ult} = (c \,.\, Nc + \gamma\, D_f \,.\, Nq + 0{,}5\, \gamma \,.\, B \,.\, N\gamma)} \qquad (2)$$

Where q_{ult} is ultimate bearing capacity value, and c is cohesion, ɣ is unit weight of soil, D_f is the depth of foundation, B is width of foundation, and Nc – Nq - Nɣ is bearing capacity factors.

After the bearing capacity data process complete, bearing capacity data are plotted on a map according to undisturbed soil sampling coordinate. The zonation made by using kriging method.

4. Result

4.1. Engineering Geological Map

Based on the results of geological mapping techniques and laboratory testing with reference USCS, the study area can be divided into five engineering geological units (figure 3) as follows :

1. Silt with High Plasticity (MH)
2. Silt with Low Plasticity (ML)
3. Clay with High Plasticity (CH)

[Figure 3]

4.2. Bearing Capacity Values

There are 18 samples taken in this research. it spread in the educational area of Padjadjaran University. All of it processed by triaxial test to determine the mechanical properties parameters. After that, the machanical properties parameters processed by using Terzaghi formula to obtain the bearing capacity values.

[Table 1]

4.3. The Zonation of Shallow Foundation Bearing Capacity

The zonation of shallow foundation bearing capacity at 1 meter depth is based on the lowest values of the soil bearing capacity. In this study, the lowest q_a value obtained from simulations using continuous type of foundation on the general shear failure condition. The range of bearing capacity in this study area is from 2.12 to 6.31 tonnes / m^2. The value range can be classified into five groups (figure 4), as follows :

1. Zone of allowable bearing capacity (qa) < 3 tonnes / m^2. This zone is spread in the Northwest and Southwest areas of research,
2. Zone of allowable bearing capacity (qa) 3-4 tonnes / m^2. This zone is spread in almost all parts of the study area, as follows the Central, West and Northwest,
3. Zone of allowable bearing capacity (qa) 4-5 tonnes / m^2. This zone is spread across parts of the Southeast, Central, and Northern areas of research,
4. Zone of allowable bearing capacity (qa) 5-6 tonnes / m^2. This zone is located on the Northeast and Central regions of research,
5. Zone of allowable bearing capacity (qa) > 6 tonnes / m^2. This zone is located in the Central part of the study area.

[Figure 4]

5. Conclusions

Besed on geology condition, research area is dominated by volcanic material such as tuff, volcanic breccia and tuffaceous sandstone. The residual soil is is dominated by fine grains. With a high content of fine grains, the soil has a plastic nature. Plasticity in soil acquired from plastic nature owned by clay particles. The different types of soil is influenced by rock origin.

The differences in percentage of soil grain size affects the formation of soil types. It also affects the mechanical characteristics of the soil because the percent of clay affect the value of soil cohesion. The percentage of soil grain size also affects the value of the friction angle because the grain size affects whether the relationship between the grains in the soil interlocking or not.

This research area is suitable for development of infrastructures as long as the weight of the infrastructures does not exceed the allowable bearing capacity. If we want to build a building with load exceed allowable bearing capacity, we should increase the depth of the foundation required.

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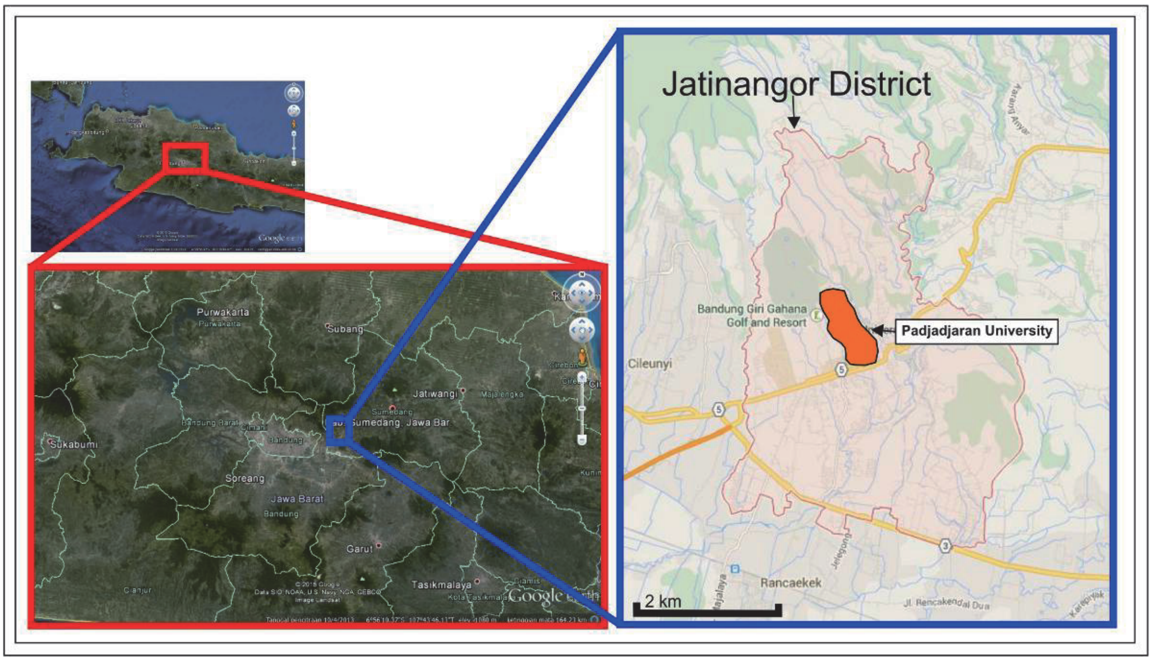

Fig. 1 The location of research area (taken by google earth, April 29th, 2015)

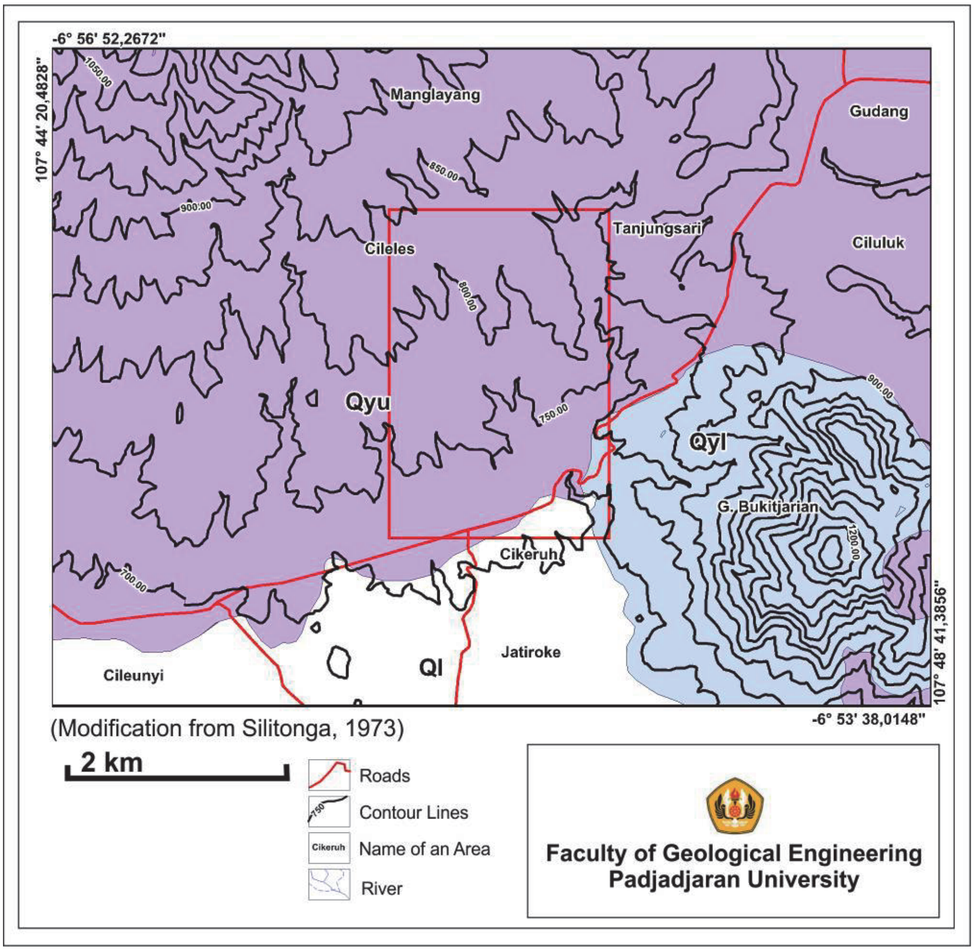

Fig. 2 Geology Condition of Research Area (modification from Silitonga, 1973)

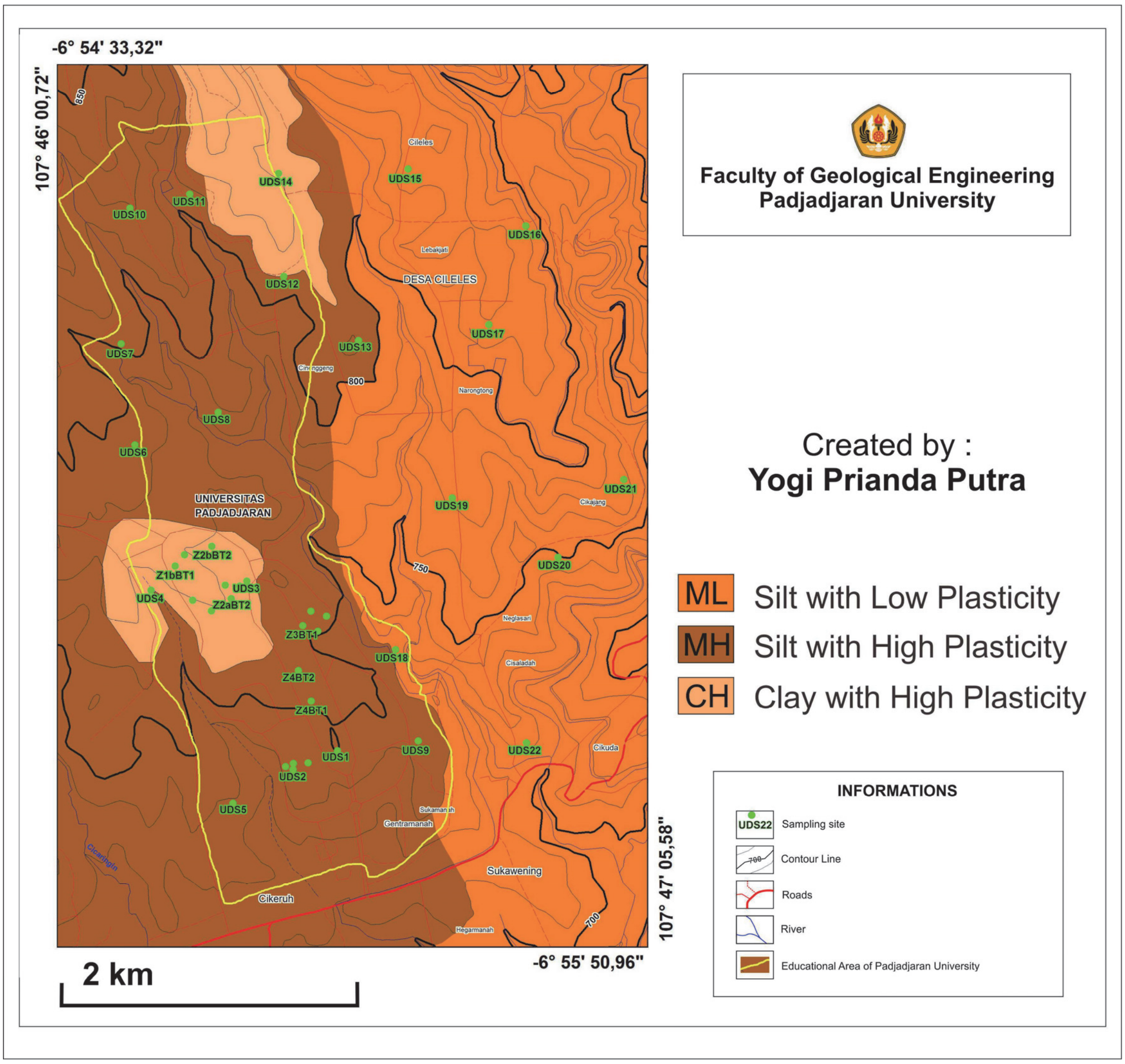

Fig. 3 Engineering Geological Map of Research Area

Table 1 q_{ult} and q_a of all samples calculate in general shear failure of continuous footing simulation in one meter depth

Bearing Capacity			**Laboratory Test Result**	
Sample Codes	**General Shear Failure**		**ϕ (Angle of Internal Friction)**	**c (Cohesion)**
	qult (tonnes/m2)	**qa (tonnes/m2)**	**(°)**	**kg/cm^2**
Z1aBT1	16,71	5,57	4,826	0,206
Z1aBT2	13,38	4,46	3,453	0,175
Z1bBT1	6,75	2,25	4,116	0,062
Z1bBT2	10,45	3,48	3,625	0,122
Z2aBT1	14,9	4,97	4,863	0,178
Z2aBT2	20,4	6,8	4,785	0,264
Z2aBT3	13	4,33	3,81	0,16
Z2bBT1	12,24	4,08	4,057	0,147
Z2bBT2	15,99	5,33	4,036	0,254
Z3BT1	11,85	3,95	3,634	0,147
Z3BT2	18,94	6,31	6,146	0,209
Z3BT3	15,47	5,16	5,672	0,168
Z3BT4	17,43	5,81	3,972	0,232
Z4BT1	12,42	4,14	5,424	0,106
Z4BT2	10,36	3,45	4,18	0,15
Z5BT1	13,53	4,51	3,431	0,181
Z5BT2	17,58	5,86	2,834	0,256
Z5BT3	6,37	2,12	3,552	0,058

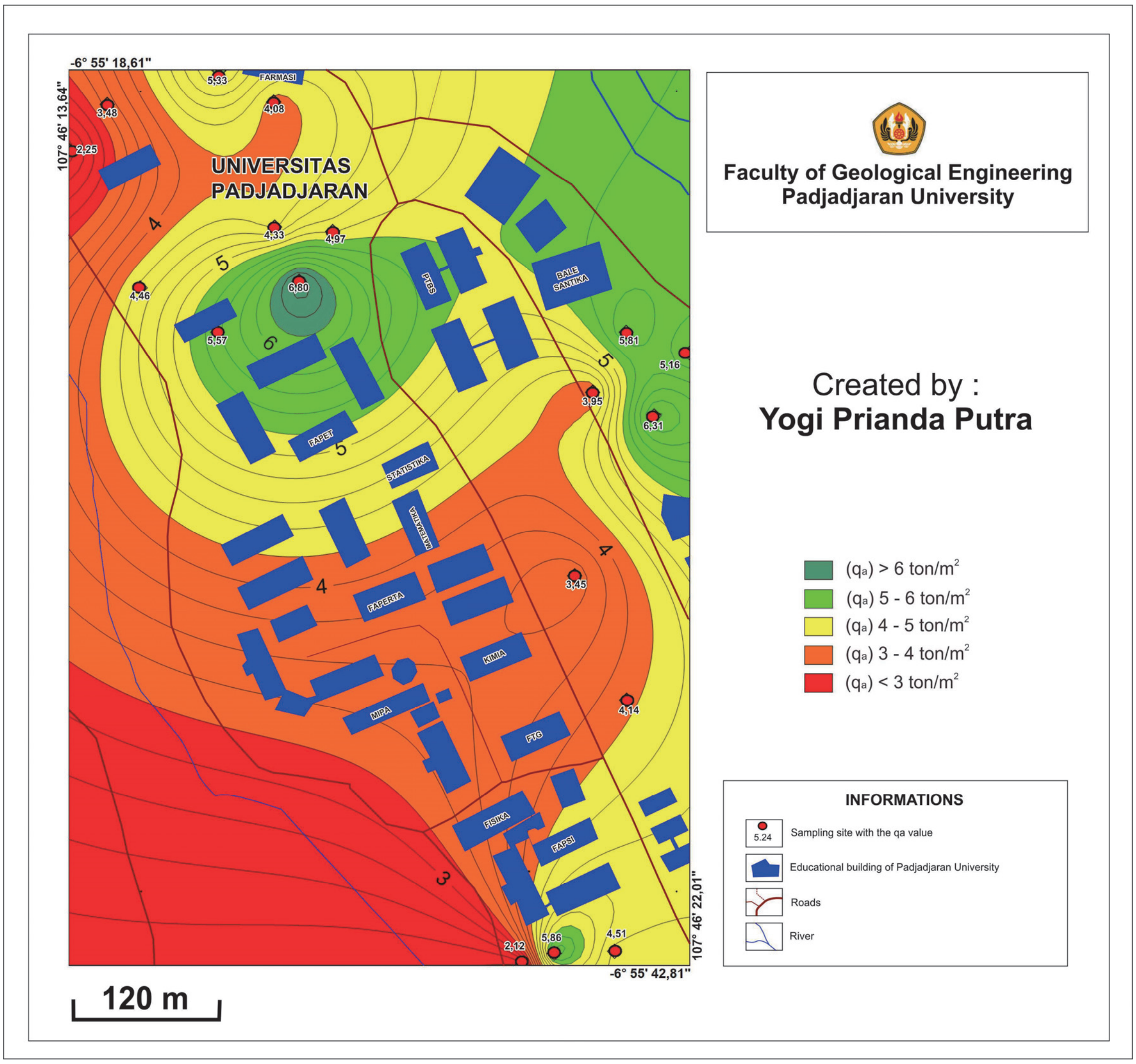

Fig. 4 The zonation of static shallow foundation bearing capacity on Educational Area of Padjadjaran University