2190-7976-1-PB.pdf

Ukarst : Universitas Kadiri Riset Teknik Sipil
Volume 5 Number 2 Year 2021

ISSN (*Online*) 2581-0855
ISSN (*Print*) 2579-4620

Available online at
http://ojs.unik-kediri.ac.id/index.php/ukarst/index

http://dx.doi.org/10.30737/ukarst.v3i2

Bearing Capacity Modification Of Clay In The Kedungsigit Village Using Zeolite

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ARTICLE INFO

Article history :
Artikel masuk : 30 – 11 – 2021
Artikel revisi : 03 – 11 – 2021
Artikel diterima : 10 – 12 – 2021

Keywords :
Bearing Capacity, Shear Strength, Soil, Tread Foundation, Zeolite.

IEEE Style in citing this article: [19]
M. Mariri, R. Ziaie Moayed, and A. Kordnaeij, "Stress–Strain Behavior of Loess Soil Stabilized with Cement, Zeolite, and Recycled Polyester Fiber," J. Mater. Civ. Eng., vol. 31, no. 12, p. 04019291, 2019, doi: 10.1061/(asce)mt.1943-5533.0002952.

ABSTRACT

Clay is a type of soil with a high level of water content. These properties make clay soils have a low low bearing capacity which can have an impact on the buildings above them, such as cracked walls, raised foundations, bumpy roads and so on. The soil in Kedungsigit Village, Karangan District, Trenggalek Regency is clay and needs to be repaired to build a strong building. This study aims to modify the value of the bearing capacity of clay. Modifications were made by adding Zeolite with a percentage of 0%, 5%, 10%, 15%, and 20%. Zeolite is used because it contains mineral kristal alumina silikat which have the ability to bind grains between aggregates. Observations were made on the characteristics of clay including testing of volume weight, shear strength, and bearing capacity using the Terzaghi method. The results showed the optimum value for the addition of 15. In testing the bearing capacity of the soil using the tread foundation, the value of 32,470 t/m^2 was obtained for the addition of 15% zeolite and 21,376 t/m^2 for the original soil. From these results it is known that the use of zeolite can increase the value of the bearing capacity of the soil. So that these modifications can be used as an effort to improve soil in Kedungsigit village.

1. Introduction

Soil is a material consisting of various aggregate elements or solid mineral grains that are bound to each other or are not cemented [1]. Soil consists of a wide variety of grain sizes. The grain size can be classified into four groups, namely gravel, sand, silt, and clay [2]. One of the most common types of soil is clay. Clay is an aggregate of microscopic and submicroscopic soil particles (cannot be seen clearly if only using an ordinary microscope), which comes from the chemical decomposition of constituent rock elements. Clay has a particle size of less than 0.002 mm, but in some cases, particles measuring 0.002 mm to 0.005 mm are still classified as clay particles. Clay has several properties, namely low permeability, high capillary water increase, is cohesive, and the consolidation process is very slow.

Ukarst : Universitas Kadiri Riset Teknik Sipil
Volume 5 Number 2 (2021)
ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Clay soil has characteristics that distinguish it from other soils. In moderate water conditions, clay has plastic properties [3]. Meanwhile, in dry conditions, clay is tough and does not peel off easily. So the clay is able to expand and shrink very quickly so that the clay has a significant enough volume change, and this happens because of the influence of water [4]. Soil that has a high clay content causes low soil bearing capacity and can cause damage to buildings such as cracked walls, raised foundations, bumpy roads, and so on.

The land has a vital role in infrastructure development work. The condition of the soil is very influential on the development carried out. If there is damage to the soil, it will be hazardous for the buildings on it [5]. This is evidenced in several buildings in Kedungsigit Village, Karangan District, Trenggalek Regency, experiencing bumpy roads and foundation cracks. Because the land has the function of receiving the direct load of the building on it, the foundation of the building must be planned as well as possible [6][7][8]. In designing the foundation, one must pay attention to several aspects, namely the settlement and bearing capacity of the soil [9][10]. The bearing capacity of the soil is the ability of the soil to bear pressure or resist settlement due to loading, namely the shear resistance spread by the soil along its shear planes [11][12][13]. The soil bearing capacity test aims to determine the bearing capacity of the soil in each layer and to determine the depth of the supporting layer, namely the hard soil layer [14][15]. If the soil bearing capacity is low, it will result in a decrease. Considering these conditions, it is necessary to make efforts to increase the value of the bearing capacity of the soil [16].

The application of additional materials to increase the bearing capacity of the soil continues to be developed recently [17]. One of the material that can be used is Zeolite [18][19]. Zeolite is a hydrated porous alumina silicate crystalline mineral that has a three-dimensional skeletal structure created from the tetrahedral $[SiO_4]^4$ and $[AlO_4]^5$ [20][21]. Several previous studies stated that the addition of zeolite and cement to the soil was able to increase the unconfined compression (UCS) value. However, there are still not many studies that use zeolite to increase the bearing capacity of the soil [22][23].

This study was to determine the effect of the use of zeolite on the bearing capacity of the soil in Kedungsigit Village, Karangan District, Trenggalek Regency. The addition of zeolite used using variations of 0%, 5%, 10%, 15%, and 20%. A series of tests will be carried out including volume weight test and shear strength test. After getting the data, the soil bearing capacity will be tested with reference to the addition of the optimum zeolite. From these results, it is known that the use of zeolite can increase the value of the bearing capacity of the soil. So that these modifications can be used as an effort to improve the soil in Kedungsigit Village.

http://dx.doi.org/10.30737/ukarst.v5i2

2. Research Method

This research method is carried out experimentally by testing in the laboratory in accordance with applicable standards. The test was carried out at the Civil Engineering Laboratory of Kadiri University.

2.1 Research Material

The materials used in this study were clay and zeolite with the following description.

2.1.1 Clay

Clay are classified as expansive soils which mostly consist of silt with a considerable amount of clay. The clay used in this study was obtained from Kedungsigit Village, Karangan District, Trenggalek Regency. The soil is taken at random and will be tested for shear strength in the laboratory. The soil gradation used in the shear strength test must meet the requirements of passing sieve no. 40. Whereas in the volume weight test, the test is carried out directly on the soil by taking a random place. Soil condition will be shown in **Figure 1.**

Source: Personal Documentation

Figure 1. Soil in Kedungsigit Village.

2.1.2 Zeolite

The zeolite used in this study had a size smaller than 0.425 mm or passed sieve no. 40. Zeolite is obtained from buying through the marketplace. The use of zeolite serves as a material to increase the bearing capacity of the soil. Zeolite conditions will be shown in **Figure 2.**

http://dx.doi.org/10.30737/ukarst.v5i2

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Source: Personal Documentation

Figure 2. Zeolite.

2.2 Research Design

The research was conducted in several stages. The research began with the preparation of materials, and the provision of Zeolite added materials. Then proceed with the original soil testing process, including testing the water content and grading of the sieve. Furthermore, testing the soil with a combination of Zeolite at the percentages of 0%, 5%, 10%, 15%, and 20% covering the density, consistency, compaction, and shear strength tests. Based on the series of experiments, the optimum zeolite addition was analyzed. Followed by testing the bearing capacity to determine the value of the bearing capacity by comparing the original soil with the addition of optimum Zeolite. At this stage, conclusions and suggestions can be drawn about modifying the bearing capacity of the soil using Zeolite.

2.3 Soil Characteristic Test

Soil characteristics test is an activity carried out by taking soil samples to determine the conditions and characteristics of the soil [24]. This test is carried out so that the soil can support the load on it so that there is no shift and subsidence of the soil. Soil characteristic testing includes water content test, density test, consistency test, compaction test, and shear strength test.

1. Volume Weight Test

   Volume weight is showing the ratio between dry soil weight and soil volume including soil pore volume. The calculation of the volume weight test is as follows.

   $\gamma = \frac{W}{v}$

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With Description :

γ = Volume Weight

W = Soil Weight

V = Soil Volume in mold

2. Shear Strength Test

The soil shear strength test aims to determine the shear strength of the soil so that the safety and comfort of the structure above the soil is obtained. In the shear test, the shear angle will be obtained based on the graph of the shear strength test results. [25][26][27].

2.4 Soil Bearing Capacity

The soil bearing capacity test aims to determine the ability of the soil to withstand the load or pressure on each layer and to determine the depth of the supporting layer, namely the hard soil layer [28][29]. If the soil bearing capacity is low, it will result in a decrease. Therefore the bearing capacity of the soil needs to be tested before placing the load on it. The theory of calculation of bearing capacity testing used the Terzaghi method.

$\sigma Ult = \alpha.c.Nc+Df.\gamma1.Nq+B.\beta.\gamma2.N\gamma$

With Description:

σ Ult = Ultimate bearing capacity

β = Coefficient

α = Constant

γ1 = Volume weight of soil beside foundation

c = Soil cohesion

γ2 = Volume weight of soil under foundation

Df = Foundation depth

Nc, Nq, Nγ = Soil bearing capacity factor

B = Foundation width

3. Results and Discussions

3.1 Soil Characteristic Test

Soil characteristic tests were carried out, including volume weight test, and shear strength test. The results of testing the soil characteristics are as follows.

1. Volume Weight Test

Soil volume weight tes is used to get the value that will be used in the calculation of the bearing capacity of the soil. The results of soil volume weight test shown in **Table 1.**

http://dx.doi.org/10.30737/ukarst.v5i2

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Table 1. Volume Weight of Original Soil and Zeolite Mixture of 5%, 10%, 15%, and 20%.

Sample	Volume Weight (gr/cm^3)
Original Soil	1,67
Soil With 5% Zeolite	1,73
Soil With 10% Zeolite	1,78
Soil With 15% Zeolite	1,89
Soil With 20% Zeolite	1,77

Source: Research Results

From **Table 1.** it is found that the volume weight of the original soil is 1,67 gr/cm^3, while after the zeolite is combined with changes at the 5% level, the volume weight is 1,73 gr/cm^3, at 10% the Zeolite content is 1,78 gr/cm^3, at 15% it is 1,89 gr/cm^3, and at 20 % is 1,77 gr/cm^3.

2. Shear Strength Test

The shear strength test is used to find the value of the shear angle and cohesion in the soil.

Source: Personal Documentation

Figure 3. Shear Strength Test

Figure 3. show the shear strength test. The results of the shear angle can be seen in **Table 2.** below.

Table 2. Shear Angle of Original Soil and Zeolite Mixture of 5%, 10%, 15%, and 20%.

Sample	Shear Angle
Original Soil	22°
Soil With 5% Zeolite	23°
Soil With 10% Zeolite	24°
Soil With 15% Zeolite	25°
Soil With 20% Zeolite	24°

Source: Research Results

http://dx.doi.org/10.30737/ukarst.v5i2

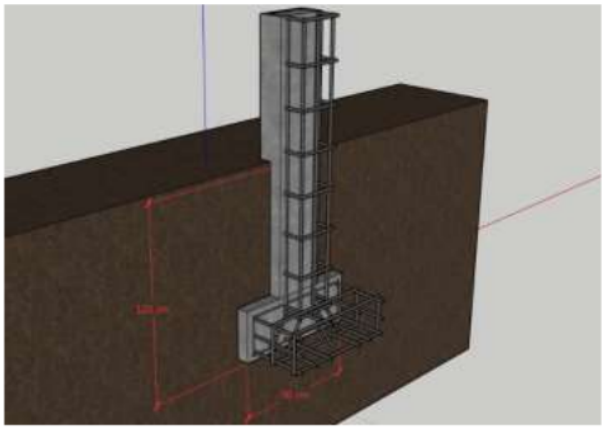
From **Table 2.** the results of the shear angle on the original soil are 22°, while after the Zeolite are combined with changes at 5% levels, the shear angle is 23°, at 10% Zeolite content is 24°, at 15% is 25°, and at 20% is 24°. Of the four variations of the addition of Zeolite, the value of the shear angle is most significant at the addition of 15% Zeolite.

The cohesion value obtained on the original soil and the addition of 5%, 10%, 15%, and 20% zeolite was 0 t/m^2.

Based on the following soil characteristics testing, the results showed that the most optimum level of Zeolite mixture was at a level of 15%. This is then used as a reference for testing the bearing capacity of the soil.

3.2 Soil Bearing Capacity Test

The foundation used in this study is a footed foundation with a foundation depth of 1.2 m and a width of 0.5 m. The calculation of the bearing capacity of the soil used in this study is the Terzaghi method. Due to using a square foundation, a constant of 1.3 is used and a coefficient of 0.4.



Source: Personal Documentation, Drawn Using AutoCAD

Figure 4. Square Foundation Planning.

From the results of the data that has been obtained in the previous test, the original soil data is obtained as follows:

Constant (α) = 1,3
Coefficient (β) = 0,4
Cohesion (c) = 0 t/m^2
Foundation depth (Df) = 1,2 m
Foundation width (B) = 0,5 m

http://dx.doi.org/10.30737/ukarst.v5i2

ISSN (*Online*) 2581-2157
ISSN (*Print*) 2502-9304

Volume Weight (γ) = 1,67 gr/cm^3 = 1,67 t/m^3

Shear Angle (ϕ) = 22°

Soil Bearing Factor

Nc = 20,66

Nq = 9,52

Nγ = 6,88

From these data, the bearing capacity of the original soil can be calculated as follows:

σ Ult = 1,3 . 0 . 20,66 + 1,2 . 1,67 . 9,52 + 0,4 . 0,5 . 1,67 . 6,88

= 21,376 t/m^2.

From the calculation of the bearing capacity of the original soil using the Terzaghi method, the results obtained are 21,76 t/m^2.

While the soil data with the addition of 15% Zeolite obtained the following data:

Constant (α) = 1,3

Coefficient (β) = 0,4

Cohesion (c) = 0 t/m^2

Foundation depth (Df) = 1,2 m

Foundation width (B) = 0,5 m

Volume Weight (γ) = 1,89 gr/cm^3 = 1,89 t/m^3

Shear Angle (ϕ) = 25°

Soil Bearing Factor

Nc = 25,1

Nq = 12,7

Nγ = 9,7

From these data, it can be calculated the bearing capacity of the soil with the addition of 15% Zeolite as follows:

σ Ult = 1,3 . 0 . 25,1 + 1,2 . 1,89 . 12,7 + 0,4 . 0,5 . 1,89 . 9,7

= 32,470 t/m^2.

From the calculation of the bearing capacity of the soil with the addition of 15% Zeolite using the Terzaghi method, the results obtained are 32,470 t/m^2.

Based on the results of the calculation of the bearing capacity of the soil, it can be seen that there is an increase in the value of the bearing capacity of the soil that has been given the addition of Zeolite by 15%. Thus the addition of Zeolite by 15% makes the value of the bearing capacity of the soil increase so that it is suitable for increasing the value of the bearing capacity of the soil.

http://dx.doi.org/10.30737/ukarst.v5i2

4. Conclusion

From the research that has been done shows that the use of zeolite can increase the value of the bearing capacity of the soil. This is indicated by the use of 15% Zeolite content, the results of the volume weight test are 1,89 gr/cm^3 and and the shear strength test produces a shear angle of 25^o. And the value of the original soil bearing capacity is 21,376 t/m^2, and the value of the soil bearing capacity with the addition of 15% Zeolite is 32,470 t/m^2. Thus it can be concluded that the soil with a mixture of 15% Zeolite can increase the bearing capacity of the soil.

5. Acknowledgments

Researchers support Kadiri University, especially the Faculty of Engineering, which has provided the opportunity to conduct research and prepare reports.

http://dx.doi.org/10.30737/ukarst.v5i2

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http://dx.doi.org/10.30737/ukarst.v5i2

2190-7976-1-PB.pdf

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