EVALUATION THE USING OF PLASTIC SACK RUBBISH AS FABRICS ON EXPANSIVE EMBANKMENT

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ABSTRACT

Soil stabilization or soil treatment has been employed and developed time by time. Fabrics are commonly used, especially polypropylene (PP), polyvinyl, or polyethylene. Plastic rubbish is solid waste that comprised by PP. This paper described them as soil reinforcement and their application. The fiber mixtures vary in length that are 5 mm, 10 mm, 20 mm and the content 0.5%, 1% of dry weight. The main equipment for this test is direct shear test (DST).

According the test result and discussion, it was shown that the rubbish (plastic sack) has enhanced the shear strength of clay soil. Fiber content 0.5% is better than 1 % to provide shear resistance. The stability of embankment, analyze by Bishop Method with RSS program, increased from 1.458 to be 2.247 at 0.5% fiber content – length 20 mm.

Keyword: fiber, inclusion, reinforcement.

INTRODUCTON

Soil stabilization or soil treatment has been done since ancient period. Meanwhile, the technique or method in soil stabilization developed time by time. Some technique was presented and employed by researchers and engineer. Unfortunately, because of the soil condition in nature are varies and very complex to defined, it caused any difference techniques due to a case and others. Therefore, the technique could not be generalized for all soil type in varies state. In general, on techniques is proper to one soil type, others (*Lee, et all, 1983*). One of the technique, that aim giving the reinforcement to soil with include materials into soil mass.

Generally, in the mezzo scale, the inclusion materials use mezzo elements (not too large) and mixing into soil randomize. This method was developed from reinforcement concept that contributed by root. Fabrics are commonly used as inclusion materials, especially polypropylene, polyvinyl, or polyethylene. Really, that is more expensive, relatively. Meanwhile, plastic also consist of those materials, but their strength may not equal with geosynthetics. Daily, we know that plastic as waste, perhaps, cause pollution to environment. On the one side, this problem should be solved by proper technique.

When, the plastic waste was placed on the adequate placement, possible, they contribute more advantage. In the civil work, such as soil reinforcement, might they can be meritorious. According their material consisted, this paper concern with the utilization of plastic sack fiber's as inclusion material into expansive embankment. The using in civil work may contribute to solve waste excess in the world.

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THEORY

Soil reinforced with fabric

Henry Vidal (*France*) in 1969, first, employed soil reinforced with included metal plate into soil. *Mc. Gown et all* (1978) implemented a technique with high strain material which their failure strain is higher than soil's. Therefore, reinforcement worked at low strain to stain failure of soil. After the strain-failure was elapsed, reinforcement remains giving tensile strength. This stage prevented sudden failure.

The concept of soil reinforced with fabric was developed from soil reinforcement with adventitious root. The main problem within root is weathering along with the time, moreover, if the plant is wilt eventually. Weathering of root will form a hollow space that ease water flow through soil and reduce the stability. Other, it need more time to prepare those root be strong and include to soil mass. According this state, a research should be governed to fulfill the root problem by mean substitute root with imbedded synthetic fiber into soil mass. Obviously, the fiber is better, strength and lifetime, than root.

Soil reinforced with fabric is based on the shear strength both soil particle and fiber. As know that, soil disable to against tensile stress. The basis concept is illustrated in Figure 1 below (*Muntohar, 1999*).

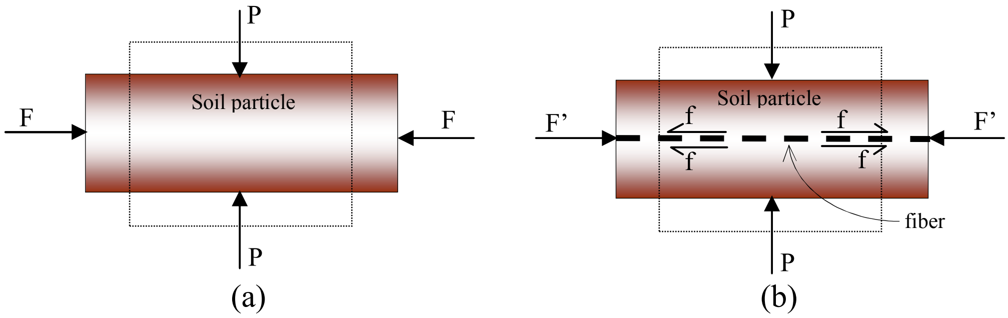


Figure 1. The basis concept of soil reinforced with fiber (a) without reinforcement (b) with fiber inclusion (*Muntohar, 1999*)

Mercer et all (1992) applied the fiber inclusion with *mesh elements* at spur horse arena, parking area for heavy weight vehicle, roadway shoulder and runway. The result is well and satisfies. *Alwahab* and *Al-Qurna* (*1995*) has ever done the research. The research shown the fiber included within clay soil had ability to enhance soil strength.

Some research presented difference properties between pure soil (without reinforcement) and soil reinforced with fabrics. *Nataraj* and *Mc. Manis* (*1997*) has been implemented a series of laboratory test for soil reinforced with fibrillated fabrics. The experiment result increasing parameter of shear strength of soil i.e.: internal friction enhanced to 64 %, and 45 % for soil cohesion.

For a fabric imbedded in soil, *Broom* (within *Koerner and Welsh, 1980*) also has conducted an interesting series of laboratory triaxial tests. His work is for dense and loose sands at low (20 kPa) and high (200 kPa) confining pressures. In these tests, Broom puts the fabrics within three configurations. The fact shows that placement of the fabric caused increasing deviator stresses. The proper configuration where fabrics are placed on top and bottom, and center of specimen has highest deviator stress for dense and loose sand. Therefore, it indicates if fabric was placed at properly places, it will be give highest strength.

Plastic Rubbish and Their Properties

Rubbish is solid waste that consists of unused organic and inorganic substance, they should be recycled in order safe and friendly with environment, and to maintain the development invest due to damage. This statement was declared at the decree of Minister of Public Work No. 184/KPTM/1991 concerning the endorsement of 18 The Concept on National Standardization (SK SNI) in Public Work sectors. (*Hartoyo, 1998*)

Chemically, plastic sack is categorized into inorganic solid waste. The plastic sack is light in weight and useful, frequently, as cover for some material such as granular and powder. Therefore, plastic sack is more advantage than other pack (*Anonymous, 1994*) as follows:

1. Resistance acid and bases,
2. Endurance to microorganism,
3. Ductile,
4. Resistance to compression caused by heavy weight,
5. Failure strain 14% - 25% highly than others sack like as gunnysack, 3% only.

The raw material of plastic sack is *polypropylene* (PP) and their properties as shown as follow (*Anonymous, 1984*):

1. Specific gravity: 0.902 – 0.906
2. Tensile strength: 31000 – 38000 kN/m^2 (4500 – 5500 lb/in^2)
3. Compression strength: 38000 – 55000 kN/m^2 (5500 – 8000 lb/in^2)
4. Striking resistance: 0.03 – 0.1 m – N/m (0.5- 2 ft – lb/in)
5. Toughness: R85 – R110

EXPERIMENT DESIGN

Material

The soil is expansive clay. It was dug from quarry in Ngramang, Kedungsari, Pengasih, Wates, Kulon Progo. The area is under D.I. Yogyakarta province. The sample was sieved and passed the sieve size #40 (ASTM standard).

The fiber or fabrics is used plastic sack. The plastic sack is rubbish taken from TPA Piyungan. Their strength is appropriate lower than fabricated. To determine the fibers, the sack was cut off within vary length size, such as 5 mm, 10 mm, and 20 mm. The width of fiber is 2 mm.

Then, both soil sample and fibers was blended randomize and made and formed in the direct shear test ring; diameter 10.14 cm and height 11.68 cm. The fiber content is also varies 0.5% and 1% of soil in dry.

Test Equipment

The main test equipment is a set direct shear test (DST). The test was implemented at unconsolidated undrained (UU). It means that along horizontal moving, the sample could not be consolidated and pore water was not permitted to drain. The velocity rate of horizontal shifting was set constant 0.6 mm/minutes. Other test was implemented such as Atterberg limit, grain size distribution, CBR, and free swelling test to determine the clay soil properties.

TEST RESULT

Soil Properties

The physical and geotechnical properties of tested soil as show as in the Table I following.

Table I The tested soil properties

Physical and Geotechnical Properties	Result
Grain size:	
- Finer	84.64%
- Coarse	15.36%
- Clay particle	40.00%
Natural moisture content	45.45%
Atterberg limits:	
- Liquid limit (LL)	81.55%
- Plastics limit (PL)	23.15%
- Plasticity index (PI)	58.40%
- Shrinkage limit (SL)	13.76%
Shear strength parameter:	
- Cohesion (c)	34.14 kPa
- Internal friction angle (φ)	15.09^{O}
California Bearing Ratio:	
- Unsoaked	1.92%
- Soaked	0.57%
Free swelling (primary swell)	41.91%

Base on the Unified Soil Classification System, the specimen is categorized into CH. It is clay with very high plasticity.

Shear Strength

The shear strength was known from DST. The test data, then, was analyzed and the result can be seen in the Table II to Table III below.

Table II Shear strength parameter from DST with varies fiber content and length

Fiber Content (%)	Cohesion (kPa) at fiber length:			Internal friction ($\_^{O}$) at fiber length:		
	5 mm	10 mm	20 mm	5 mm	10 mm	20 mm
Clay	34.14			15.09		
0.5	48.82	44.67	50.87	25.59	37.30	38.06
1	54.09	41.25	36.24	23.86	27.50	52.37

Table III Shear strength with varies fiber content and length

Fiber content (%)	Shear Strength (kPa) at varies fiber length								
	under σ_n = 12.71 kPa			under σ_n = 25.42 kPa			under σ_n = 50.84 kPa		
	5 mm	10 mm	20 mm	5 mm	10 mm	20 mm	5 mm	10 mm	20 mm
Clay	37.57			41.00			47.85		
0.50	54.90	54.36	60.82	60.99	64.04	70.77	73.17	83.41	90.67
1.00	59.71	47.87	52.72	65.33	54.49	69.21	76.57	67.72	102.18

The data above will be applied in embankment stabilization that will be presented later.

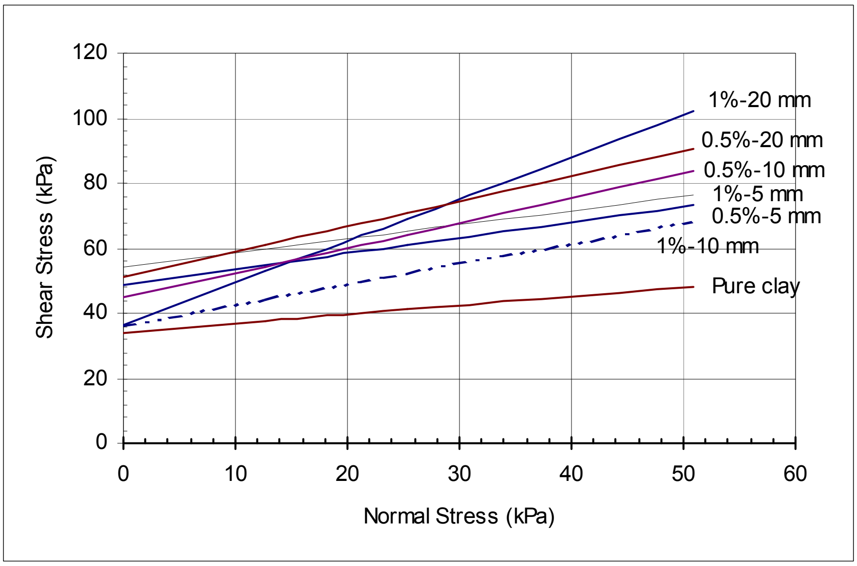


Figure 2. Cohesion and internal friction angle determination in varies fiber length and content

Shear Stress – Shear Displacement Relationship

The shear stress and shear displacement, as the result from DST, is given in the Figure 3 to 5.

DISCUSSION

Shear Stress – Shear Displacement Behavior

The shear stress and shear displacement relationship, each mixed with fiber, is presented in the Figure 4 to 6 above. These figure show that the clay soil, without fiber mixing, has lower shear strength than the clay reinforced with fiber. In the different normal stress, also represent the same behavior that the clay soil imbedded with fiber has higher shear strength. The maximum shear stress was attained at fiber length 20 mm in varies normal stress (see Figure 3 to 5).

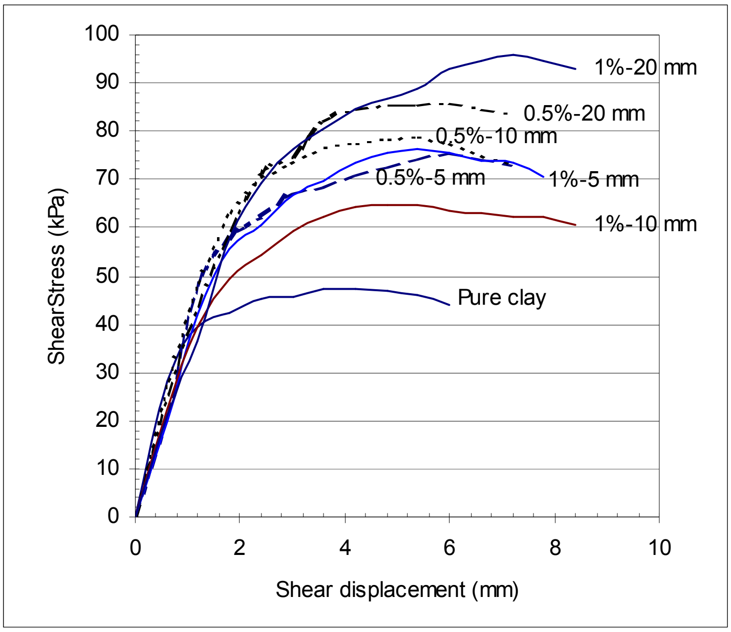


Figure 3. Shear stress – displacement relationship in varies fiber length and contents under 50.84 kPa normal stress

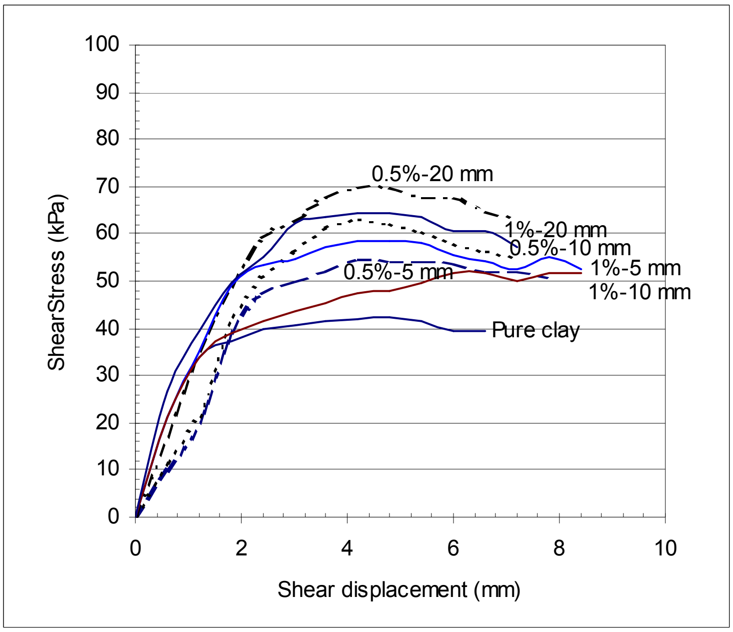


Figure 4. Shear stress – displacement relationship in varies fiber length and contents under 25.42 kPa normal stress

Other side, the kindness of the mixed fiber into soil has ductile behavior. It can be seen after their peak was elapsed, they remain available against with shear resistance until the rupture attained. It indicates that the composite material has been established. Hence, the sudden failure can be prevented early.

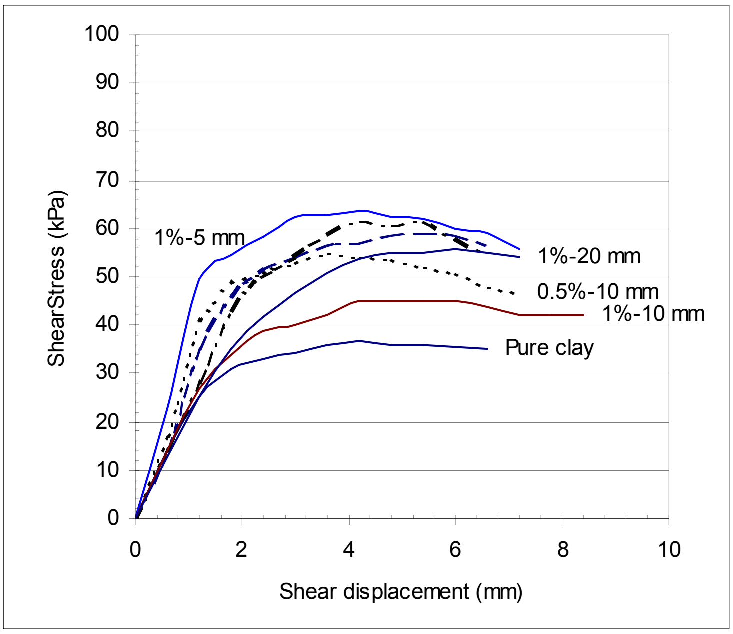
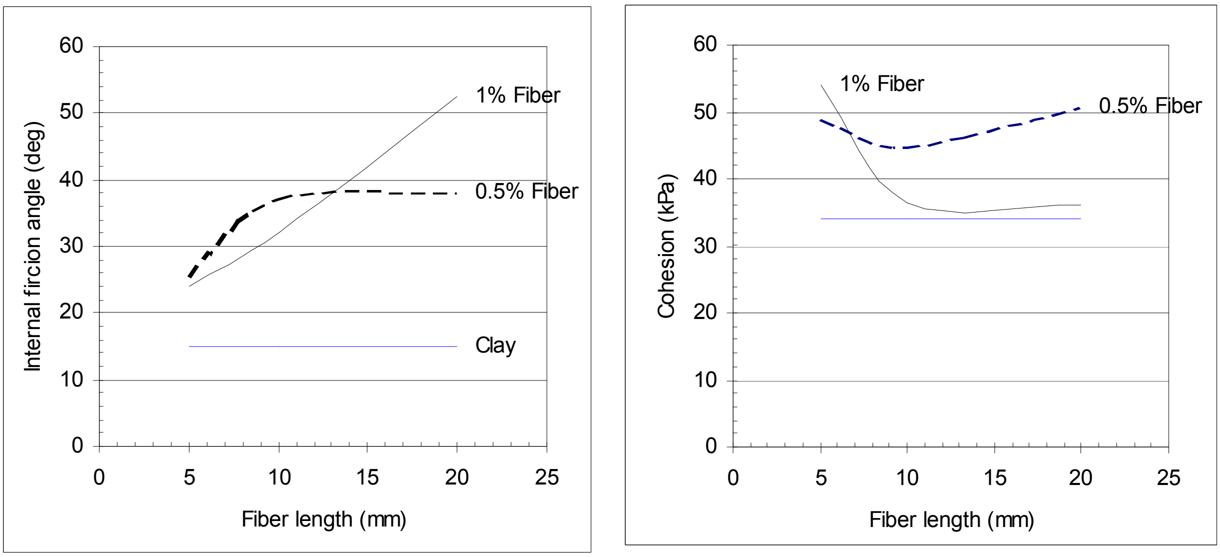


Figure 5. Shear stress – displacement relationship in varies fiber length and contents under 12.71 kPa normal stress

Shear Strength Parameter

Shear strength parameter was determined by mean plotted the shear stress as vertical axes and normal stress as horizontal axes within a graph (see Figure 2 previous). The slope of linear line is the internal friction, and the intersections point both linear line and vertical axes defined the soil cohesion (*Cernica, 1998*). To calculate and to determine the shear strength parameter and to illustrate the stress-strain relationship was used a soil mechanic package program, SMLAP. It is easier and accurate to use.



(a) (b)

Figure 6. Shear strength parameter with vary fiber length, (a) internal friction angle, (b) cohesion

The shear strength parameter of clay soil, without fiber, is defined respectively 34.14 kPa for cohesion and 15.09^{O} for internal friction angle. Mixed fiber was changed the soil cohesion and internal friction angle, as presented in Figure 6. Fiber mixing has enhanced the soil cohesion and internal friction angle. The fiber length, as shown in Figure 6(a), has increased the internal friction angle. Otherwise, despite the internal friction increased, the cohesion is not interfered by fiber length. Instead, the cohesion inclined to decrease due to increasing length (see Figure 6(b)), but the cohesion is still higher than clay soil. *Vidal* (*1969*) described that was composed by composite soil reinforced with fabrics.

Change of shear strength parameter, cohesion and internal friction angle, caused the change of shear strength as shown in the Figure 7. The shear strength tends to increase with increasing fiber length. The highest strength was attained at 20 mm fiber length.

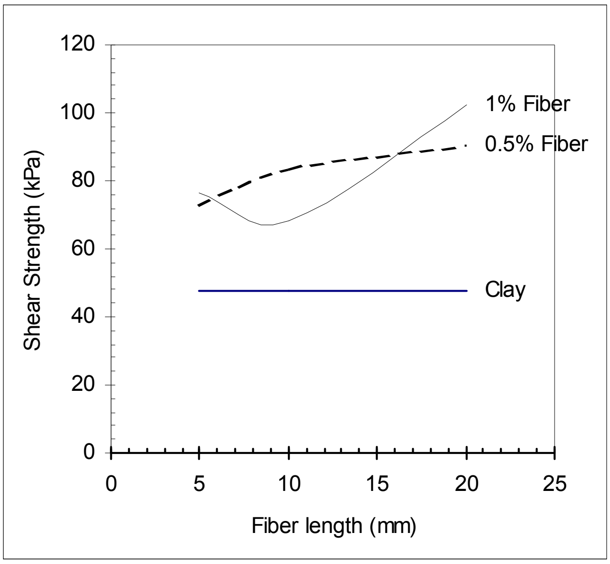


Figure 7 Correlation fiber lengths with shear strength under 50.84 kPa normal stress

Embankment Evaluation

To evaluate the usage of plastic sack fiber, this paper describe with case study. The evaluated embankment is represented in the appendix. To calculate and analyze the slope stability was used a computer program "Reinforced Slope Stability" (RSS) version 2.0 that was developed by GEOCOMP Corporation and FHWA. The input and output of RSS can be seen in the appendix.

According the slope stability analysis, the safety factor (SF) of the embankment, without imbedded with fiber, is 1.458 less than required SF = 1.5. The condition different after the embankment reinforced with plastic sack fiber. The safety factor change to be, respectively, SF = 1.770, and SF = 2.247 at fiber mixed 1% - length 10 mm, and 0.5% fiber – length 20 mm. The detailed result as given in the Table IV below.

Table IV Slope stability analysis with RSS, the SF of embankment

Fiber Content (%)	Safety Factor (SF)			Remarks
Fiber length	5 mm	10 mm	20 mm	
Clay	1.458			SF < required SF (-1.5), the slope instable
0.5	2.015	1.966	2.247	SF > 1.5, the slope stable
1	2.204	1.770	1.736	SF > 1.5, the slope stable

From the Table IV above can be concluded that the fiber mix has increase the stability of embankment. Nevertheless, at 1 % fiber content, the safety factor inclines to decrease.

It is caused by decreasing of soil cohesion and the unit weight of soil. Although, the plastic fiber has enhanced the safety of slope, it is also important to know how the rate of consolidation. Remind, the embankment is compacted with rubbish materials, it is well to test the other geotechnical properties.

CONCLUSIONS

According the test result and previous discussion, it can be known that the rubbish (plastic sack) has enhanced the shear strength of clay soil. Mixing of 0.5% fiber content is better than 1 % to provide shear resistance.

The stability of embankment, analyzed by Bishop Method with RSS program, increased from 1.458 to be 2.247 at 0.5% fiber content – length 20 mm. Although the shear strength of soil enhance for each fiber content and length, it should be detailed with other test to know other geotechnical properties.

ACKNOWLEGMENT

The support provided by Soil Mechanic Laboratory during this research is appreciated. The author also wishes thankful to Endang S. Hisyam, ST., who assisted and prepared this research. The great thank is also appreciated to Prof. Dr. Buddhima Indraratna. M.Sc. (Department of Civil Engineering, University of Wolongong, NSW Australia), who urge the author.

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The Input Data for RSS Computer Program

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*****************************************************************************
*****                              R S S                               *****
*****                   Reinforced Slope Stability                     *****
*****             (c)1992-1996 by GEOCOMP Corp, Concord, MA            *****
*****************************************************************************

         File: D:\CIVILI~1\RSS\imogiri.dat
         Date: Mon 01-01-:1, 10:36:36
         Name: Agus SM, ST.
Problem Title: Penelitian Embankment Jl. Imogori
  Description: Inklusi serat - serat plastik (Kondisi Tanpa Serat)
      Remarks:
*****************************************************************************
*****                            INPUT DATA                            *****
*****************************************************************************
Data for Generating Simple Problem

               X-Coordinate for Toe of Slope: 10.00 m
               Y-Coordinate for Toe of Slope: 10.00 m
                             Height of Slope: 6.00 m
                              Angle of Slope: 80.0 deg
                  Angle Above Crest of Slope: 0.0 deg
              Surcharge Above Crest of Slope: 1.0 kPa
          Depth to Water from Crest of Slope: 2.00 m
                Unit Weight of Soil in Slope: 16.80 kN/m^3
                  Cohesion for Soil in Slope: 34.14 kPa
            Friction Angle for Soil in Slope: 15.1 deg
           Unit Weight of Soil in Foundation: 16.80 kN/m^3
             Cohesion for Soil in Foundation: 34.14 kPa
       Friction Angle for Soil in Foundation: 15.1 deg
          Required Internal Factor of Safety: 1.50
           Required Sliding Factor of Safety: 1.50
Earthquake Loading
       Horizontal Acceleration Coefficient: 0.100
         Vertical Acceleration Coefficient: 0.000
*****************************************************************************
*****                             RESULTS                              *****
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Critical Surface
       Factor of Safety: 1.458
       Circle Center X : -2.40 m
       Circle Center Y : 26.98 m
       Circle Radius : 21.03 m
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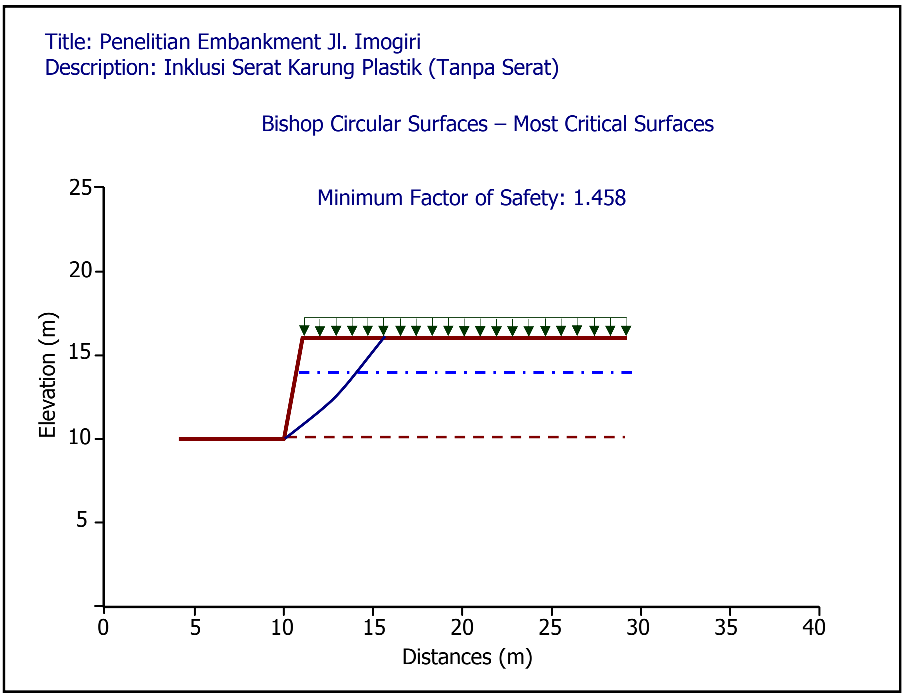

Figure A.1 The critical surfaces, print out of RSS for clay embankment without fiber inclusion

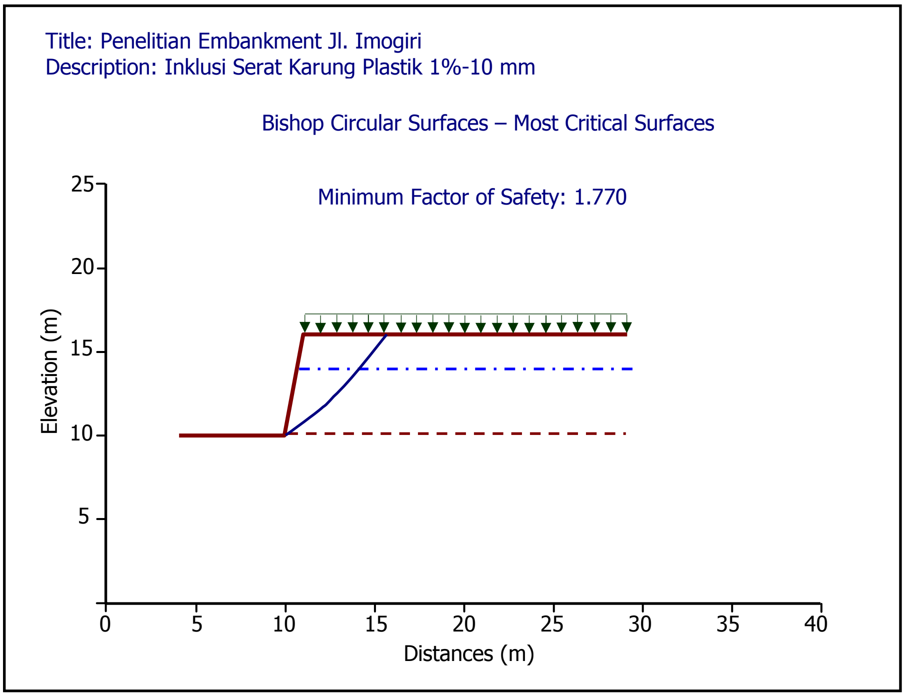

Figure A.2 The critical surfaces, print out of RSS for clay embankment with fiber 1% - 10 mm