

## **Analysis Slope Stability of River Embankment Stability at Muar River, Panchor, Johor**

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**Abstract:** This investigation aims to discover the reason of the collapse and to evaluate the slope stability so that remediation measures for stabilisation can be proposed at Muar River embankment, Panchor Town, Johor. A computer simulation of slope stability using Plaxis 2D to establish the overall displacement and safety factor is carried out for the purpose of easing investigations of failure cause. The river embankment collapsed at 40m depth, and the back analysis of the safety factor (FOS) is computed based on different height of the river embankment. The stimulation results showed that when the depth of the embankment is more than 30m, the slope failure has happened. In addition, the stimulation results in increased slope instability since the moisture or pore-water pressure in the slope increases the soil shear strength or decreases it. FOS is determined is 1.069 when the slope 1 is stable.

**Keywords:** Slope Stability, Embankment, Plaxis 2D, Factor of Safety

### **1. Introduction**

Slopes stability are the ability to withstand and travel on the covered slopes of the earth. The balance between shear stress and shear strength determines stability. Preparatory factors can affect a previously stable path, which makes the path unstable. In general, geologists, engineering geologists, or geotechnical engineers do research, study (including modelling), and design mitigation. In order to assess relative slope stability on the basis of observations on site, geologists and geologists may also use their knowledge of the earth process and their capacity to interpret surface geomorphology. Geotechnics mechanics play a major role in the development of slope stability studies in the development of soil and rock mechanics.

This research focuses on the failure of river embankment slope, the reconstruction process and the failure of the riverbank were carried out. Although several works on mitigation were prepared and built before the project was constructed, there are many complexities related to the material, which are of complex origin. Different methods have been implemented and evolved over the years in order to deal

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with this slope stabilisation issue. The methods were now more computer-based than manual. Independent functionality is provided to evaluate the paths that can fail by measuring the protection factor. Plaxis software are among the popular solution. In the geotechnical field of engineering, including deformation, stabilisation, and flow, the Plaxis Software is an IT computer system that conducts finite element analyses (FEA). The input procedures allow the improved output facilities to provide computational data.

The objective of the study is to construct two model of the slope for river embankment in Muar River using Plaxis software. Next, to identify the main cause of slope failure in Muar River at Panchor town, Johor. Lastly, the objective is to determine the factor of safety of the failure slopes using Plaxis software.

## 2. Materials and Methods

The soil samples were collected from the site at Muar River. The soil foundation consists of 5 layers of soil which are very soft clay, very soft clay (1), soft to stiff sandy clay(2), very stiff clayey silt(3) and sand.

In this investigation, the water that cannot expel from saturated clay soils soon caused all soil layers to be undrilled. In addition, Mohr Coulomb models the fill of embankments and sand layers, whereas Soft Soil Models are employed for soil layers. However, because to the rigidity and strength of the material used for building the embankments, the embankment filler is chosen to be drained.

PLAXIS 2D was utilised to simulate the entire geotechnical system, two-Dimensional modelling of a plan strain FE was carried out. It is crucial to include ultimate stability in the study of slope stability concerns. The overall safety factor in this situation is interesting to evaluate. Therefore, a more suitable definition of safety factor is safety factor equals  $S$  (maximum available) to  $S$  (equilibrium need), where  $S$  represents shear strength.

The following Table 1 and Table 2 shows the soil properties that used in Plaxis 2D.

**Table 1: Summary of material properties used in Plaxis 2D (Slope 1)**

| Depth (m) | Soil Type                | Type      | $E_u$ (kPa) | $C'$ (kPa) | Friction angle, $\phi'$ (degrees) | Poisson's ratio ( $\nu$ ) | $\gamma_{sat}$ ( $kN/m^3$ ) | $\gamma_{st}$ ( $kN/m^3$ ) | $E_{inc}$ ( $kN/m^2$ ) | $C_{inc}$ ( $kN/m^2$ ) |
|-----------|--------------------------|-----------|-------------|------------|-----------------------------------|---------------------------|-----------------------------|----------------------------|------------------------|------------------------|
| 0 - 3     | Sand fill                | Drained   | 20,000      | 0.5        | 30                                | 0.30                      | 20                          | 22                         | 0                      | 0                      |
| 3 - 8     | Very soft clay           | Undrained | 1900        | 7          | 0                                 | 0.35                      | 11                          | 15                         | 94                     | 0.4                    |
| 8 - 16    | Very soft clay           | Undrained | 2500        | 8          | 0                                 | 0.35                      | 11                          | 16.5                       | 387                    | 1.5                    |
| 16 - 24   | Soft to stiff sandy clay | Undrained | 3000        | 10         | 27                                | 0.30                      | 20                          | 22                         | 94                     | 0.4                    |
| 24 - 30   | Very stiff clayey silt   | Undrained | 4000        | 12         | 29                                | 0.30                      | 22                          | 24                         | 88.3                   | 3.7                    |

**Table 2: Summary of material properties used in Plaxis 2D (Slope 2)**

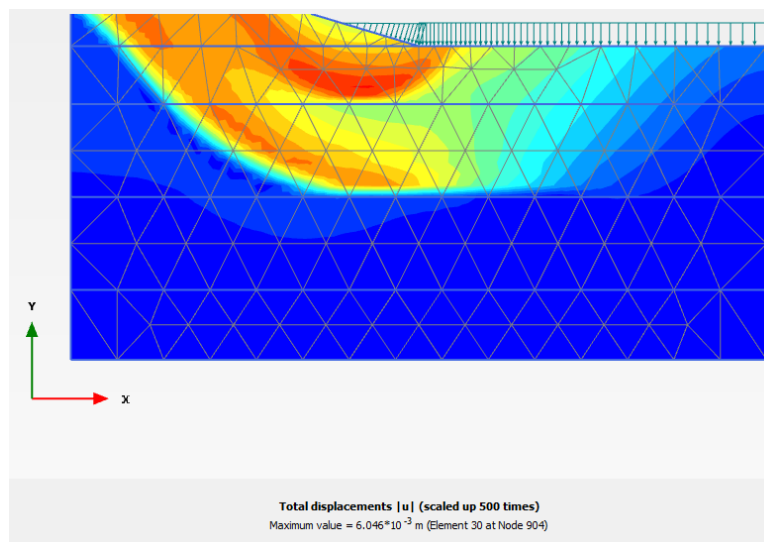
| Depth (m) | Soil Type                | Type      | Eu (kPa) | C' (kPa) | Friction angle, $\phi'$ (degrees) | Poisson's ratio ( $\nu$ ) | $\gamma_{sat}$ (kN/m <sup>3</sup> ) | $\gamma_{sta}$ (kN/m <sup>3</sup> ) | $E_{ine}$ (kN/m <sup>2</sup> ) | $C_{ine}$ (kN/m <sup>2</sup> ) |
|-----------|--------------------------|-----------|----------|----------|-----------------------------------|---------------------------|-------------------------------------|-------------------------------------|--------------------------------|--------------------------------|
| 0 - 9     | Sand fill                | Drained   | 20,000   | 0.5      | 30                                | 0.30                      | 20                                  | 22                                  | 0                              | 0                              |
| 9 - 20    | Very soft clay           | Undrained | 1900     | 7        | 0                                 | 0.35                      | 11                                  | 15                                  | 94                             | 0.4                            |
| 20 - 28   | Very soft clay           | Undrained | 2500     | 8        | 0                                 | 0.35                      | 11                                  | 16.5                                | 387                            | 1.5                            |
| 28 - 34   | Soft to stiff sandy clay | Undrained | 3000     | 10       | 27                                | 0.30                      | 20                                  | 22                                  | 94                             | 0.4                            |
| 34 - 40   | Very stiff clayey silt   | Undrained | 4000     | 12       | 29                                | 0.30                      | 22                                  | 24                                  | 88.3                           | 3.7                            |

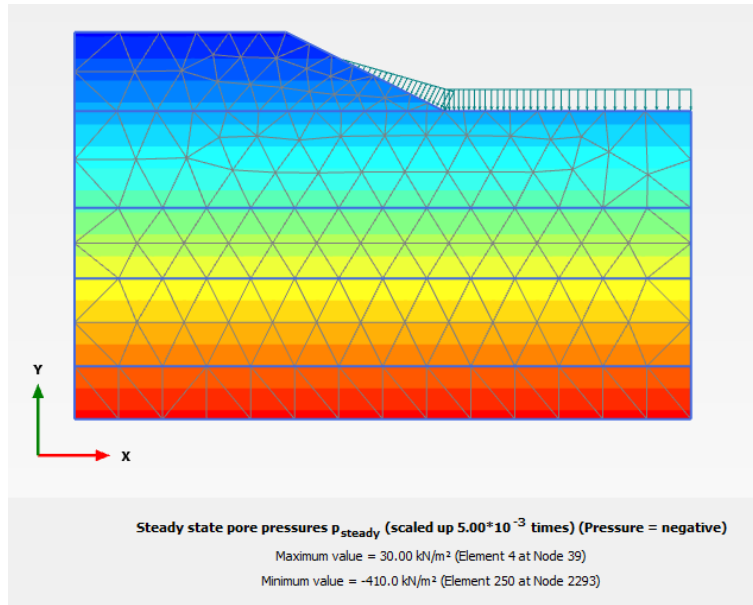
### 3. Results and Discussion

This part includes the results of finite element simulation of slope cases. Different soil properties have been used as shown in Table 1 and Table 2. These circumstances are generally the true situation of path stability and may be compared and the behaviour of the slopes can be predicted. The analysis includes the study of side slope stability (i.e the collapse of the soil at the critical zone of the slope, safety analysis and displacement) under specific condition.

In PLAXIS, the material data set contains the soil characteristics. The Mohr-Columb model was used as input parameters for the material model and the soil attributes derived from the data. With excavated slope geometry the starting phase is determined. In this phase initial stresses are produced utilizing the loading of gravity. During the following step, security analysis was performed. For mesh generation, medium coarseness was used.

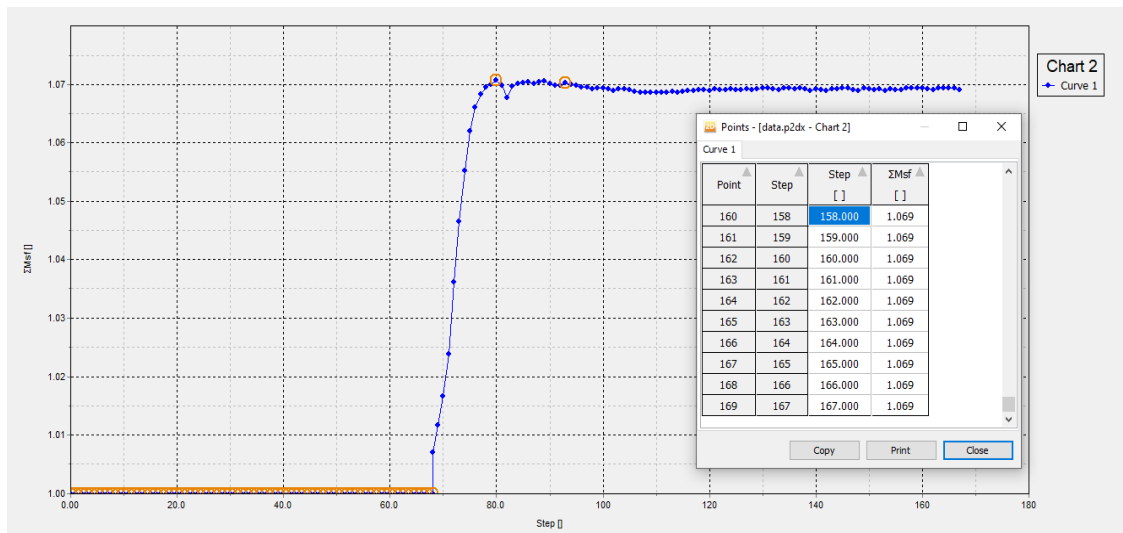
Figures 1 illustrate the total displacement profile for slope 1 which is where the slope condition is stable. Maximum value of displacement is  $6.05 \times 10^{-3}$  m, for element 30 at nodes 904. Using the same parameters but different height, slope 2 is simulated as shown in Figure 2. The total displacement cannot be calculated because the slope failure occurred. Maximum value of pore pressure is 30 kN/m<sup>2</sup> for element 4 at node 39 and -410 kN/m<sup>2</sup> for element 250 at nodes 2293.

**Figure 1: Total displacement profile (Slope 1)**



**Figure 2: Pore pressure (Slope 2)**

The result for safety factor is obtained as shown in Figure 3 and Table 3. The value for safety factor in slope 1 is 1.069, which is more than 1 while the value for slope 2 is lower than 1.



**Figure 3: Factor safety phase (Slope 2)**

**Table 3: Factor safety phase (Slope 2)**

| Soil element                       | Stress point  | Local number | X<br>[m] | Y<br>[m] | P <sub>water</sub><br>[kN/m <sup>2</sup> ] | P <sub>active</sub><br>[kN/m <sup>2</sup> ] | Head<br>[m] | P <sub>steady</sub><br>[kN/m <sup>2</sup> ] | Suction<br>[kN/m <sup>2</sup> ] | Suction <sub>eff</sub><br>[kN/m <sup>2</sup> ] |
|------------------------------------|---|--------------|----------|----------|--|---|-------------|---|---------------------------------|--|
| Very stiff clayey silt<br>Soil_1_1 | 3290  | 2            | 64.685   | 5.621    | -353.785                                   | 0.000                                       | 41.000      | -353.785                                    | 0.000                           | 0.000  |
|                                    | 3291  | 3            | 60.631   | 5.621    | -353.785                                   | 0.000                                       | 41.000      | -353.785                                    | 0.000                           | 0.000  |
|                                    | 3292  | 4            | 63.754   | 2.991    | -380.086                                   | 0.000                                       | 41.000      | -380.086                                    | 0.000                           | 0.000  |
|                                    | 3293  | 5            | 63.754   | 4.504    | -364.957                                   | 0.000                                       | 41.000      | -364.957                                    | 0.000                           | 0.000  |
|                                    | 3294  | 6            | 62.493   | 4.504    | -364.957                                   | 0.000                                       | 41.000      | -364.957                                    | 0.000                           | 0.000  |
|                                    | 3295  | 7            | 64.734   | 2.181    | -388.190                                   | 0.000                                       | 41.000      | -388.190                                    | 0.000                           | 0.000  |
|                                    | 3296  | 8            | 64.734   | 4.138    | -368.621                                   | 0.000                                       | 41.000      | -368.621                                    | 0.000                           | 0.000  |
|                                    | 3297  | 9            | 63.448   | 5.681    | -353.189                                   | 0.000                                       | 41.000      | -353.189                                    | 0.000                           | 0.000  |
|                                    | 3298  | 10           | 61.817   | 5.681    | -353.189                                   | 0.000                                       | 41.000      | -353.189                                    | 0.000                           | 0.000  |
|                                    | 3299  | 11           | 61.817   | 4.138    | -368.621                                   | 0.000                                       | 41.000      | -368.621                                    | 0.000                           | 0.000  |
|                                    | 3300  | 12           | 63.448   | 2.181    | -388.190                                   | 0.000                                       | 41.000      | -388.190                                    | 0.000                           | 0.000  |
|                                    | Clus. 5 - El. 276<br>Very stiff clayey silt<br>Soil_1_1 | 3301         | 1        | 5.315    | 5.243                                      | -357.571                                    | 0.000       | 41.000                                      | -357.571                        | 0.000  |
| 3302                               |   | 2            | 5.315    | 0.379    | -406.215                                   | 0.000                                       | 41.000      | -406.215                                    | 0.000                           | 0.000  |
| 3303                               |   | 3            | 9.369    | 0.379    | -406.215                                   | 0.000                                       | 41.000      | -406.215                                    | 0.000                           | 0.000  |
| 3304                               |   | 4            | 6.246    | 3.009    | -379.914                                   | 0.000                                       | 41.000      | -379.914                                    | 0.000                           | 0.000  |
| 3305                               |   | 5            | 6.246    | 1.496    | -395.043                                   | 0.000                                       | 41.000      | -395.043                                    | 0.000                           | 0.000  |
| 3306                               |   | 6            | 7.507    | 1.496    | -395.043                                   | 0.000                                       | 41.000      | -395.043                                    | 0.000                           | 0.000  |
| 3307                               |   | 7            | 5.266    | 3.819    | -371.810                                   | 0.000                                       | 41.000      | -371.810                                    | 0.000                           | 0.000  |
| 3308                               |   | 8            | 5.266    | 1.862    | -391.379                                   | 0.000                                       | 41.000      | -391.379                                    | 0.000                           | 0.000  |
| 3309                               |   | 9            | 6.552    | 0.319    | -406.811                                   | 0.000                                       | 41.000      | -406.811                                    | 0.000                           | 0.000  |
| 3310                               |   | 10           | 8.183    | 0.319    | -406.811                                   | 0.000                                       | 41.000      | -406.811                                    | 0.000                           | 0.000  |
| 3311                               |   | 11           | 8.183    | 1.862    | -391.379                                   | 0.000                                       | 41.000      | -391.379                                    | 0.000                           | 0.000  |
| 3312                               |   | 12           | 6.552    | 3.819    | -371.810                                   | 0.000                                       | 41.000      | -371.810                                    | 0.000                           | 0.000  |

The research indicated that the slope 2 factor safety is less than slope 1, showing clearly that the slopes are likely to collapse. The occurrence verifies this study as the slopes had previously collapsed. FS for slopes 2 is low, as the slopes is made from low cohesive soft clay. The friction angle is nearly negligible as the soil is clay. Thus, shear strength exclusively comes from the coherence parameter rather than from the angle of friction. In addition, the shear strength does not increase with the increase in depth on pure, cohesive soil.

In contrast FS is maximal for slope 1 because of the relatively large friction angle ( $\pm 37.34^\circ$ ), and both cohesion parameter and friction are responsible for the shear strength. In addition, FS is high due to a slope angle lower than slope 2.

#### 4. Conclusion

This research was conducted to construct the two model of slope of river embankment in Muar River using Plaxis software. The model was construct using the same soil properties but with different height. Next, for the second objective which is to identify the main cause of slope failure in Muar River, the analyses of slope were done using Plaxis software. The result show that slope 1 is stable and slope 2 is likely to collapse because the height for slope 2 higher than slope 1. To achieve the last objective that is to determine the factor of safety of the failure slopes using Plaxis software. The slope 2 factor safety is less than slope 1, showing clearly that the slopes are likely to collapse. The occurrence verifies this study as the slopes had previously collapsed. FS for slopes 2 is low, as the slopes is made from low cohesive soft clay. The friction angle is nearly negligible as the soil is clay. Thus, shear strength exclusively comes from the coherence parameter rather than from the angle of friction. In addition, the shear strength does not increase with the increase in depth on pure, cohesive soil.

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