Minimizing Embankment Slope of Rear Parts to Overcome Leakage

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Abstract. The surrounding area of the river Kr. Pandrah is an area that every five years experience flooding. The biggest flood in 2006 has been classified as natural disasters and has destroyed public property around the area Pandrah. For that, we need a study to get an alternative to overcome. Based on the survey data and information from multiple sources and analysis of the existing condition in 2006 that the highest flood ± 0.60 m, using the HAC-RAS program obtained the largest discharge of 350 m³/ sec. River cross-section is modified into a compound with a wide cross-section of the river is still based on the existing width. The width of the left and right banks of 5 meters from the riverbank and the embankment crest width of 3 meters with a slope of 1: 1. Testing the stability of the embankment crest width of 3 meters with a slope of 1: 1 Testing the stability of the embankment is done by using the program Geo-Slope method Bishop Grid and Radius way obtained a safety factor during the development of downstream 2.146, 2.143 upstream development, steady seepage 1.667 downstream, upstream of the steady seepage 1.183, 1.597 rapid drow down upstream and downstream rapid drow down 1,682, all the figures were below the standard security numbers. But after the biggest flood in 2016, the high embankment and duration of inundation occur above the initial predictions, so there is some point leak embankment. For further improvement can be made by reducing the slope angle of the back or make drainage embankment.

1. Introduction
Kr. Pandrah surrounding is a lowland that always gets annual floods, especially the Bantayan and Gampong Cot Leubeng villages. At both villages whenever the rain is temporary or continuously occurred, the flood is there, even the big flood occurs every five years. If there is a flood, river Kr. Pandrah is very easy to overflow, starting from Pandrah Kandeh village, Pandrah Janeng, Meunasah Reudeuep, Mns. Teungoh, Blang Gampong and Gampong Kuta Reusep, respectively, are always submerged by water. The puddle is thought to be caused by the physical condition of the Pandrah river that is unable to accommodate the flood discharged of 350 m³/sec, which occurs every five years.

The management has been carried out by the government through the strengthening of river cliffs by making gabions along the Pandrah river. This has not yet solved the problem but was only able to cope...
with the landslide on the river's cliffs. However, water still overflowed over the river cliffs. To overcome this condition, here we try to study the causes of the occurrence of the river, from the results of this study it can be concluded that the installation of gabions on the left and right sides of the river can narrow the flow of water, and also flow turbulence and sedimentation on the riverbed due to the large scour upstream river.

2. Literature Review

According to [1], one alternative to overcome this is to increase the channel capacity and make flood embankment on the left and right of the river to form a pluralistic channel appearance. The addition of this embankment certainly does not require the same height at all points, because it requires measurement of elevation points along the left and right of the river. This is to avoid simultaneous embankments due to internal effects.

[2], dividing the causes of embankment landslides consists of internal and external effects. External influences that cause an increase in shear force without strong shear changes from the soil, such as due to implementation in the field sharpen the slope of the cliff or deepen soil excavation and erosion on the riverbed. While the influence occurs due to the increasing influence of pore water pressure inside the embankment. Because it requires minimum security control of the embankments in each condition, namely during the downstream development, upstream construction period, steady downstream downstream, steady upstream upstream, rapid downstream downstream and rapid downstream downstream [3].

The basic principle used to analyze slope stability is to review the balance of boundaries [4], namely by comparing the existing shear strength of the soil parameters with the shear strength that occurs. The comparison numbers are the number of security factors. In the calculation, it is considered that the slope/embankment slope line occurs in the circular plane of the circle. This landslide field is further divided into several segments and the forces acting on each segment are taken into account. The forces acting on the landslide field are as shown below:

![Figure 1. The forces acting on the slices](image-url)
To do this calculation, the slope is divided into several segments and then a review of one segment is carried out as shown above.

In reference [5], it explains that the safety factor ($F_K$) is a comparison between the existing shear strength and the shear strength needed to maintain stability. If the shear strength = $s$, the shear strength to maintain stability is = $S / F_K$. To get prices for security factors used the formula:

$$F_K = \frac{1}{\sum W \sin \alpha} \times \sum \left[ c' \times b + (W - u \times b) \times \tan \phi \right] \times \frac{\sec \alpha}{1 + \frac{\tan \phi \times \tan \alpha}{F_K}}$$

Where:

- $F_k =$ security factor
- $W =$ segment weight
- $\alpha =$ angle formed by the percentage
- $c'$ = soil cohesion
- $b =$ segment width
- $u =$ pore water pressure

3. Research Method

The study was conducted by studying the existing literature relating to the study area, especially the results of the survey and inventory of the river area of the Bireuen Regency. Then done re-survey. Primary data collection includes the topographic data of the Pandrah river and the existing morphology of the river as well as the highest flood data that has ever occurred. Other data needed regarding the riverbed elevation, original soil elevation, and riverbank elevation.

Based on the data, then the characteristics of the river are analyzed which contribute to the flood discharge Kr. Pandrah. The study of elevation was carried out to obtain the largest flood discharge that occurred at that time, namely by making 81 observation stakes with a distance of 50 meters each. After obtaining the data, the calculation of the magnitude of the flood discharge that occurs every five years is done, that is by using the HAC-RAS Software, for an average flood inundation of 0.60 meters above the riverbank, the biggest flood discharge is 350 m3dt. Based on the results of this calculation obtained by the planned water level elevation, planned elevation of the embankment and elevation of each stake, the height of the embankment is highly dependent on the original land elevation.

According to [6], the calculation of embankment stability was highlighted in three conditions, namely the development period without earthquakes, steady seepage and Rapid draw down in the upstream and downstream areas of the river. Calculation of embankment stability was carried out using the Geo-Slope Bishop Method Grid and Radius software. In the method of Bishop (simplified), where the value ($X_n - X_{n+1}$) considered equal to zero, that is by calculating the safety factor of the embankment, and carried out a thousand trial points in each condition, namely during the downstream construction, upstream construction, downstream Steady site, steady seepage upstream, Upstream and Rapid Downs are downstream, while embankment dimensions are taken based on the planning standards of the Directorate General of Irrigation.

4. Result and Discussion

Based on the results of the analysis of the condition of the existing river channel in the Pandora area and some of the information found can be summarized as follows:

a. During floods (occurring every year), River Kr. Pandrah is not able to accommodate the flow discharge that comes from the existing river channel so that it is abundant to agricultural areas and residential villages.
b. During the rainy season, all the area around the village is flooded with an average of 0.6 meters high, especially the Bantayan village and the Cot Leubeng village with inundation for about 5 days. Whereas in the dry season most of the area is dry.

c. Based on information from the community in the village of Gampong Pandrah Kandeh, Pandrah Janeng, Meunasah Reudeup, Mrs. Teungoh, Blang and Gampong Village Kuta Reusep is always submerged by water, since 2004 the overflow of water that occurred in their village reached approximately 1 meter inundated for 3-5 days. Before entering 2006, there was only an abundance of water as high as 30 cm which inundated their village for 3-4 hours.

d. The maximum water level that has ever occurred is about 30 cm below the shoulder of the Banda Aceh State Road, before being made a gabion on the left and right sides of the river. However, after the presence of water gabions often overflows and contributes to the large flow of discharge due to narrowing of the dimensions of the channel.

In handling the problems as described above, an alternative treatment at that time was carried out by making embankments on the left and right sides. The embankment was made at a distance of 5 meters from the existing river lip. The result of the modification became a compound look. With the biggest narrowing of the dimensions of the channel.

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From the calculation of the plan's water level, the existing cross section is obtained in several sections and extends the river, while at the same time can provide an overview of the siltation of rivers in the Pandrah region as shown below.

![Figure 2. Horizontal cut of the Pandrah river](image)

![Figure 3. Vertical cut of Pandrah river](image)

Based on the elongated cut image above, it can be said that almost along the river is not the same depth, there are certain areas very deep or it can be said that the flow type of the river is non-uniform flow, so the elevation conditions of the existing river banks vary greatly. More shallow areas of elevation of the river bed are found in the elevation of the low-lying ground of the existing river. This is more
common in the area around the Bantayan village and Cot Leubeng village which is easily flooded, with a long puddle of approximately 5 days and an average inundation of 0.60 meters.

To avoid this condition, a dike is made. Making embankments is not the same in all places, depending on the elevation of the land on the banks of the existing rivers left and right. The average embankment is made as high as 3 meters on the right and left sides of the river and is expected to be able to accommodate 350 m$^3$/s of discharge, because the dimensions of the river are already enlarged, this can be seen with the above discharge conditions the height of the embankment plan is an average of 0.80 meters.

Actually the checkpoint is not required for the security of the embankment, because the embankment height below 5 meters is not required for slope stability analysis, but because the area is a dike that is submerged for a long time and the flood water is high, so that the seepage cutting the back slope of the embankment and it is feared that leaks will occur on the embankment body, so control of the stability of the embankment is needed in several conditions, namely during the Development period, Steady seepage and rapid draw down. For the purposes of calculating the stability, soil data is assumed, namely with clay sand deposits $C = 9$ Kn / m$^3$, at an compaction $17$ Kn / m$^3$, enuh saturated $= 21.60$ Kn / m$^3$ and $\phi = 22^\circ$. foundation ground $C = 8$ Kn / m$^3$, $\gamma 18$ Kn / m$^3$ and $\phi = 22^\circ$.

If this happens, then one way to avoid these leaks is to reduce the slope of the back of the embankment so that the bottom of the embankment is sufficient or by making a drain. Some forms of seepage line conditions cut the back slope as shown in the following figure:
The picture above shows the form of avalanches that occurred on the Pandah embankment against 1000 landslide test points. By using the Geo-Slope Program Bishop method Grid and Radius, the results of the minimum safety factor in each condition are obtained, namely in the downstream development period $F_{Kh} = 2.146 > F_{K \text{ standard}} = 1.50$, Upstream development period $F_{Kh} = 2.143 > F_{K \text{ standard}} = 1.50$, Steady seepage Downstream $F_{Kh} = 1.667 > F_{K \text{ standard}} = 1.25$, Steady seepage Upstream $F_{Kh} = 1.186 > F_{K \text{ standard}} = 1.20$, Upstream Rapid down down $F_{Kh} = 1.597 > F_{K \text{ standard}} = 1.25$ and Downstream down down $F_{Kh} = 1.682 > F_{K \text{ standard}} = 1.23$.

Based on the results of the landslide test above it turns out that the minimum safety factor is greater or equal to what is required, thus the position of the embankment is safe against landslides and no other safeguards are needed. However, when the floods that occurred in December 2016 puddles and the depth of the flood exceeded the initial estimate in 2016, it was seen that at this time in some points in the field there was a leak in the body of the embankment. Due to the high flooding and long inundation, the seepage lines cut the rear slope. To overcome the current condition, one of the steps that can be taken is to reduce the slope of the rear slope, so that the embankment is sufficient or can be made drainage of the embankment (toe drain).

5. Conclusion

The following are some conclusions obtained from the results of a study of the making of flood dikes on the river Kr. Bireuen Regency Pandah. The object of study is a river located in a basin area (depression) that gets a load of reservoir water flow from two rivers in the upper reaches. For the average embankment height of 3 meters, after controlling for landslides with various conditions, it turns out that the minimum safety factor is greater or equal to what is required, thus the embankment can be said to be quite safe against landslides. The embankment turned out after being submerged for seven days and the flood water level of up to five meters in the biggest flood in December 2016 could not survive so that the seepage line cut the back of the embankment and there was a leak at several points on the embankment to avoid this. the slope of the rear embankment slope, so that the bottom of the embankment is sufficient or by making drain drainage (toe drain). With the construction of this embankment, the Pandah river is already a compound type river and has been able to accommodate the largest five annual flood discharges of 350 m$^3$/sec which occurs every five years, while the area is safe against flooding.

References

[1] Maryono, A., et. Al. 2002, Eko-Hidrolik Pembangunan Sungai (Menanggulangi Banjir Dan Kerusakan Lingkungan Wilayah Sungai), Program Magister Sistem Teknik Fakultas Teknik Universitas Gadjah Mada, Yogyakarta.
[2] Terzaghi. K., 1987, Mekanika Tanah dalam Praktek Rekayasa, Erlangga, Jakarta.
[3] Kodoatie, R., dan Sugiyanto, 2002, Banjir (beberapa Penyebab dan Metode Pengendaliannya Dalam Prospektif Lingkungan), Pustaka Pelajar, Yogyakarta.
[4] E. Bowles. J, 1986, Sifat-sifat fisik dan Geoteknis Tanah, Erlangga, Jakarta.
[5] Hadiyatmo. H.C, 1994, Mekanika Tanah 2, Gramedia Pustaka Utama, Jakarta.
[6] Sosrodarsono, S, dan Tomigawa, M, 1985, Perbaikan dan Pengaturan Sungai, Terjemahan Yusuf Gayo, Pradnya Paramita, Jakarta.
[7] Hydrologic Engineering Center, 2010, HEC-RAS River Analysis system, Application guide, version 4.1,