

Study Of Road Stability On The Side Of The Konaweha River, Kab. Konawe, Southeast Sulawesi (Km 29+300 S/D Km 29+800) Due To The Combination Of The Effect Of River And Traffic Load)

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ABSTRACT

In 2020, a landslide occurred on the Road Section of North Konawe/ Konawe Regency – Pohara Km 29+300 to Km 29+800. The most critical damage was observed at Km 29+800, where nearly half of the roadway became inaccessible to vehicles. A temporary solution was implemented at the site by backfilling the affected area with soil reinforced by a crevice structure. To determine an appropriate long-term mitigation strategy, this study was conducted to evaluate the slope stability of the road embankment, particularly under the influence of flooding from the Konaweha River and traffic-induced loads. Simulation results revealed that the safety factor (SF) varied in response to changes in river water levels. The findings show that the safety factor increases when river water levels rise, likely due to added lateral support from the water. However, a sudden drop in water level (rapid drawdown) causes a decline in slope stability. Under native soil conditions, the lowest safety factor during drawdown was 1.06, indicating marginal stability. When using parameters based on cracked or weakened soil conditions, the safety factor dropped drastically to 0.15, highlighting a very high risk of slope failure under such conditions.

Keywords: *Konaweha River, scouring, landslides, stability*

INTRODUCTION

Road network need to be well managed following the principle of Infrastructure Asset Management. de Jesus Babo, F., & Suprayitno, H. (2025). River infrastructures can be defined as facilities and structures that support all activities related to river. Many infrastructures that exist along river stream but few of them are listed and recognized as an important part in the river system. The condition of assets that support the river function should be considered since it determines the sustainability of water supply system for many areas. Andiek Maulana, M., Suprayitno, H., & Aryani Soemitro, R. A. (2025). And The stability of infrastructure along river channel, such as bridges and embankments, is paramount to continuing service and public safety, and therefore, is essential consideration in the design, construction and maintenance.

Rendy Satrya, T., Aryani Soemitro, R. A., Andiek Maulana, M., Desa Warnana, D., & Soetanto, R. (2025).

The Konaweha River is one of the main watersheds of the Lasolo-Konaweha river area which is under the authority of BWS Sulawesi IV Kendari. The area of the Konaweha watershed as a whole is 6,487.2 km² with a river length of 327.22 km. On the peak flood discharge of the Konaweha river for a period of 25 years and 50 years, the water overflowed into the road as high as 0.41 m and 1.12 m.



Figure 1. Lasolo – Konaweha River Area

In 2020, a landslide occurred along the road section connecting North Konawe/Konawe Regency to Pohara, between Km 29+300 and Km 29+800. The most severe damage took place at Km 29+800, where nearly half of the roadway became inaccessible to vehicles. Temporary repair efforts were made by installing a makeshift retaining structure using wooden stakes



Figure 2. Temporary repairs of the landslides by placing a recess made of wooden stakes
This section is a vital segment because there are mining and processing of nickel ore.

Therefore, there's a lot of vehicles with the Over Dimension and Over Load (ODOL) category that pass through this road segment, resulting in many damaged road conditions. This Over Loading and Over Dimension (ODOL) behavior is carried out with the reason that it can provide more benefits for drivers. As a result of this behavior, the road is damaged before the planned age is reached.

Figure 3. ODOL Vehicles



LITERATURE REVIEW

Slope Stability

Slope stability is primarily determined by the shear strength of the soil, which reflects its ability to resist failure under pressure. The analysis of slope stability is grounded in the principle of limit equilibrium in plastic conditions.

The main objective of this analysis is to evaluate the safety factor (SF) in areas prone to landslides. Typically, the calculation involves comparing the resisting and driving moments acting on the slope to determine the value of the safety factor.

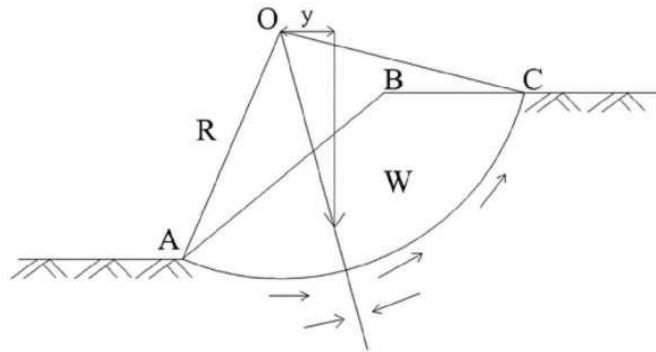


Figure 4. Slope stability analysis

(source: Hardiyatmo, 2018)

To improve slope stability, there are two approaches that can be taken in handling landslides with the aim of increasing the number of safety, including:

1. Reduce the driving force / driving moment

The way to reduce the driving force and moment is to change the shape of the slope, namely by making the slope gentler by reducing the angle of the slope itself, besides that another alternative that can be used is to reduce the height of the slope.

2. Increase the resisting force/holding moment

The way to increase the resisting force is to apply soil reinforcement methods, such as reinforcement using retaining walls, piles, or embankments at the foot of the slope.

Minimum Height of The Subgrade Above Ground Water Level And Flood Water Level

Based on the 2017 Pavement Design Manual, the minimum height of the subgrade above ground water level and flood water level is as follows.

Table 1a. Minimum height of subgrade above ground water level and flood water level

Road Class (Based on the specifications for the provision of road infrastructure)	Height of Subgrade above ground water level (mm)	Height of Subgrade above flood water level (mm)
Freeways	1200 (if there is drainage below the surface at the median)	500 (50 years annual flood)
	1700 (without median subsurface drainage)	
Highways	1200 (saturated soft soil or peat without drainage)	500 (10 years annual flood)
	800 (saturated soft soil or peat with a drainage layer)	
	600 (normal subgrade)	
Medium Roads	600	500 (10 years annual flood)
Small Roads	400	NA

If the embankment is constructed on saturated soil and the required conditions are not met, a drainage layer must be installed. This layer functions to prevent the migration of fine, soft soil particles into the foundation layer. However, the drainage layer's contribution to the overall bearing capacity of the pavement structure is not considered in the structural calculations.

Cracked Soil Approach

According to Mochtar (2020), the cracked soil approach assumes that the slope

contains existing cracks, making it more susceptible to sliding. During heavy rainfall, these cracks become fully saturated as the volume of rainwater entering them exceeds the amount draining out through the slope. This leads to a buildup of pore-water pressure within the cracks. The increased water pressure along the fracture surfaces can cause the cracks to expand, further weakening the slope and increasing the likelihood of failure.

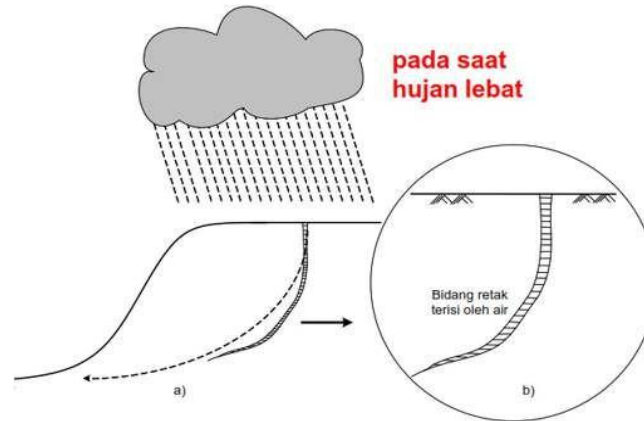


Figure 5. Cracked soils
(source: Mochtar, 2020)

As can be seen in Figure 5, the crack area which is initially short, will gradually lengthen. This happens because what is around the crack dissolves so that the soil has no cohesion value (c). because the soil has no cohesion value anymore, the behavior of the soil will resemble loose sand (behaving like sand). If the crack extends down the slope, there will be a slide due to the lack of cohesion in the part that is experiencing the crack so that the soil is not strong enough to support its own weight and the loads on it.

RESEARCH METHOD

The explanation of the research flow chart is as follows:

1. Determination of research location

The research location is determined based on the designated internship location. In this case, it is located in Southeast Sulawesi with a general theme, namely the road that has a tendency to be submerged in water during heavy rains due to the position of the road which is next to the road. River flow. Furthermore, the authors studied the problems that existed in the field with the assistance of a Mentor from the Southeast Sulawesi National Road Implementation Center, the Directorate General of Highways, Ministry of PUPR.

2. Data collection

Data collection is in the form of secondary data and primary data. Secondary data in the form of literature studies and previous research studies. The literature study in question is to collect and study existing literature and then use it as a reference in conducting this research. Secondary data collected includes data related to the height and highest flood discharge that occurred on the Konawe River, soil investigation lab data, Primary data is obtained by collecting and testing data directly in the field. This data is

the main data needed for this research.

Primary data taken is LHR data, road cross-section after a landslide occurred, while secondary data taken is data related to the height and highest flood discharge on the Konawehea River, soil investigation data and river cross-sectional data.

3. Data processing

In general, data processing is divided into 2 main stages, which is

- a. **Modeling of Road Body Stability Due to Combination of River Water Dynamics and Vehicle Overload with Assumption of Original Soil Parameters**
From the highest flood front data and traffic loads obtained, then modeling is carried out using the relevant program to determine the safety factor of the road slope at that location. Modeling is carried out using the assumption that a Rapid Drawdown occurs at that location to find the most critical condition of the slope.
- b. **Modeling of Road Body Stability Due to a Combination of River Water Dynamics and Vehicle Overload with the Assumption of Cracked Soils Approach**
After obtaining the safety factor value of the slope with the assumption of using the original soil parameters, then modeling is carried out using the Cracked Soils approach. This modeling is carried out to find out which conditions are more critical, and then these conditions are used as the basis for slope reinforcement planning.

4. Conclusions and Suggestions

Next, conclusions are drawn based on research and tests that have been carried out in accordance with the objectives of this study. This research is not absolutely correct, therefore suggestions for follow-up of this research are submitted.

DATA COLLECTION

Topography and Cross Section Data

Topographic data and cross-sectional data for both rivers and roads were obtained from secondary data in the form of topographic maps of areas where landslides occurred issued by BPJN Kendari. As for the data related to the depth of the river, it was obtained from previous research, as can be seen from the following figure

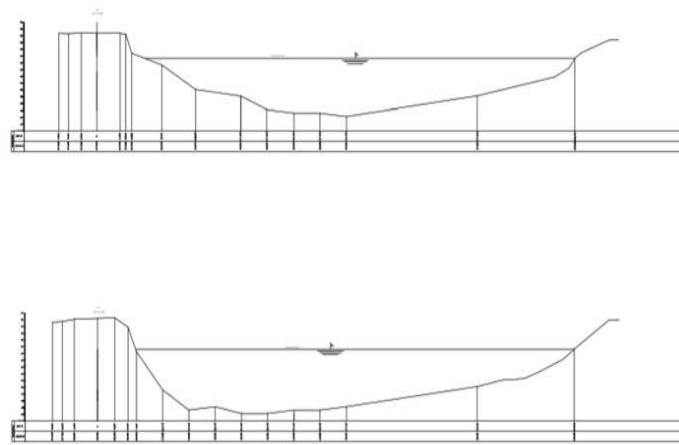


Figure 6. Cross sections of roads and rivers STA 5+800 and STA 5+750
(source: Fauzi, 2022)

Soil Layer Data and Soil Property Index

The soil layer is divided into 5 layers. The layer above the drill location is considered as fill soil material. Interpretation of the results of this soil investigation will then become input in modeling in the Geo5 program. Soil classification is done based on USCS

Table 2. Soil characteristics at the observation point locations

Layer	Thickness	Soils classification	consistency	γ_{unsat}	γ_{sat}	Cu	ϕ	Poisson Ratio	Elastic Modulus (E)
		USCS		(ton/m ³)	(ton/m ³)	(ton/m ³)	(°)	(v)	ton/m ²
Timbunan	2.2	Timbunan	Stiff	1.8	1.8	0	30	0.35	2000
I	2	ML	medium	1.8	1.8	4.1	27.0	0.3	1040
II	10	ML	medium	1.5	1.6	3	19.0	0.3	1500
III	5	CL	medium	1.9	1.9	2.5	11.0	0.3	3000
IV	7	SP	medium dense	2	2	0.0	35.0	0.25	2500
V	4	SP	dense	1.95	1.95	0	35.0	0.25	5000

RESEARCH ANALYSIS

Stability of the existing slope with variations in flood water levels and in rapid drawdown conditions with original soil parameter input

From the simulation results of variations in the flood water level on the slopes of the Konawehea river, the value of the safety factor (SF) of the slope under normal conditions of the river water level and groundwater level of -4 meters is 1.33. As a result of an increase in the river water level up to elevation 0 but the groundwater level has not increased, there has been an increase in the value of the safety factor up to 1.82. The increase in the value of the safety factor is caused by the condition of the soil which is still in normal condition, and the river water becomes a restraining force. Thus, an increase in the river water level on unsaturated soil conditions will increase the safety factor value of the slope.

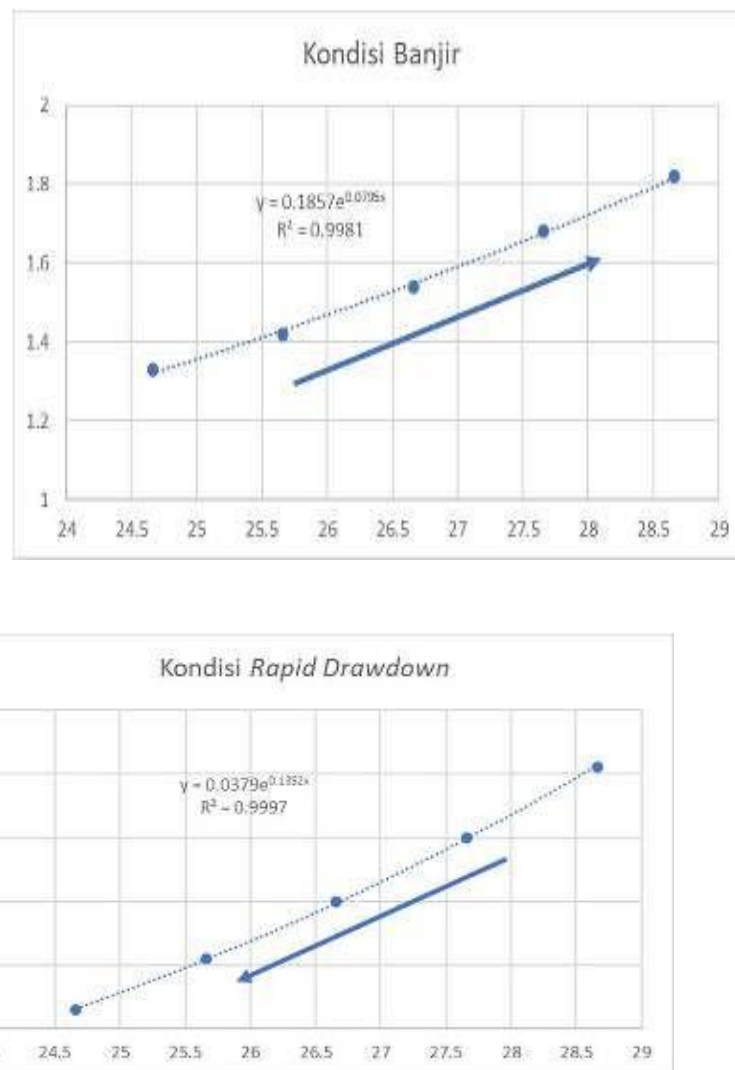


Figure 7. Graph of the relationship between flood water level elevation and safety factor in flood conditions and Rapid Drawdown for assumptions of original soil parameters

Whereas in the simulation the condition of the river water level decreasing suddenly but the soil condition is still saturated, there is a decrease in the value of the safety factor from the slope up to 1.06. This happens because the soil condition is still saturated, while the river water which functions as a barrier is lost. So that on the slopes of the Konawehea river, the lowest safety factor condition is the rapid drawdown condition. This was also conveyed by Kurniawan & Hadimuljono (2021) that a decrease in the water level adjacent to a slope or a rapid drawdown effect occurs very quickly, increasing the shear stress of the soil, causing it to slide because water has a stabilizing effect. However, because the SF of the slope is still more than 1, the slope is still in the critical category and has not yet experienced a slide. Therefore it is necessary to do an analysis using the Crack Soils Approach.

Stability of existing slopes with variations in flood water levels in rapid drawdown conditions and input soil parameters using the Crack Soils Approach

From the simulation results of variations in the flood water level on the slopes of the Konawehea river using the Crack Soils approach, the value of the slope safety factor (SF) under normal conditions of the river water level and ground water level of -4 meters is 0.36.

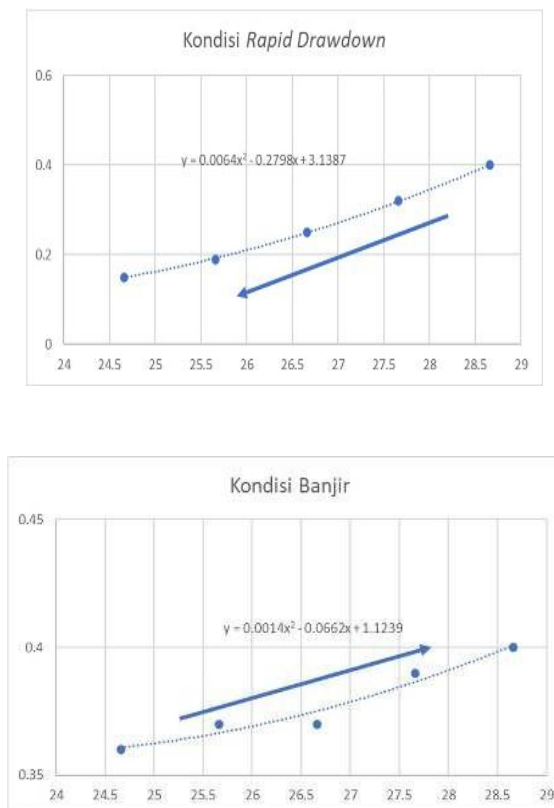


Figure 8. Graph of the relationship between flood water level and safety factor in flood conditions and Rapid Drawdown for the Crack Soils Approach assumption

As a result of an increase in the river water level up to elevation 0 but the groundwater level has not increased, there has been an increase in the value of the safety factor up to 0.4. Whereas in the simulation the condition of the river water level decreasing suddenly but the soil condition

is still saturated, there is a decrease in the value of the safety factor of the slope up to 0.15 so that the slope experiences a slide.

CONCLUSION

Conclusions and results from the analysis of various conditions that have been carried out, in connection with the objectives of this study are:

Based on the results of the analysis using the Geo5 program, the mechanism for the collapse of the slopes of the Konawehe river on road no. 030 Bts. Regency. North Konawe / Kab. Konawe – Pohara due to water dynamics on the Konawehe River and local traffic conditions are as follows:

1. The original slope of the Konawehe river with normal river water level conditions and assuming original soil parameters has a safety score of 1.33 while when the river water level reaches road level, the safety score increases to 1.82
2. The results of the analysis of the safety factor of the original slope of the Konawehe river for variations in river water level conditions assuming normal soil parameters, the most critical condition with the largest decrease in the safety factor value of up to 41% is when there is a decrease in the river water level but the soil is still in good condition. saturated with a safety value of 1.06.
3. While the analysis of the safety factor for the slopes of the Konawehe river using the Crack Soils approach with the condition of the river water level falling (rapid drawdown) up to the normal water level and saturated soil conditions, there was a decrease in the value of the safety score from initially 0.4 to 0.15
4. Based on the results of the analysis, the Konawehe river slope on road no. 030 Bts. Regency. North Konawe / Kab. Konawe – Pohara experienced a collapse under conditions of rapid drawdown as high as 4 meters and slope analysis using the Crack Soils approach.

Note. This paper has been presented in ICIFAM #1 2022, Surabaya, 21-22 June 2022, organized by Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia. ICIFAM – International Conference on Infrastructure & Facility Asset Management.

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