Factor and prevention method of landslide event at FELCRA Semungkis, Hulu Langat, Selangor

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Abstract. Landslide is known as one of the powerful geological events that happens unpredictably due to natural or human factors. A study was carried out at FELCRA Semungkis, Hulu Langat which is known as one of the areas that has been affected by landslide that involving 16 causalities. The purpose of this study is to identify the main factor that causes the landslide at FELCRA Semungkis, Hulu Langat and to identify the protection method. Data was collected from three respondents working under government bodies through interview sessions. The data collected were analysed by using the content analysis method. From the results, it can be concluded that the main factors that caused the landslide to happened are the human factor and nature factor. The protection method that can be applied to stabilize the FELCRA Semungkis, Hulu Langat is by using the soil nailing method with the support of soil create system.

1. Introduction
The world is currently plagued by natural disasters that are often associated with landslide issues. Nowadays the landslide issues had become a normal phenomenon issue, including in Malaysia. Every year the number of cases related to landslide in Malaysia are progressively increasing. A landslide is a geological phenomenon that includes a wide range of ground movements, such as rock falls, deep failure of slopes and shallow debris flows. Landslides are normally occurred at the hillside environment. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability either because of the natural causes or by human activity [1].

Hulu Langat is the fifth largest district in Selangor with a mix of urban and rural settlements. It is well endowed with beautiful forests, waterfalls and hot springs. However, Hulu Langat made the headlines due to landslides, erosions and collapsed road. In May 2011, 16 boys from an orphanage lost their lives due to a landslide at the Federal Land Consolidation and Rehabilitation Authority (FELCRA) Semungkis, Hulu Langat. The landslide that happened at FELCRA Semungkis, Hulu Langat basically might due to the same factor namely the natural factor such as weather, terrain, geology facts, debris flow. Besides, it might be caused by human activities like excavation, slope cutting or due to the close bearing distance between the slope and the building [2-6].

This study was performed at the chosen location of FELCRA Semungkis, Hulu Langat, Selangor, Malaysia where the landslide that caused 16 casualties happened. Unfortunately, there are still no convincing answer for the cause of the landslide that had happened. Therefore, the objectives of this
research are to identify the factors that causes the landslide at FELCRA Semungkis, Hulu Langat and to identify the protection method to prevent the casualties caused by landslide to happen again.

2. Literature Review

Landslides refer to the movement of rock, earth, or debris flows on slopes due to gravity. According to Varnes (1987), landslide involves five conditions; falls, topples, slides, lateral spread and flows [9]. Falls are abrupt movements of masses of geologic materials, such as rocks and boulders. Whereby, it becomes detached from steep slopes or cliffs. Moreover, falls are strongly influenced by gravity, mechanical weathering, and the presence of interstitial water. Toppling failures are distinguished by the forward rotation of a unit. Slides refer to the movement of soil parallel to planes of weakness and occasionally parallel to slope. There are three types of slide: rotational rock slump, translational debris slide, and earth block slide. Lateral spread landslides involve sudden horizontal movement on very gentle terrain. It is often initiated by earthquakes that liquefy the layer below the moving material. A flow is a spatially continuous movement in which surfaces of shear are short-lived, closely spaced, and usually not preserved. The distribution of velocities in the displacing mass resembles that in a viscous liquid. The lower boundary of displaced mass may be a surface along which appreciable differential movement has took place or a thick zone of distributed shear [10].

Landslides did not occur due to a single factor. However, according to Cruden & Varnes (1996), landslides can be triggered by natural factors or human activity. Natural factor is one of the factors that causes the landslides. For instance, geology properties of soil, rainfall, debris flow, terrain and weather [10]. The geotechnical properties of the soil including both physical and chemical characteristics. Texture and chemical composition are the main factors contributing to soil slope failures. A heavy rainfall that enters the soil will cause the soil to become softer and weaker. Thus, it can maximize the occurrence of landslide.

A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as a slurry that flows downslope. Debris flows are commonly caused by intense surface-water flow, due to heavy precipitation or rapid snowmelt, that erodes and mobilizes loose soil or rock on steep slopes. The alteration and breakdown of rock minerals and rock masses when they are exposed to the atmosphere. Weathering processes occur in situ, that is, in the same place, with no major movement of rock materials involved. Weathering is a fundamental Earth process. Weathering changes rocks from a hard state, to become much softer and weaker, making them more easily eroded.

The human factor is considered as a factor that causes the landslide to be happened. Examples of human factors are slope cutting, deforestation and bearing between the building and the slope. Cutting refers to the human activity that are normally done for development or construction. The slope area is being cut due to the purpose of construction of roads, railways and buildings. This will then cause the slope to lose its gradient and causes the slope to lose its stability. The mass removal of large trees and vegetation has a drastic increase on the probability of landslides occurring. The clear cutting of slope areas for construction will cause the slope to lose the vegetation which are known as the reinforcement for the slope. The bearing between the building and the slope are important. This is because when the building is constructed near to the slope area, it has a high possibility to face the landslide due to the bearing of the building with the slope. The near the building, the high the possibility of the slope to cause landslide.

According to Coppins and Richards (1990) vegetation are considered as the main factor that contribute for the stabilize of slope [11]. It is because the plant can influence the strength of the soil by using the root actions. The root acts mechanically towards the shear force of the soil. Vegetation can minimize the amount of water infiltrating into the soil, slow the erosion caused by surface-water flow, and remove water from the soil. The improving surface and subsurface drainage at the site can increase the stability of a landslide-prone slope. Surface water should be diverted away from the landslide-prone region by channelling water in a lined drainage ditch or sewer pipe to the base of the slope. Ground water can be drained from the soil using trenches filled with gravel and perforated pipes or pumped water well.
Removing the soil and rock at the head of the landslide decreases the driving pressure and can slow or stop a landslide. Additional soil and rock above the landslide will need to be removed to prevent a new landslide from forming upslope. Flattening the slope angle at the top of the hill can help stabilize landslide-prone slopes.

Constructing a retaining wall at the slope area can prevent the landslide from happening. This is because the construction of retaining wall can protect and support the slope. Besides, that retaining wall can also prevent the movement of ground water by placed in drill holes. These holes will then have diverted away the water that enters the slope by rainfalls.

Soil nailing construction proceeds from the top to bottom, and head plates are installed on each nail. The soil nailing is particularly well suited to excavation applications for ground conditions that require vertical or near-vertical cuts. It is suitable to be used to increase the frictional force inside the slope and also to strengthen the soil. By doing this, the internal part of the slope will be stronger due to the bond strength of the soil nails.

The Soil Create System is to establish a rigid structure and vegetation to cover the soil or rock steep slope. During the installation work, fixing and tightening wild steel bars on the long anchors to form a series of square grid pattern of Create. The wet spraying machine will be used to spray the readily mixed cement mortar on the structurally reinforcement bar in order to form a rigid structure of grid pattern. This can provide a structural protection of slope. Consequently, the spraying of Soil-Factor can provide the vegetation on the whole slope surface in order to achieve the full vegetation cover in the long run. The performance is proven to be prominent that the Ministry of Transportation and Communications of Taiwan have specified the use of Soil Create along the Cross-Island Highway. It gives advantages for erosion control and also for planting vegetation so as to improve the visual appearance of slopes.

3. Research Methodology
The methodology framework for this research is as in Figure 1.

![Figure 1 Research methodology](https://example.com/figure1.png)
4. Data Collection and Analysis

There are three respondents from government departments namely Public Works Department (JKR), Kajang Municipal Council (MPKj), and Universiti Teknologi Malaysia (UTM) which involved in interviewed session. The respondent chosen for the interview session are those that had experience and had reviewed on landslide issue at FELCRA Semungkis, Hulu Langat.

4.1 Demography of Respondent

The respondents are being labelled as RJ1 for Public Works Department (JKR), RJ2 for Kajang Municipal Council MPKj) and RJ3 for Universiti Teknologi Malaysia (UTM). As in Figure 2, the demography of respondent shows that all the respondents have experience in working at landslide issues. Therefore, it is proven that all the respondent that been chosen for the data collection are suitable and eligible to be interviewed.

4.2 Involvement of Respondent in Landslide: Issue at FELCRA Semungkis, Hulu Langat.

Table 1 shows the explanation of the respondent involvement in the landslide issue at FELCRA Semungkis, Hulu Langat.

| Respondent | Involvement of the Respondent |
|------------|--------------------------------|
| RJ1        | • Did a visit and observation at the scope of the study after the landslide  
            | • Involved in forensic report to investigate and identified the actual causes of landslide |
| RJ2        | • Had reviewed about the case study of landslide issue at Hulu Langat |
| RJ3        | • Involve in the Q&A program of the landslide issue at Hulu Langat organize by TV3  
            | • Had reviewed on landslide issue at FELCRA Semungkis, Hulu Langat |
4.3 Type of Landslide

Table 2 shows the result obtained from the respondent about the type of landslide. According to RJ2 and RJ3, the landslide at FELCRA Semungkis Hulu Langat is because of the translational slide. For this reason, the landslide mass moves along a roughly planar surface with little rotation or backward tilting. On the other hand, according to RJ1, the landslide that happened at FELCRA Semungkis Hulu Langat is caused by the combination of translational slide and also rotational slide. On this side, the rotational slide in which the surface of rupture is curved concavely upward. Then, the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide. By referring to the previous studies and also from the interview conducted, it can be concluded the landslide occurrence at FELCRA Semungkis Hulu Langat is because of translational slide.

| Respondent | Types of Landslide                          |
|------------|--------------------------------------------|
| RJ1        | Translational slide from the upper part and rotational slide at the lower part |
| RJ2        | Translational slide                        |
| RJ3        | Translational slide                        |

4.4 Geological Information of Landslide Issue at FELCRA Semungkis Hulu Langat.

Table 3 shows the geological information collected from the respondents about the landslide issue at FELCRA Semungkis Hulu Langat. According to the forensic report, the type of soil at the FELCRA Semungkis Hulu Langat is granitic sandy soil. It is important to realize that this type of soil is highly permeable and have high porosity. The land at FELCRA Semungkis Hulu Langat is for plantation purposes such as for oil palm. Other than that, the type of soil that are also found at FELCRA Semungkis Hulu Langat are coarse-grained biotite granitic which are weak against the presence of water. The height of the slope that caused landslide are around 25m to 30m with the steepness of 75 degrees to 80 degrees. This proven that, the slope is being cut too steep, since the actual slope cut must less than 45 degrees. The distance of the building and the foot slope are around 7m to 8m which are also considered as close to the slope area and the stability level. In this condition, the slope is also considered as in the dangerous zone since the stability is less than 1.

| Properties                  | Reading                                      |
|-----------------------------|----------------------------------------------|
| Types of Soil               | Granitic Sandy Soil                          |
| Use of Land                 | Plantation                                   |
| Type of Rock                | Coarse-grained Biotite Granite                |
| Height of Slope             | 25m – 30 m                                   |
| Steepness                   | 75 degree – 80 degree                        |
| Size of Landslides          | 54m width at foot slope & 45 width at top slope |
| Distance Between Building & Foot Slope | 7m – 8m                                    |
| Slope Stability             | Less than 1                                  |

4.5 Factor Causes the Landslide at FELCRA Semungkis Hulu Langat

Table 4 shows the human factor and also the nature factor that had contributes to the landslide issue at FELCRA Semungkis Hulu Langat. The data collected from the respondents shows that the main cause of the landslide are due to the human factor. However, the nature factor had also act together with the human factor and causes the landslide to happen. According to the analysis performed, it can be concluded that the major cause of the landslides is due to the human factor which are namely because
of improper construction design, steep slope cutting, clear cutting and also the close distance between the buildings and the slope. While the nature factor that causes the landslide mainly because of the rainfalls and properties of soil.

### Table 4. Causes of Landslide at FELCRA Semungkis Hulu Langat

| Causes of Landslide | Results of Findings |
|---------------------|---------------------|
| RJ1                | RJ2                | RJ3            |
| 1. Nature Factor    |                    |                |
| • Geological Properties of Soil | / | / |
| • Rainfall          | / | / |
| • Weathering        | / | / |
| • Debris flow       | / | / |
| • Use of Land Before| / | / |
| 2. Human Factor     |                    |                |
| • Clear cutting     | / | / |
| • Slope cutting     | / | / |
| • Bearing between the slope and the building | / | / |
| • Improper construction design | / | / |

### 4.5.1 Nature Factors

Table 5 shows the list of nature factors that cause the landslide to happen. The analysis of the data collected shows that the nature factors contributes to the landslides to happen. According to the survey done, it can be concluded that the major nature factor that cause the landslide is rainfall. The data given by all the respondent stated that the landslide happens due to the heavy rainfall that happens one day before the incident which are also caused by the antecedent rainfall. The antecedent rainfall refers to the continuous rain that happens before the major rain which will reduce soil suction and increases the pore-water pressure in soils. Therefore, when the major rainfall happens, the soil tends to moist and lose its strength level due to the increase in the underground water level. The high intensity of rainfall in a short period of time causes the underground water level to increase from its original level.

Another key point is the geological properties are also considered as one of the factors that causes the landslides to occur. As mentioned earlier, the granitic sandy soil is highly permeable and have a high porosity. Therefore, when it reacts together with the high intensity rainfall, the soil loss its strength and cause the slope to failure. The land use is also a factor that need to be considered. Previously, the land is used for plantation. When the plantation was being removed for the construction of the orphanage, the land loss its soils cover and causes the water run-off to increase.

### Table 5. Nature Factors That Causes the Landslide at FELCRA Semungkis Hulu Langat

| Causes of Landslide | Results of Findings |
|---------------------|---------------------|
| RJ1                | RJ2                | RJ3            |
| 1. Nature Factor    |                    |                |
| • Geological Properties of Soil | / | / |
| • Rainfall          | / | / |
| • Weathering        | / | / |
| • Debris flow       | / | / |
| • Use of Land Before| / | / |

### 4.5.2 Human Factor

Table 6 shows the human factors that contribute to the landslide. According to the data collected from the respondent and also the forensic report, it can be concluded that the major cause of the landslide at FELCRA Semungkis Hulu Langat is due to the human factor. By referring to the analysis done, the main human factor that causes the landslide to happen is improper construction design, steep slope cutting and also clear cutting. The improper construction design done by the land owner himself causes the landslide to happens. This is because, due to the development of the orphanage
purposed the land owner had cuts the foot slope steep around 75 degrees to 80 degrees with the distance of 7m to 8m between the building and also the slope. Moreover, the slope area that been cut off was been clear cut and no protection method been applied at the slope area which had been clear off. Therefore, when the heavy rain occurs, the soil at the upper part of the foot slope lose its strength and causes the landslide to happens.

| Causes of Landslide                  | Results of Findings |
|--------------------------------------|---------------------|
| Human factor                         | RJ1  | RJ2  | RJ3 |
| Clear cutting                        | /     | /    | /   |
| Slope cutting                        | /     | /    | /   |
| Bearing between the slope and the building | /     | /    | /   |
| Improper construction design         | /     | /    | /   |

4.6 Process of the Landslide at FELCRA Semungkis Hulu Langat.
Figure 3 explained the process of the landslides occurrence. The improper construction design with the steep slope cutting for more than 45 degrees at the foot slope causes the upper soil layer that are rich in humid component being removed and clear cutting had been carried out for the construction purpose. After the clear cut, no vegetation or protection method had been applied at slope area that been clear off after the construction work. During 20th May 2011, a heavy rain with the reading of 60mm at 2pm to 5pm and 50mm/hour at 3pm to 4pm causes the underground water level to increase and causes the landslide to happen on the next day during the major rainfall.

![Figure 3. Process of Landslide](image)

4.7 Protection Method to Stabilize the slope of FELCRA Semungkis Hulu Langat
According to the data collected from the respondent, some suggestions of protection method had been recommended by the respondent in purpose to stabilize the slope of FELCRA Semungkis Hulu Langat. Table 7 shows the summary on types of protection method from the three respondents.

From the point of view of RJ1, the soil nailing method and gravity wall will be the suitable protection method to prevent the landslide from happens. For this reason, a landslide should not only treat from the external part by using retaining walls or other methods. The proper way to treat the landslide should be
by internal and also the external. Therefore, RJ1 suggested to use the soil nailing as an internal treatment to increase the frictional force inside the slope and gravity wall as an external treatment.

However, from the point of view of RJ2, Gabion wall will be more suitable to be used because it is quite cheap and stronger. RJ3 proposed to redesign the slope and this will be the best protection method. Redesigning the slope to become stable with a correct steepness are more important because without a stable slope there is no point of applying any of the protection method because it will still cause failure. Therefore, RJ1 suggested to redesign the slope to become stable. The soil nailing and soil create system can be applied to make the slope extra 5% stronger. The soil nailing can increase the frictional force inside the slope and the soil create system can increase the external strength of the slope. By using the soil create system, the slope will be having a full green appearance.

| Respondent | Type of protection method          |
|------------|-----------------------------------|
| RJ1        | - Soil nailing                    |
|            | - Gravity wall                    |
| RJ2        | Gabion wall                       |
| RJ3        | - Redesign the slope              |
|            | - Soil nailing with soil create system |

5. Discussion and conclusion

According to the data that been collected from the respondents, it can be concluded that the landslide at FELCRA Semungkis, Hulu Langat were 90% caused by the human factor and 10% by the nature factor. By referring to the research done on literature review in term of factors that causes landslides, three type of human factors and three type of nature factors that been research had contributed to the cause of landslide such as clear cutting, slope cutting, bearing between the building and the slope, geological properties of soil, rainfalls and also the weathering. However, there are two more factor that had been identified via the interview section which was known as the improper construction design and also the previous used of land.

The improper construction design mentioned refer to the type of construction which was not built up to code/standard and was not constructed according to the intended design. The foot slope near the Madrasah Al-Taqwa Children Orphanage Home were been cut for more than 45 degrees in the purpose of development. It is proven that the construction that been carried out was an illegal project which was done by the land owner itself and was built without having the concern from the local authorities. The construction work that been carried out at the scope of study were known as unsafe and ineffective to perform the intended function. As the result, the occurrence of the landslides.

Additionally, the previous use of land is also considered as one of the cause of the landslide because according to the data collected. The land of the FELCRA Semungkis Hulu Langat was actually used for the plantation purpose. Therefore, when the plantation is being removed for construction process, the soil cover was also being removed together with the plants. When the soil cover been removed, the on land water or which was known as the water run-off will then increase and causes the rainfall to enter the soil surface easily. Thus, during the heavy rain, the rainfall that enter the soil at the slope area causes the underground water level of the slope to increased and causes the slope to become moisture and lose and causes the landslide to happens.

From the analysis done, there are various of protection methods that can be applied to prevent the landslide from happening such as vegetation, excavating the head, improve of drainage system, retaining wall, soil nailing and soil create system. Two new ideas had been identified via the interview from the experienced respondents. The two new ideas that are being recommended are the treatment of internal and external part of the slope and also the redesigning of the slope.

The two methods explain that the main matter in stabilizing the slope is not by applying the protection method and it should be by treating the slope before applying a protection method. This is because when the slope area was being treated correctly, any type of the protection method that are suitable for
the soil and slope can be applied. Thus, it can guarantee to be safer than the slope that have not been treated and been applied protection method. As an idea suggested by the respondent, a slope should not only be being treated externally by just applying a retaining wall. It should be treated from both the internal part and also the external part to make it stronger.

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