GEOGRID ANALYSIS OF SOIL SHEAR STRENGTH

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Abstract

Improving soil conditions is one solution to the problem of increasing soil carrying capacity and minimizing settlement. With the development of technology in the geotechnical field, soil strengthening can be done by installing synthetic materials such as the use of geogrids. Geogrids rely on high tensile strength and low creep elongation, for the case of landslides geogrids are placed on a layer of soil, backfilled, and compacted layer by layer so as to maintain stabilizing soil by distributing it to be strong. Tensile purpose of this study To describe the use of geogrids in their role as one of retaining wall reinforcement. In planning, the retaining wall must be able to withstand the loads acting on it, both externally and internally. , shear and slip bearing capacity, and settlement. Internally stability indicates the stability of the type of reinforcement itself, in this case such as tensile capacity, friction capacity, bending capacity.

Keywords: Retaining wall, Sheet Reinforcement, Geogrid, Internal Stability, External Stability.

INTRODUCTION

It is recognized that increased development activities have had a positive impact on the development aspect, but unknowingly this can have negative implications for soil stability and can lead to geotechnical problems such as land slides.

Earth reinforcement work on retaining walls is now widely known as the Mechanically Stabilized Earth (MSE) wall. The application of this technology has been used in ordinary retaining walls, bridge abutments, slope rehabilitation, even retaining walls with soft soil structures.

An important aspect that supports the success of soil reinforcement systems with geogrids is that the two materials can form a certain geometry that allows the transfer of loads from one material to the other. The analogy with reinforced concrete is that the reinforced concrete system is supported by a bond between the iron contained in the concrete and the dry cement mixture (Koerner, R.M, 1990).

The important parameters required for the reinforcement of retaining walls are high tensile and shear strength. Geogrid has these advantages compared to other geosynthetic materials, besides that geogrid is specifically for reinforcement functions. The large openings in the geogrid allow plants to grow easily through them. So besides being strong, geogrid is also environmentally friendly. These openings also allow for better interaction between the geogrid and the embankment material above it because the embankment material can enter between the openings so that they are more integrated.

The principle of reinforced soil is almost the same as that of reinforced concrete. Combining two materials that have different properties to form a unified structure that supports each other.

LITERATURE REVIEW

REINFORCED LAND

Reinforced soil in retaining walls is a construction material consisting of frictional backfill material and linear reinforcement (reinforcement) sheets, usually placed horizontally. The reinforcement system, which can withstand high tensile forces, resists lateral deformation of the reinforced soil mass. Reinforced earth structures: embankment material, linear reinforcement (reinforcement) sheets, combined with the embankment, form the reinforced soil mass, and the outer layer, which has the role of preventing the embankment material behind the retaining wall from sliding.

RETAINING WALL

A retaining wall is a structure designed and built to withstand lateral (horizontal) pressure on the soil when there is a change in the ground elevation that exceeds the at-rest angle in the soil. An important factor in designing and building a retaining wall is to ensure that the retaining wall does not move or the soil slides due to gravity. The lateral earth pressure behind the retaining wall depends on the internal shear angle (phi) and cohesion (c). Lateral pressure increases from the top to the very bottom of the retaining wall. If it is not planned properly, the earth pressure will push the retaining wall causing construction failure and landslide.

TYPES OF RETAINING WALLS

In most construction processes, it is sometimes necessary to change the cross-section of the ground surface in some way to produce a vertical surface or close to it (Whitlow, 2002). The new sections may be self-loading, but in some cases a lateral retaining wall structure may require support.

Gravity Walls

• Masonry Walls

Can be made of concrete, brick or hard stone. The strength of the retaining wall material is usually stronger than that of the subgrade. The legs are usually made of concrete and will usually be one-third or one-half the width of the retaining wall. The stability of this wall depends on the mass and shape.

• Gabion Walls

Gabion is a collection of cubes made of galvanized steel mesh or woven strips, or plastic mesh (woven products) and filled with crushed stone or cobbles, to produce a retaining wall with free drainage channels.

Crib Wall

This type of retaining wall is formed with precast concrete, stretchers are made parallel to the vertical surface of the retaining wall and headers are placed perpendicular to the vertical surface. In the empty space filled with material that has free drainage, such as sand and excavated results.

• Reinforced Concrete Wall (Cantilever Reinforced Concrete Wall)

Reinforced concrete cantilever walls are the most common modern form of gravity walls, either in an L shape or an inverted T shape. Shaped to produce a vertical cantilever slab, a simple cantilever, some using the weight of the embankment behind the wall to keep the wall stable. It is suitable for walls up to 6 m high (Whitlow, 2001).

In Situ or Embedded Walls

• Sheet Pile Walls

This type is a flexible structure that is used especially for temporary works in harbors or in places with poor soils. The materials used are timber, pre-cast concrete and steel. Timber is suitable for temporary work and supports for cantilever walls up to 3 m high. Pre-cast concrete is used for heavy permanent structures. Meanwhile, steel has been widely used, especially for cantilever and tied-back type retaining walls, with various choices.

Cross section, strong bending capacity and can be used again for temporary work. Cantilever will have economic value if only used up to a height of 4 m (Whitlow, 2001). Anchored or tie-back walls are used for a wide variety of applications in different soils.

• Braced or Propped Walls

Props, braces, shores and struts are usually placed in front of retaining walls. These materials reduce lateral deflection and bending and driving moments are not required. In drainage channels, struts and wales are used. In excavations with a fairly large area, framed shores and raking shores are used.

• Contiguous and Sectant Bored-Pile Walls

Walls of contiguous bored piles are formed from one or two rows of piles tightly packed together.

• Diaphragm Walls

Usually constructed as a narrow excavated channel temporarily reinforced with bentonite slurry, reinforcement material is poured into the channel and concrete is placed through a tremie. This method is used in difficult soils where sheet piles would be problematic or levels with high water levels or confined areas.

Reinforced Soil Walls

According to Schlosser (1990), the concept of reinforced earth was introduced by Henry Vidal in France. Vidal observed that when the sand layer was separated by horizontal sheets of steel, the soil was stronger against vertical loading. Then later this type of reinforcement began to be used for reinforcement in the construction of retaining walls.

The mechanism for increasing the shear strength of reinforced soil has been explained in several ways.

1. According to Schlosser and Vidal (1969), the pullout strength of the reinforcement and the transfer of stresses in the soil to the reinforcement produce visible cohesion.

2. By using reinforcement in the ground, it also results in an increase in the restraint stress, this was stated by Yang (1972).
3. Basset and Last (1978) assume that reinforcement provides anisotropic resistance to soil displacement in the direction of reinforcement.
4. The concept of soil behavior is proven by Schlosser and Long (1972) from the results of the triaxial test on soil samples given reinforcement with aluminum sheets, that in a small confining stress, the soil will collapsed due to slip. With the reinforcement, the strength of the system increases due to the influence of visible cohesion.

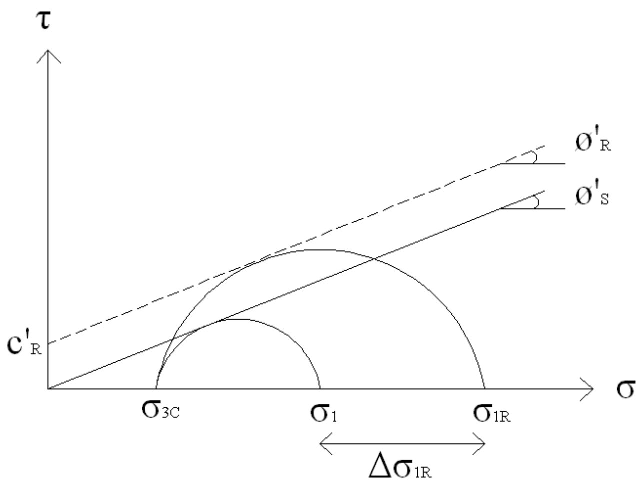

Figure 1. Explanation of cohesion shown in the increase in strength due to reinforcement.

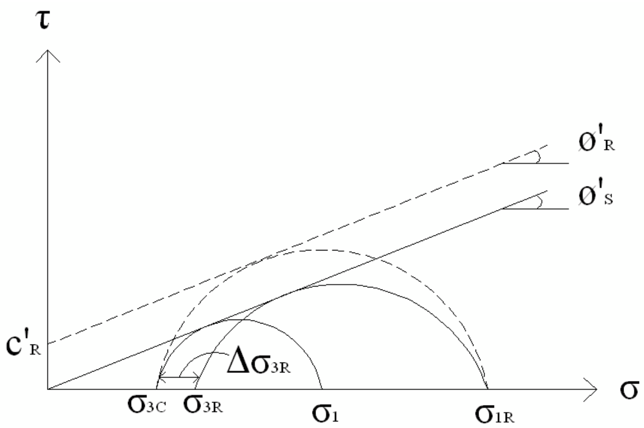

Figure 2. The concept of raised reinforced soil confinement

In areas where failure occurs due to breaking of the reinforcement, the strength increases because the concept of anisotropic cohesion appears as explained in the Mohr diagram in **Figure 1.** c'_R is the visible cohesion produced by the reinforcement. σ_{1R} is the increase in the major principal stresses at failure. Sliding angle of reinforced sand is taken the same as unreinforced sand, which is based on the appropriate assumptions, described in **Figure 2.**

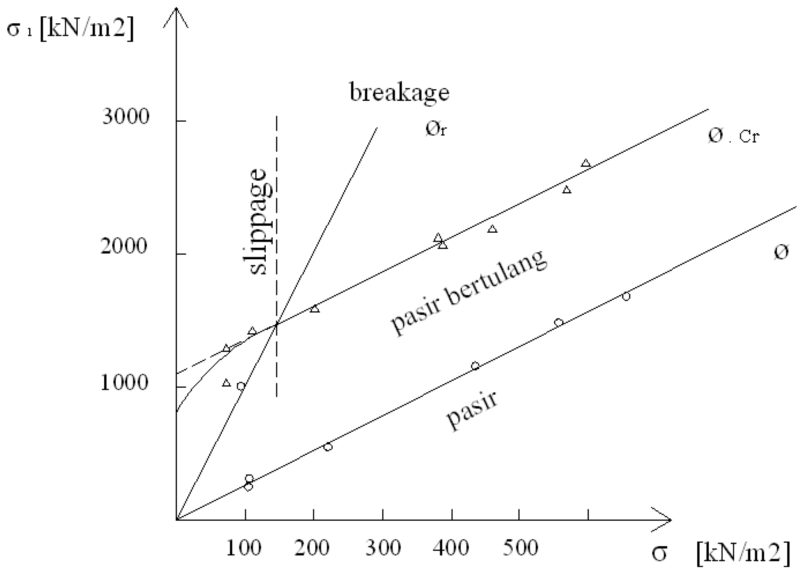

Figure 3. Strength lines for sand and reinforced sand.

METHOD

Sand soil material testing is carried out by taking sand soil samples that have been provided according to testing purposes, the research carried out consists of:

1. Testing of physical properties, namely testing of grain size analysis by sieve analysis and testing to determine specific gravity (Gs) according to standards.
2. Testing of mechanical properties, is testing to determine the maximum and minimum dry unit weight (□d) and direct shear testing according to standards.
3. Tests to determine the relative density (Dr) of 20-40% which will be tested with a fall height experiment.

This research was carried out using a continuous foundation model placed on a transparent box filled with sand under conditions of relative density (Dr). Testing is separated into two stages of testing, namely preliminary testing and main test, this is done so that the results are get more detailed and detailed. Testing the physical properties of the sandy soil material is carried out to determine its grain size, by conducting a sieve analysis it can be known the classification of the sandy soil material [6].

Direct share testing was carried out to determine the inner angle (□) of a sample of sandy soil material with a relative density (Dr) of 40-50% [7]. In this experiment, a sample of sandy soil was placed in the tool and then given a constant vertical stress (normal stress) with each magnitude 0.099 kg/cm^2; 0.198 km/cm^2; 0.397 kg/cm^2 and then the sample is given a shear stress with a constant strain rate and slowly enough to the maximum value. With carry out several experiments where the normal stress is different, a diagram of the relationship between the shear stress and the normal stress can be made as shown in **Figure 4.**

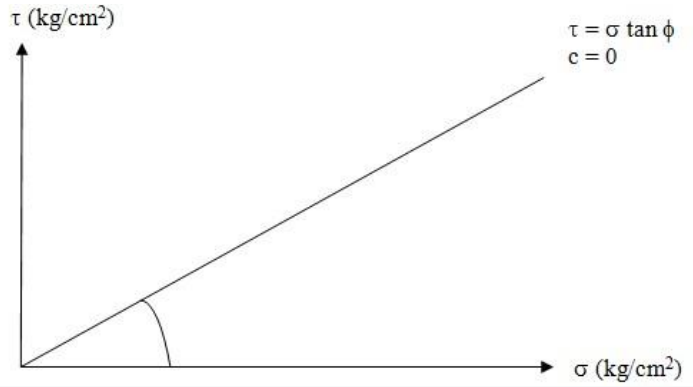

Figure 4. Graph of the relationship between shear stress (T) and normal stress (a).

RESULTS AND DISCUSSION

There are 3 types of land to be reviewed:
- Base ground
- Land behind the structure

- Base ground:
$\gamma = 20$ kN/m^3, $\emptyset = 35°$, c = 20 kN/m²
- Land behind the structure
$\gamma = 18$ kN/m^3, $\emptyset = 32°$, c = 0 kN/m²

The ultimate bearing capacity is calculated using the Meyerhoff formula taking into account the sloping loading conditions (retaining walls that are slightly inclined), then:

$$q_u = s_c d_c i_c b_c g_c c N_c + s_q d_q i_q b_q g_q p_o N_q + s_\gamma d_\gamma i_\gamma b_\gamma g_\gamma 0.5 B \gamma N_\gamma$$

• For elongated foundations, then:

$$s_c, s_q, s_\gamma = 1$$

• Foundation factor below ground level :

$$po = Depth\ of\ foundation\ x\ \gamma Base\ ground = 1.5\ x\ 20 = 30\ kN/m$$

• Depth factor d_c, d_q, d_γ = 1s

• H =Σ P_a = 371.777 kN

• R_v = 1536.264 kN

• B' = B = 2 m

• A' = 4.775 m
So :

$m = \frac{2+b/L}{1+B/L}$ (because L is assumed to have infinite length)

$$i_q = \left[1 - \frac{H}{R_v + A'ccot\varphi}\right]^2$$
$$= \left[1 - \frac{371{,}777}{1536{,}264 + 4{,}775\ 20\ cot35}\right]^2$$
$$= 0.6048$$

For φ = 35, from table the carrying capacity factors of Meyerhoff (1963), Brinch Hansen (1961), and Vesic (1973), Nc = 46.12 N_c = 46,12, N_q = 33,30, N_γ = 37,15.

So :

$$i_c = \left[i_q - \frac{(1 - i_q)}{N_c \tan\varphi}\right]$$
$$= \left[0{,}6048 - \frac{(1 - 0{,}06048)}{46{,}12 \tan 35}\right]$$
$$= 0.592$$

$$i_\gamma = \left[1 - \frac{H}{R_v + A'ccot\varphi}\right]^{m+1}$$
$$= \left[1 - \frac{371{,}777}{1536{,}264 + 4{,}775\ 20\ cot35}\right]^{2+1}$$
$$= 0.4704$$

So:

$$qu = s_C\, d_C\, i_C\, b_C\, g_C\, c\, N_C + s_q\, d_q\, i_q\, b_q\, g_q\, p_o\, N_q + s_\gamma\, d_\gamma\, i_\gamma\, b_\gamma\, g_\gamma\, 0.5\, B\, \gamma\, N_\gamma$$
$$qu = (1\ x\ 1\ x\ 0{,}592\ x\ 1\ x\ 1\ x\ 20\ x\ 46{,}12) + (1\ x\ 1\ x\ 0{,}6048\ x\ 1\ x\ 1\ x\ 30\ x\ 33{,}30) + (1\ x\ 1\ x\ 0{,}4704\ x\ 1\ x\ 1\ x\ 0{,}5\ x\ 2\ x\ 37{,}15)$$
$$qu = 1167{,}731\ kN/m^2$$

Wall pressure on subgrade when calculated by Meyerhoff method:

$$q_{maks} = \frac{R_v}{L - 2e}$$
$$= \frac{1536{,}264}{6{,}024 - 2\ x\ 0{,}774}$$
$$= 343{,}222\ kN/m^2$$

Safety factor against subgrade bearing capacity failure:

$$F = \frac{q_u}{q_{maks}} = \frac{1167{,}731\ kN/m^2}{343{,}222\ kN/m^2} = 3{,}40 > 2$$ Ok!

If the structural pressure on the subgrade is assumed to form a trapezoidal distribution:

$$q_{maks} = \frac{R_v}{L} x(1 + \frac{6e}{L})$$
$$= \frac{1536,264}{6,024} x(1 + \frac{6\ x\ 0,774}{6,024})$$
$$= 451,626\ kN/m^2$$
$$F = \frac{q_u}{q_{maks}} = \frac{1167,731\ kN/m^2}{451,626\ kN/m^2} = 2,58 > 2$$ Ok!

So with L = 6.024 m, the wall meets the requirements for external stability.

Internal Stability

Try the vertical spacing of reinforcement S_v = 1 m. So the number of layers of vertical reinforcement is 7 meters : 1 meter = 7 layers.

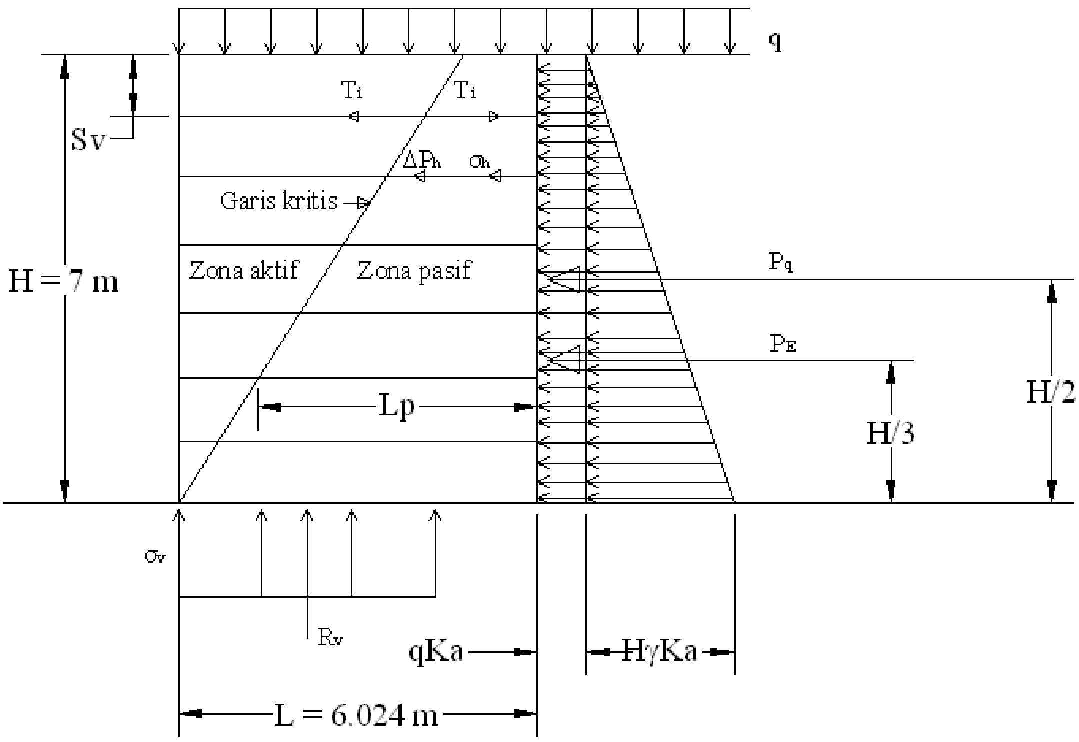

Figure 5. Forces acting on a reinforced retaining wall.

CLOSING

Assuming that the distribution of earth pressure on the soil is uniform then:

$$\sigma_v = \gamma z + q$$
$$= 18z + 110$$

Where K is equal to:

$$K_a = tan^2(45 - \frac{\varphi}{2})$$

$$K_a = tan^2\left(45 - \frac{35}{2}\right) = 0{,}2709$$

For sheet-shaped reinforcement, the price is K = K_a = 0,2709.

$$\sigma_h = K\sigma_v$$
$$= 0{,}2709\sigma_v \ kN/m^2$$
$$\Delta P_h = K\sigma_v S_v$$
$$= 0{,}2709 \ x \ \sigma_v \ x \ 1 = 0{,}2709 \ \sigma_v \ kN$$

The angle of friction between the soil and the reinforcement is:

$$\mu = tan\frac{2\varphi}{3}$$
$$\mu = tan\left(\frac{2x35}{3}\right) = 0{,}431$$

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