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## I. BACKGROUND

At the moment construction of a flood control reservoir is being carried out with a water holding capacity of 9,150 m<sup>3</sup> with a reservoir area of 3,650 m<sup>2</sup> resulting in the formation of slopes on the three sides of the reservoir with slope heights of 12.5-14.5 meters, with slope angles of 55-65 degrees, where the toping is a residential area (Sulardi, Agus Sugianto, 2018). The problem faced is the problem of the difficulty of installing slope protective wall structures, because of the steep slope conditions and limited land conditions. The causes of the problem are pair factors, namely the steep slopes and the specifications of clay material in blackish gray and delicate texture that is fragile and becomes porridge if exposed to rainwater (Sulardi, Agus Sugianto, 2018). For these problems, control has also been carried out by covering the slopes with tarps to prevent softening and landslide of land by rainwater. On the upper side of the slope is scovered with a thin layer of lightweight concrete to prevent the permeation of rainwater, and manual inclinor installation is performed to monitor slope movement (Sulardi, 2016). However, this does not solve the problem because partially, there is still a collapse of slope land debris, so it is feare that mass slope failure will occur if slope protection is not carry out immediately.

With the background of these problems, this research is to do to overcome the problem to provide answers to research questions and find how to deal with these problems and safely. If this research is not carried

out, the problem in the field will get worse, there will never be resolve, and the existing will also never find the answer. With this research, it is expectice that the problem can find with well, and the problems can be solved and safely.

The objectives expected to be achief through this research activity are (a) Provide a description of specifications, shapes, dimensions, and configuration of slope protective walls with the grasshopper feet method, and (b) Provide an overview of how to install slope protective walls with the grasshopper feet method. To achieve these objectives, further research questions were developed to be found through this research activity, namely (a) What is the description of specifications, shapes, dimensions and configuration of slope wall protection with artificial grasshopper foot method, and (b) How to carry out installation structure of slope wall with artificial grasshopper foot method.

The basic principle of protective slope structure with grasshopper foot method is to refer to the basic of balance on rock climbers or on grasshoppers who use both feet to rest and one hand to hold (three-point contact) so that their body weight can rest on vertical walls. The concept of a retaining wall using the artificial grasshopper foot method is a wall-mounted retaining wall made from reinforced concrete with ground anchor resistance at the top and in the contact area on the back side of the ground wall. This ground anchor pair serves to enlarge the resistance force (friction) on the ground wall so that it is safe against friction and lateral. This ground wall rests notch legs on size slopes that are installed every distance of 2 meters and installed zig-zag and so that it can suppress the shift of the ground wall towards the bottom. The gravity of the retaining wall is supported by the support of the drill pile foundation by reinforcing reinforced concrete wall fins.

## II. RESEARCH METHODS

### a) Approach methods

This research is used research using the case study approach method, namely case studies overcoming the difficulties of installing a protective slope of land on a flood control reservoir. The forces acting on the soil wall are lateral forces due to the active soil pressure of the slope as high as 13 meters and the vertical force in the form of soil retaining wall and soil weight. The stability of the lateral force is obtained by the ground anchor strength (Hary Christady Hardiyatmo,

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2001). At the topping of the concrete retaining wall slab and the installation of ground anchor made of 19 mm diameter reinforcement with a distance of 1-meter installed with zig-zag 2 meter depth with bored and mortar injection to produce a large resistance force and able to withstand lateral forces due to active soil pressure (Robert W. Day, 2006). The stability of the retaining wall against this lateral force is enlarge with pairs of stiffened concrete columns mounted vertically on the walls of the concrete slab at a distance of 3 meters. The potential for additional active soil pressure due to the water content is reduce by installing drainage pipes on the concrete slab every 1-meter distance. Vertical force derived from the weight of the concrete slab of the soil wall itself (Suyono Sosrodarsono, Kazuto N, 1988) is reduce by supporting feet on the back of the retaining wall so that the vertical force forwarded to the foundation is relatively small. The vertical style residuals that are not reduced by notch feet are supported by a 60 meter diameter drill pile foundation with a depth of 10 meters with reinforcement of a 5 meter high concrete reinforced concrete wall size mounted on 4 wind directions so as to produce carrying capacity large and safe supporting the structure of the retaining wall safely. The behavior approach of the slope wall protection structure to do by structural analysis using the STAAT Pro. V. 8i program (Sulardi, Agus Sugianto, 2018).

#### b) Specifications of protective walls of artificial grasshopper slopes

The specification of slope protective wall material with the grasshopper foot method adopts the refractory mounting with the foot placemat and anchor shear connector (Sulardi, 2017) and installing truck bonded soil walls (Sulardi, 2016).

The material specifications of the ground protective wall with the method of artificial grasshopper feet are as follows :

- Material specifications, reinforced concrete with concrete quality K-350
- Concrete slab wall, bottom side width. 30 cm and the width of the upper side. 15 cm
- Supporting tread, palm size. 45x60Cm, height 60 Cm, forms an angle of 90o to the slope and is fitted with a hose with a distance pole. 2 meters
- Ground anchor, with the basic material of 19 mm diameter reinforcement and protected with a corrosion-resistant coating, the depth of entry into the minimum soil. 90 cm
- Drainage pipe with thick layers of palm fiber. 5 cm
- Upper stiffeners, concrete blocks 15x20 Cm, 2 meters long with a threaded reinforcement. 19 mm with 2 meters embedded depth
- Formwork, thick multiplex. 14 mm with a laminate surface

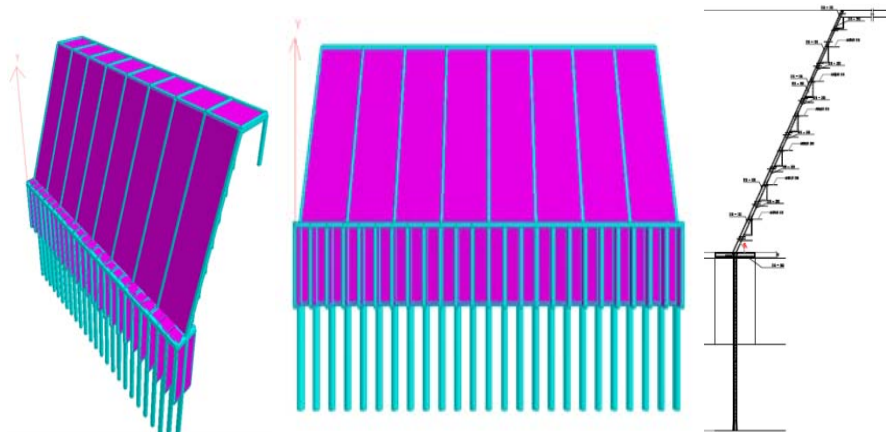


Figure 1: Slope wall protection with the artificial grasshoppers foot method

#### c) Equipment Used

- Digging and soil work
- Concrete work
- Tools b, Pipe mounting
- Tools c, Reinforcement and welding work
- Equipment d, Scaffolding, stairs, and
- Tools e, Other work
- Support f, Personal protective equipment (PPE) and other work safety equipment
- Other work aids according to the conditions at work

#### d) Installation Method

- Install the supporting foundation of the slope protective structure with a drill pile foundation structure reinforced with several fins so that the drill pile foundation becomes rigid, sturdy and stable
- Install the concrete slab capping on the slope protective structure, making sure the shape, dimensions, and configuration of the installation are in by the design
- Install work tools to help to scaffoldfor work, material and work equipment

- d. The shape of a support tread plate with shapes, dimensions, and configurations according to the design
- e. Install a series of reinforcement bonding beams at the top of the slope with minimum ground anchor depth. 2 meters
- f. Install a ground anchor with a threaded 19mm diameter material, insert it into the ground by pressing it to a minimum. 90cm by leaving the outside side as a binder of the wall reinforcement
- g. Install the reinforcement wall of the slope by making sure the concrete decking has firmly installed and tie a reinforcement circuit with the ground anchor tip
- h. Install drainage pipes, making sure the inside of the pipe has been wrapped in palm fiber
- i. Install slope protective wall formwork, make sure the drainage pipes are place, and the formwork has firmly installed
- j. Perform casting slope protective wall to a height of 120 cm and allow the concrete to harden well for 3x24 hours
- k. After the concrete hardens, do the casting again on top by first saturating the concrete covering with clean water and anchoring with a bonding agent, this casting reaches a height of 30% of the total height of the protective slope concrete wall and let it harden well
- l. After the concrete hardens, do the casting again on top by first saturating the concrete covering with clean water and anchoring with a bonding agent, this casting reaches a height of 50% of the total height of the protective slope concrete wall and let it harden well
- m. After the concrete hardens well, do the casting again on top by first saturating the concrete topping with clean water and anchoring with a bonding agent, this casting reaches a height of 75% of the total height of the protective slope concrete wall and let it harden well
- n. After the concrete hardens, do the casting again on top of it by first saturating the concrete covering with clean water and sprinkling the top with the bonding agent, casting it to reach the entire height of the protective slope, including the support beam at the top and let it hardens well
- o. Perform hard treatment (curing) by covering the topping of the protective wall of the slope with a wet sack
- p. Formwork can be remove if the concrete is 21 days old and has hardened completely, while still doing hard maintenance by moisturizing.

### III. RESULTS AND DISCUSSION

The structure of the sloping wall with the grasshopper foot method is the result of innovation by imitating the behavior of rock climbers and the behavior

of the grasshoppers that can rest on the upright wall with three supports namely on both legs and one hand, or with two hands and one leg can move upward steady and safely. The protective slab concrete slab wall has a wall supporting foot size of 45x60x60 Cm resembling a console every 2 meters apart which is installed alternately so that the wall load is flat. As a binder, ground anchors are used based on a screw diameter of 19 mm in diameter and are cooked into the ground by drilling and pressing. This ground anchor drill hole is first injection with concrete mortar as a bond. After hardening the ground anchor, it will function as an anchoring system in general. To repair between the inside of the protective wall of the soil and the slope of the soil surface, the surface of the targeted by notch so that the surface forms cracks when concrete mortar casting is carried out, the fillings will be filled with concrete mortar.

The results showed a 50 Cm diameter bored pile model with reinforced concrete fill material with FC.29,7 concrete quality, 5 meter drill mast depth, then at 5 meters above it consisted of a drill pole reinforced with 5 meter high concrete wall fins on the north, south, east and west with a fin length of 1.5 meters and after reinforced concrete fins are installed and filled with soil with brownish red sandy clay proven to support a 14 meter sloping wall slope angle of 65 degree. Based on the stress contour that works due to the combination load on the slope wall slab, the maximum stress that occurs is  $17.6794 \text{ N / mm}^2 < \sigma$  permits are  $289.2962 \text{ N / mm}^2$  (0.85 FC), within safe limits whereas the amount of deflection in the concrete retaining wall slab that occurs at the beam is  $-3.156 \text{ mm} < 10 \text{ mm}$  ( $1/200 \text{ L}$ ), within the safe limit. The foundation of the drill poles with stiffening fins is the development of tack foundation as a result of the improvement of researchers who have won the Gold Medal in the CIP program of PT. Pertamina and its status are currently in the progress of proposing patent rights at Kemenkumham with No. Registration P00201700891, dated February 08, 2017. The method of installation of slope structures with the grasshopper leg proved to be well applied and from work safety aspects during foundation work and installation of slope protective walls with the grasshopper foot method has donated 1,800 safe working hours (zero incident) without an accident.

The application of structural stability with the three-point contact principle on the protective wall is on pairs of footstools above the excavation sites which make the structure of the slope protective wall resting well on the slope so that it becomes an inseparable part and can protect the soil from the effect of rainwater runoff so that it can prevent slope landslides. The sites on the slope surface will function as a substitute for the practice foundation, and the ground anchor will be a substitute for the nature of the grass roots which can tie the aggregate to the slope so that it blends well. The

roughness of the soil surface, which is then covered by concrete mortar will be a substitute for hair roots in grass plants which enlarges the bond between the soil and the slope-protective structure. The drainage pipes on the protective slope concrete wall will drain the water trapping in the ground slope so that it can reduce and suppress as little as possible the influence of water weight on the soil wall and the presence behind the soil wall, while a water that is not drained out will function the soil remains moist under conditions of maximum plasticity.

#### IV. CONCLUSION AND SUGGESTIONS

##### a) *Conclusions*

From the research activities that have been carried out, the following can be take:

1. Specifications of slope protective wall structure with grasshopper foot method is reinforced concrete slope protective wall equipped with the ground anchor at the top and on a concrete slab with 19 mm threaded diameter reinforcement armature material 2 meters deep, equipped with supporting footprints inside and drainage channels to remove water content in the slope.
2. The method of installing retaining walls is a method of artificial grasshopper feet by installing pedestal foundations, installing capping beams, installing anchor toppings, installing placards and ground anchor walls, installing drainage channels, installing reinforcements and formwork and casting using FC. 29,7 concrete quality mortar.

##### b) *Suggestions*

The following are some suggestions that can be given for further research related to the use of slope protective structures with the grasshopper foot method as follows:

1. The research is needed to make the protective wall of the slope of the grasshopper foot method with precast concrete slab by first installing a ground anchor to fasten the precast concrete slab
2. It is necessary to develop segmental protective slope structure methods to install precast retaining wall concrete slabs on ground anchoring so that the installation is faster and more practical.

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