


# Chapter 164

## Stability analysis of talude of areal Morro Branco by simulating GeoSlope software

 [10.56238/tfisdwv1-164](https://doi.org/10.56238/tfisdwv1-164)

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### **ABSTRACT**

Stability analysis of slopes is of significant importance today. This is due to the need for urban expansion and to take care of places whose stability is given by a slope. Therefore methodological study in the geotechnical area has become a great increasing in the last years. Such increasing is a result of technological advances that make it possible to obtain more accurate data and effective, whereas they seek provide more security on the slopes due to the population growth including others applicabilities on the various branch of engineering. Slope stability analysis must consist of the factors of more relevance like topography, the ground geology, hydrogeology, weather and the humans actions interference on the place, mainly if this place is in an urban area or next to one, furthermore, the entire stability of the area who is studied, will be guaranteed with positives considerations of these factors. The present research has its main focus, the elaboration of an analysis the stability of a slope on the sandpit of Morro Branco (situated on Porto Grande-AP city council), in order to verify and analyze the surface of rupture. This analysis was employed the Bishop method for slope stability checking, with the use of the software GeoSlope-GeoStudio<sup>®</sup>, which will identify the slope safety factor studied.

**Keywords:** stability, slope, software, factor, security.

## **1 INTRODUCTION**

The stability of stooqe is an area of geotechnical study that has evolved over the years. This development occurred mainly due to technological advances, which seeks to provide more efficient, cheaper and safer services and products. In this case, ensuring the permanence of safe and effective areas is important and can be used in various engineering sectors such as road construction, railways, mining, etc.

This type of analysis depends on a number of factors that stand out, topography, geology, hydrogeology, climate, earthquakes and even human action itself, and this instability will almost always be the result of one or more of these factors.

With the advent of computer science, which brought a significant increase in the ability to calculate with more speed, it is possible to make faster analyses and with less possibility of errors than manually. With the help of these tools, it is easier and safer to evolve the calculation methods, and it is now possible to analyze several possibilities in an even smaller time, point out criticisms and identify limitations that these methods have.

Numerical methods are employed in engineering due to their better efficiency, compared to classical methods, but still cannot predict with full precision the behavior of anisotropic bodies (when behavior varies with direction).

The main focus of this work is to develop an analysis of the stability of a hill top of The Areal de Morro Branco (located in the municipality of Porto Grande-AP), in order to verify and analyze the rupture surface. In this analysis, the Bishop method was used to verify the stability of the slope, using the *GEOSLOPE-GEOSTUDIO program*®, which will identify the safety factor of the slope studied.

## 2 MATERIALS AND METHODS

The analysis of stability of slope in the area of geotechnics was for many years performed based on the Limit Balance Theory, and is still used today. This type of analysis formulates hypotheses about stresses along the surface and requires information on soil resistance (FERREIRA, 2012).

The theory is used in order to estimate the balance of a soil mass, where the rupture occurs along a surface. The rupture resistances are equal at all points along the ruptured surface, adopting a safety factor equal to 1.0, in balance or imbalance (FIORI; CARMIGNANI, 2009).

According to Fabricio (2006), the analysis can be considered directly, being relevant the entire length of the surface or by segments of the mass. Most methods are based on the Limit Balance Theory, and have been perfecting themselves with demonstrations of calculations performed by computer software.

### 2.1 SAFETY FACTOR

For the occurrence of instability of a talude, factors such as: modification of the mechanical characteristics of the soil can be listed; modification of the groundwater level throughout the year; occurrence of earthquakes and changes in the geometry of the talude. The presence of these factors has as a consequence the increase in the active forces and decreased soil resistance, which leads to the slippage (SILVA, 2011).

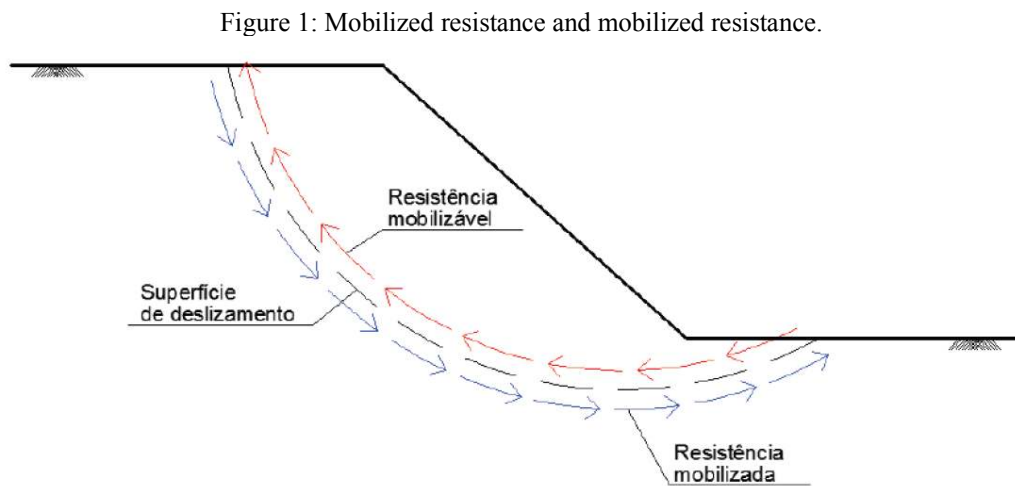
The slip will happen when the stresses of mobilized cuts of the ground in a longitudinal extension of a surface are exceeded, however when critical state conditions are reached there is shear resistance is mobilized by the ground, with the function of stabilizing the set of acting forces.

Figure 1 helps to understand the two forces at the ground, where: the forces that induce the slip represented by blue arrows, and the forces that resist the movement represented by the red arrows.

Thus, the safety factor of the slope is defined according to equation 1, making it possible to analyze the stability of the slope.

$$FS = \frac{t_b}{t_{mob}} \quad (1)$$

Where  $t_b$  portrays the mobilized resistance and  $t_{mob}$  the mobilized resistance.



Source: FERREIRA, 2012.

Under different conditions of slope limit balance, it is calculated between the ratio of the forces resistant to slipping and the forces favorable to movement, and the FS is expressed in equation 02.

$$FS = \frac{\text{forças resistentes}}{\text{forças favoráveis}} \quad (2)$$

In Tabela 1, the classification of taludes according to the result of the safety factor is shown, for the analysis of its stability.

Table 1: Classification of the stake according to the FS.

Safety Factor (FS)	Relative stability
FS < 1	Unstable (right break)
FS = 1	Unstable balance
1 < FS < 1.5	Precarious stability
FS ≥ 1.5	Stable

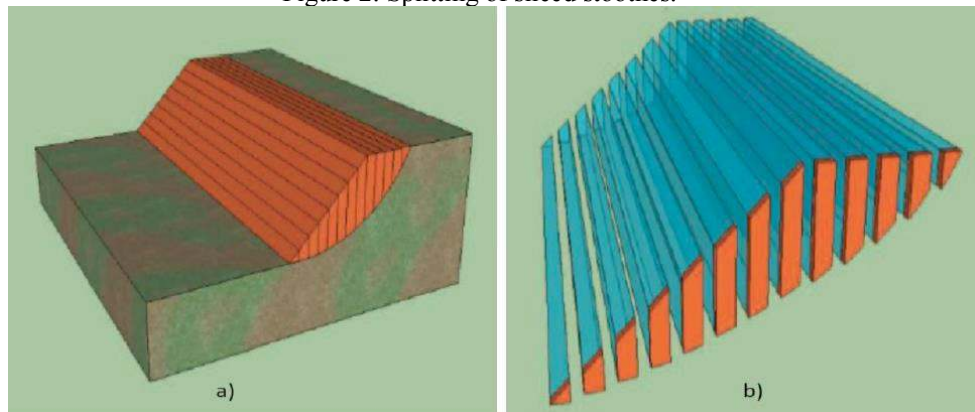
Source: SILVA, 2011.

## 2.2 BISHOP METHOD

The Bishop method considers the analysis of a talude, using the resulting forces (acting) existing in the middle of the reactions between horizontal and vertical direction slices (Figura 2) (Figura 3), on

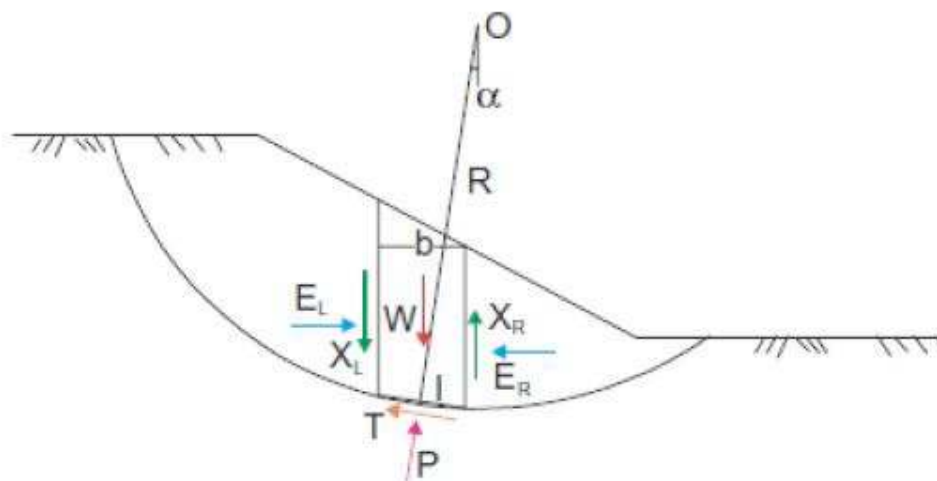
circular surfaces. This method is an improvement of fellenius' method, since it disconsiders horizontal forces.

Figure 2: Splitting of sliced stoothes.



Source: SILVA, 2011

Figure 3: Forces applied to a slice of soil by Bishop's method.



Source: LIMA, 2002

The hypothesis of analysis considers: the forces between the slices are horizontal, the rupture surface is circular, there is no shear force between the slices, ignores the forces of cuts between the slices and satisfies the balance of moments. The safety factor (FS) can be determined using equation 3.

$$FS = \frac{\sum[c.l + (P - u.l).tg\phi]}{\sum W.sen\alpha} = \frac{\sum[c.b + (W - u.b)tg\phi]}{m\alpha} \quad (3)$$

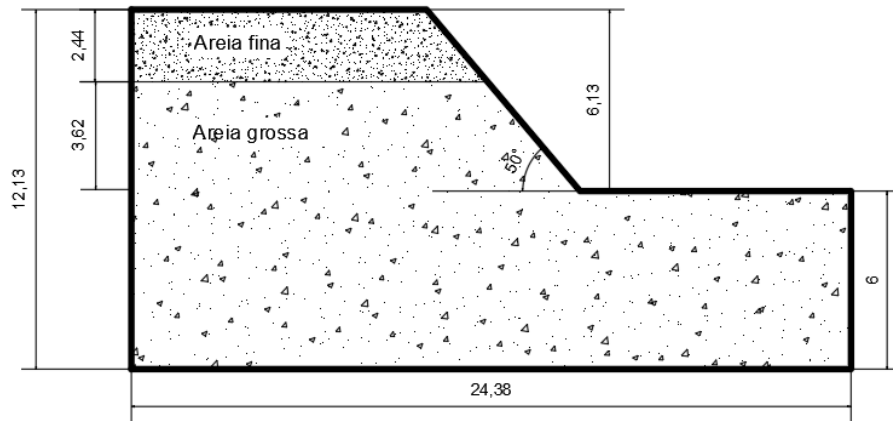
### 2.3 USE OF GEOSLOPE-GEOSTUDIO® SOFTWARE IN TALUDE STABILITY ANALYSIS

The stability of the slope studied was analyzed using bishop's slice method with *GEOSTUDIO®* *GEOSLOPE* software. The properties for analysis (Tabela 2) were determined with a specific weight in situ, cohesion and friction angle test in the parameters proposed by Marangon (2006). The geometry of the stake adopted in the work is illustrated in Figure 4.

Table 2: Properties of the table to be analyzed.

Soil Properties	Data
Specific weight fine sand ( $\gamma$ )	1.5 KN/m <sup>3</sup>
Specific weight coarse sand ( $\gamma'$ )	1.7 KN/m <sup>3</sup>
Cohesion (c)	0 KPa
Friction angle ( $\phi$ )	30°

Figure 4: 2D profile of the slat.



## 2.4 USE OF GEOSLOPE GEOSTUDIO ®

*GEOSLOPE* is a program that presents a simple interface facilitating its use, and can be applied to slope analysis, dam, foundations and other technical applications (Figura 5). For analysis of the scan under study, the standard sequence used in Table 3 is used in the mong.

Figure 5: GEOSLOPE software interface.

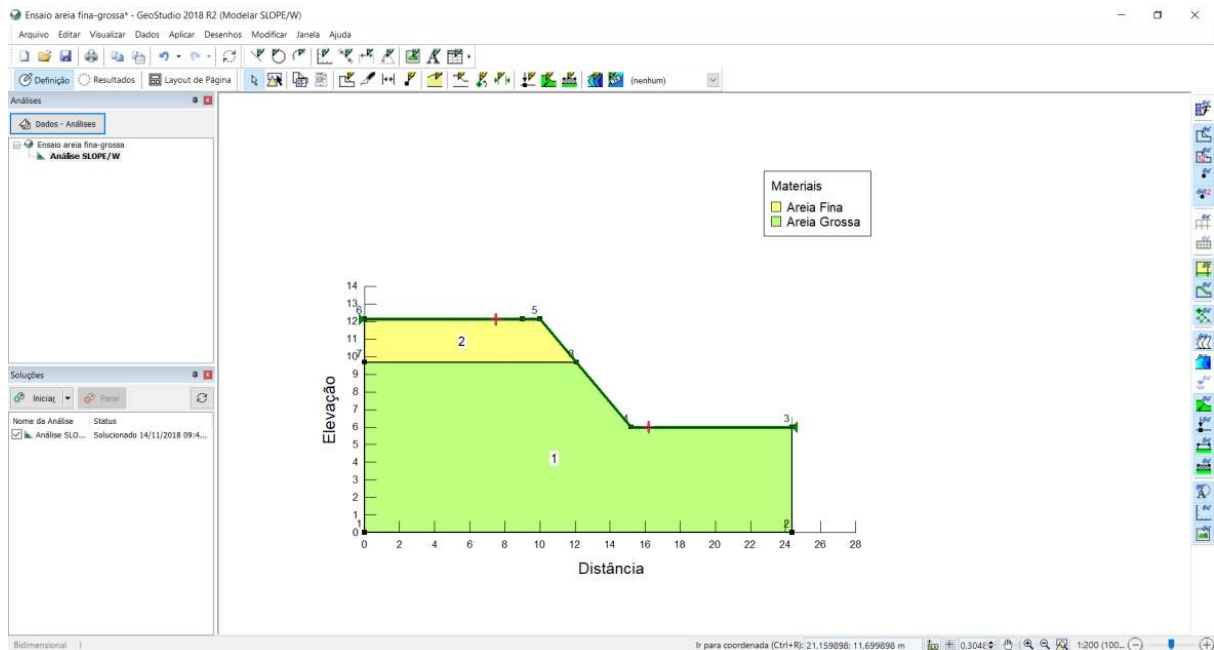
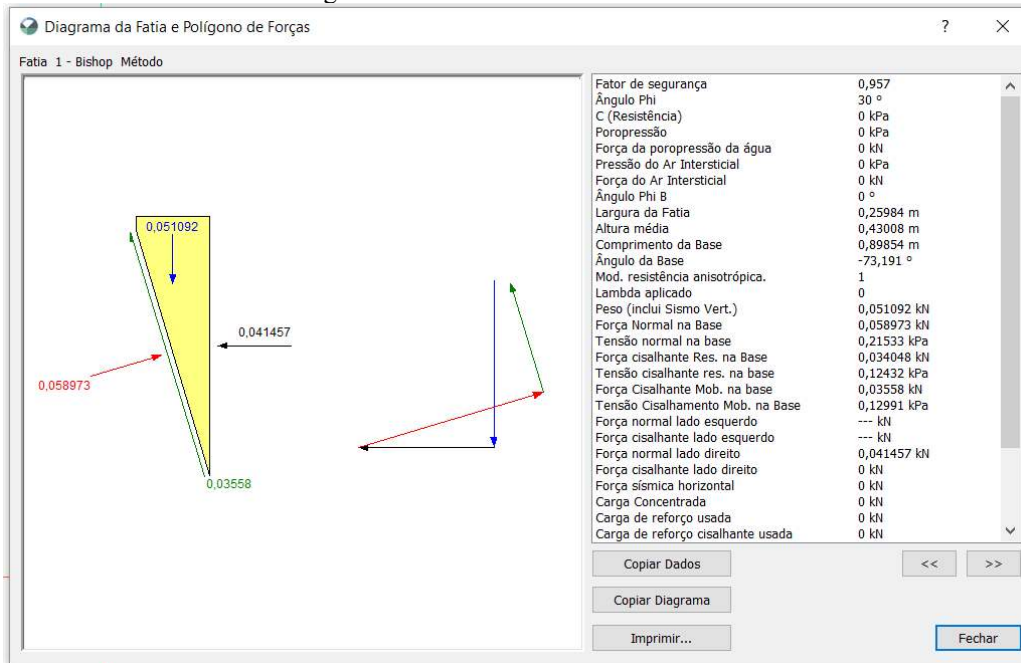


Table 3: Steps for application of GEOSLOPE Software in slope stability under study.

Stage	Description
a) Definition of geometry	6.13 m with 50° slope
b) Dimensions of layers with distinct properties	Fhi considered two types of materials constituent of the talude (table 02)
c) Definition of water level	The talude was considered dry (no water level)
d) Definition of the properties of the materials of the layers	AS soil propriedades are presented in Tabela 02 (Coesão, angle of friction, density)
e) Choose the method for analysis and define the number of slices in the	the method of analysis chosen was the Bishop Method, with 30 slices.
f) Results	The results are commented on in the item.

Figure 6: Forces at work on a slice of the talude.

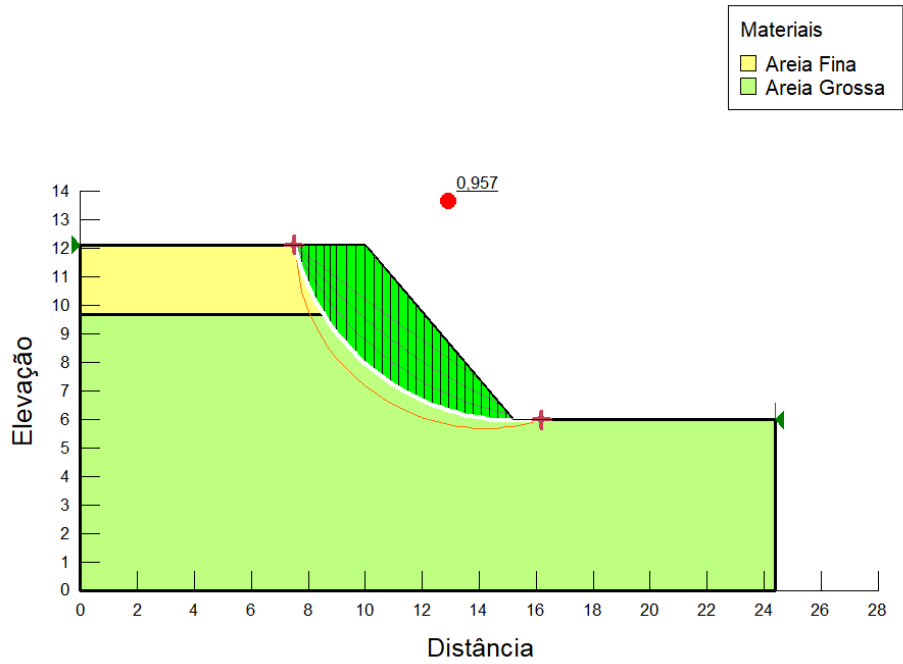


The reason for the sum of the disturbing forces by the sum of the forces resistant to the rupture of the talude is equal to the safety factor. The software allows you to visualize the scheme of forces at work in each slice, as an example of Figure 06.

### 3 RESULTS AND DISCUSSION

The safety factor obtained by Bishop's method through *the GEOSLOPE* software was 0.957, which means that it is in critical conditions of resistance and inence of rupture. To apply the rupture geometry, that is, the entry and exit of the rupture was considered 2.5 m at the entrance and 1 m at the exit, because the scale presented traction crack at 2.5 m from the crest of the ridge, so the slip occurson the face of the ridge. Figure 7 shows the profile of the rupture (green zone in slice), possible rupture extensions in this profile (lines) and entry and exit of the search surface (red cross).

Figure 7: Result of the calculation by bishop's method and the safety factor at the top (0.957).



Normal tension, mobilized shear and shear resistance are represented in figures 8, 9, 10, respectively. The graphs show that the highest stresses add up to 5.5 m from the beginning of the stresses (traction slit) towards the foot of the talude, which represents that the highest stresses are located near the foot of the same.

Figure 8: Graph of the normal tension along the course.

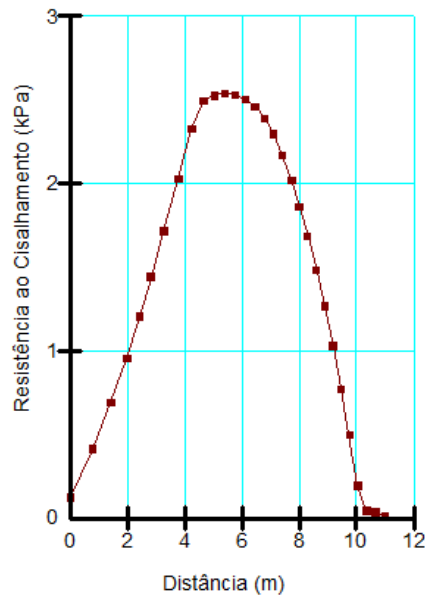
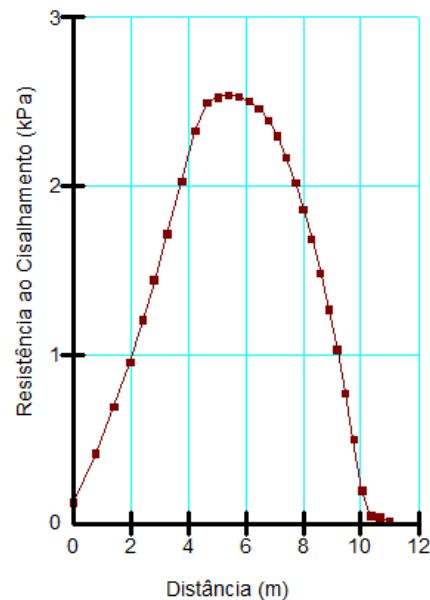
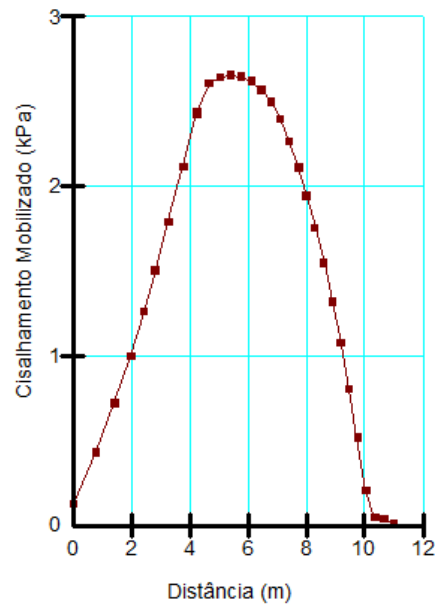


Figure 9: Graph of the shear mobilized along the vine.



#### 4 CONCLUSION

The use of *geoslope* software proved to be a simple application and requires few resources to perform simulations, however, the simulated data obtained were satisfactory, and show reliability, having the possibility of being applied as auxiliary methods in the analysis of geotechnical problems.

In the field, the area and the studied area had traction cracks at 2.5 m from the crest of the ridge, thus, the simulation proposed by the program is consistent with the actuality in situ, and the safety conditions of the talude point to instability, and it would collapse by sliding at any moment.

Although the applicability of the program is satisfactory, the use of other more complex methods, which in turn, may have greater precision when compared to the applied one, is not dispensed with.

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