# Analysis of the Concrete Compressive Strength of Wailawa River to Withstand Partial Landslides on The Slopes of Mount Kohara, Tawiri Village, Ambon City

**Felix Charlos Johnlow Kastanya**
*Fakultas Teknik*
*Universitas Kristen Indonesia Maluku*
*Ambon - Indonesia*

**Richrisna Helena Waas**
*Fakultas Teknik*
*Universitas Kristen Indonesia Maluku*
*Ambon - Indonesia*

## ABSTRACT

Landslides that occur on the slopes of Mount Kohara generally occur during the rainy season between May and October, so the material on the slopes is also transported due to the landslides and is also deposited in the Wailawa river. The material contained in the Wailawa river is analyzed to determine its character and if it is made into concrete it can contribute to resisting the landslides. The objectives of this study were: (1) to analyze the potential amount of material volume in the Wailawa river (2) to analyze the character of landslides that occur on the slopes of Mount Kohara (3) to analyze the physical and mechanical properties of the Wailawa river material (4) to analyze the compressive strength of the concrete cubes using the material of the Wailawa river. The methods used were field observations on the Wailawa river in Tawiri village, the test on characteristics of the material, and the test on the compressive strength of concrete in the structural laboratory, and literature studies. The results showed that the volume of material in the Wailawa river that could be utilized by the community was 1228.67m$^3$. Landslides at each location occurred at different times. Landslides in 2020 occurred with the total of landslide volume at location I amounting to 2,012 m$^3$ while at location II the total landslide volume was 11.93m$^3$. The material characteristic test showed that coarse aggregate can be used for making concrete, but the organic content contained in fine aggregate must be washed if it is to be used in normal concrete. The ability of concrete to withstand compression by a mixture of 1: 2: 3 had the highest strength of 151.62 kg/cm$^2$ or equivalent to 12.35 MPa and concrete with the lowest strength was shown by concrete with a mixture of 1: 7: 9 which had a minimum concrete strength of 10.12 kg/cm$^2$ or equivalent to 0.82 Mpa. The demonstrated ability of concrete indicated that the concrete can withstand the shear forces of the soil.

***Keywords***—*Landslide; Meterial; Compressive strength; Concrete mixture.*

## I. Introduction

Some of the slopes of Mount Kohara (as the community is now called) are inhabited by the majority of Tawiri villagers, but the mountain can be categorized as a hill. The slopes of Mount Kohara are part of Mount Kadera [1] in Tawiri village, Ambon city often experiences partial landslides in every rainy season due to the disturbance of the slope stability, where the rainy season generally occurs between May and October with high rainfall in May, June, and July [2]. This resulted in material casualties that occurred in 1984, while in 2011, 2013, and 2017 partial landslides took place again on several parts of the slopes.[3]

Effort to utilize slopes, one of which is the cutting of the foot of the slope, is one of the causes of landslides. The landslide that occurs is in the form of a mixture of grayish to yellow-red rock and soil which is dominated by fallen sand and forms a burrow causes some of the soil to hang off the slope head. The formation of *avur* on the slopes allows the closure of water flow due to falling trees during heavy rain which results in flash floods, causing material casualties experienced by residents who live on these slopes.[3]

The flow of water mixed with rock and soil material flows during the rainy season because of the landslides and due to erosion. The landslide material moves with the water when it rains and enters the Wailawa river, so some of the rock and sand also settles in the river which causes buildup or sedimentation.

The condition of the Wailawa River shows an irregular distribution of piles of material. The rock color is dominated by dark colors while the sand is more dominated by light colored grains. The position of the water flow often changes after the completion of the flood, or the rainy season causes the accumulation of material in a new location that will be overgrown with shrub grass after the next few days if the rainy season has passed. Therefore, the material in the Wailawa river in the village of Tawiri continues to accumulate and will reduce the water flow area which causes the overflow of flood water to come out of its path and crash into the settlements if not utilized.

The above conditions direct this research with the aim of: (1) analyzing the potential amount of material volume of the Wailawa river, (2) analyzing the character of landslides that occur on the slopes of Mount Kohara, (3) analyzing the physical and mechanical properties of the Wailawa river material, and (4) analyzing compressive strength of concrete cubes using the Wailawa river material.

## II. Research Method

To find out the properties of the size of the Wailawa river, the study was carried out using the method of field observations: in the form of collecting data on watersheds. The measurement was made using a meter and a Garmin 78s GPSmap. Landslide slopes survey was also carried out in the same way, which was observing the landslide location.

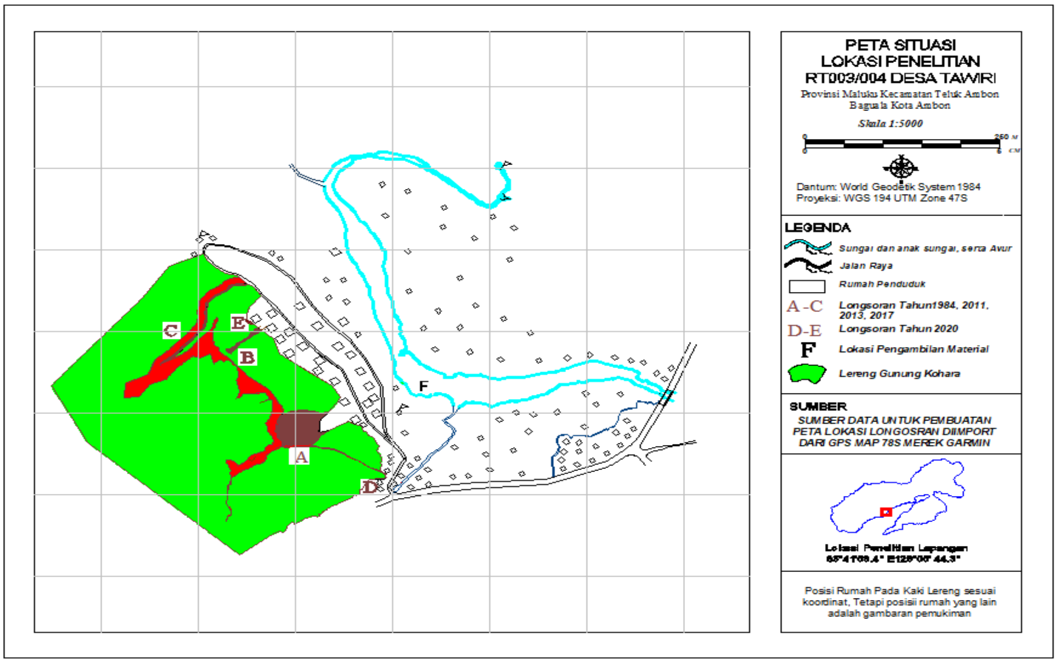


Figure 1. Study Site

Grading values and material characteristics (fine and coarse aggregates) were obtained by conducting tests at the structural laboratory of the Faculty of Engineering, Universitas Kristen

Indonesia Maluku. The aggregate gradient is the grain size distribution of the aggregate. If the aggregate grains have the same size (uniform), the pore volume will be large. Conversely, if the grain size varies, the pore volume will be small,[4] so in order to uniform the aggregate grains, a filter for sand was used as the final filter and the initial filter was of 40mm. Tests were carried out to determine the character values of the material include: Water content,[5] Absorption,[6] Volume Weight,[7] Relative density ,[7] and Organic Content. [6][8]

To determine the level of strength of concrete, a mixture of cement for 1 $m^3$ of 325 kg was used,[9] with an initial FAS of 0.55 for the type of concrete that enters the soil experiencing alternating wet and dry.[10] The mix design started with a 1: 2: 3 mixture with the weight of cement as the initial guideline, and 2 times more fine aggregate were added, followed by 3 times more coarse aggregate where the weight of the material was guided by the weight of the cement. The mixture 1: 3: 5 to 1: 7: 9 also had the same method so that it applied to the determination of coarse and fine aggregates, but the weight of cement did not change. However, materials (fine aggregate and coarse aggregate) were increasingly used.

A high level of structural strength requires a high compressive strength of concrete.[11] To determine the compressive strength of concrete, tests were carried out using compressive strength testing equipment at the Structural Laboratory of the Faculty of Engineering, Universitas Kristen Indonesia Maluku. Literature studies are used to analyze information about the existence of rivers and landslides due to patterns that are always displayed based on visual observations in the field, so that the conclusion is about the character of the two field conditions.

## III. Result and Discussions

### A. Characteristics of Wailawa River

Wailawa river can be categorized as [12] regim (flow regim) which is a river that tries or changes in seeking a balance between degradation and sediment aggression.[12] The morphometric characteristics of the watershed (DAS) that were analyzed were the area of the watershed,[13] where the measurement of the Wailawa river to determine the usable part of the material started from low on the river with a position of S03$^o$ 42' 00.4" E128 $^o$ 05' 56.9". This position has a length of 6.7 meters from the Wailawa Bridge which is a bridge connecting the national road. The end of the measurement was stopped in position S03$^o$ 41' 46.6" E128 $^o$ 05' 48.7"

The river that flows through the land (village) of Tawiri has the largest width of 59 m and the smallest width of 6 meters and the length surveyed and having a potential as a quary is 1200 m. Moving water does not completely fill the area in which it passes. Therefore, the volume owned by the Wailawa river using the calculation "take 2 meters height of aggregate deposits (gravel and sand)" followed the slope patterns that form along the river. The average width of 26.7 meters which is a collection of measurements to locations that have different widths and lengths of the survey location of 1200m get a volume of 1228.67m3 if the collection is carried out with human power capabilities.

### B. Landslides in 2020

Landslides in general are the movement of soil, rock, and organic matter down a slope due to the influence of gravity which produces a new shape on the slope after movement. [14] The landslides occurred in 2020 were as many as 2 points along the slopes of Mount Kohara, Tawiri Village RT003/RW004. Landslides were started with heavy rain for more than one day, so that the soil fell from the slope which was open without protection on the ground in the form of grass growing on the ground. This condition is caused by slope cutting by the community. Falling continues every time it rains and causes holes in the slope body, eventually causing more landslides due to the hanging top of the slope. After the landslide, a new shape is formed, as in *waji* cut on the slope.

Figure 2. Landslides at the location behind Mr. Dani's house

**Table 1. Landslide properties location 1**

| No | Description | P (m) | L (m) | Height/Thickness (m) |
|---|---|---|---|---|
| 1 | Length of the cut slope | 55.1 | | |
| 2 | Slope | $32^o$ | | |
| 3 | Slope Height | 1.5 - 6 | | |
| 4 | part of the slope that begins to slide | | | |
| 5 | Part I | 3.1 | 1.2 | 0.3 |
| 6 | Part II | 3.2 | 1.4 | 0.2 |
| 7 | Volume of Falling I | 1.116 | $m^3$ | |
| 8 | Volume of Falling II | 0.896 | $m^3$ | |
| 9 | Weight / Volume ($\gamma_b$) [3] | 1.55 | $gr/cm^3$ | |

There was pressure at location I caused by the soil in Part I of 1729.80 kg because the volume of the moving soil was 1.12 $m^3$ and the soil pressure in Part II was 1388.80 kg because the volume of the moving soil was 0.90 $m^3$.

**Table 2. Landslide properties location 2**

| No | Description | P (m) | L (m) | Height/Thickness (m) |
|---|---|---|---|---|
| 1 | Length of the cut slope | 20 | | |
| 2 | Slope | $42^o$ | | |
| 3 | Slope Height | 1.2 - 5 | | |
| 4 | part of the slope that begins to slide | | | |
| 5 | Part I | 4 | 3.5 | 0.7 |
| 6 | Part II | 6.3 | 2.25 | 0.15 |
| 7 | Volume of Falling I | 9.8 | $m^3$ | |
| 8 | Volume of Falling II | 2.13 | $m^3$ | |
| 9 | Weight / Volume ($\gamma_b$) [3] | 1.55 | $gr/cm^3$ | |

At location 2, the ground pressure in Part I was 15190.00 kg due to the volume of the moving soil as much as 9.8 $m^3$, and the soil pressure in Part II was 3295.69 kg because the volume of the moving soil was 2.13 m3

## C. Physical and Mechanical Properties of the Wailawa River Material

Aggregates are concrete mixture materials that are bonded together by cement adhesive. Based on the relative density, aggregate is divided into three groups, namely: (a) normal aggregate, which has a relative density between 2.5 to 2.7; (b) light aggregate, the relative density of which is less than 2.0; and (c) heavy aggregate, whose relative density is more than 2.8. [15] The results of tests carried out at the Structural Laboratory of the Faculty of Engineering obtained data on material characteristics (coarse gravel aggregate and gravel fine aggregate). Fine aggregate (sand) has the following characteristics: Water content 19.27%, Water absorption 20.13, Sand volume weight 1.19 gr/$cm^3$, apparent density 2.24, dry density 1.55, SSD density 1.86. The organic content that dissolves together in the sand after testing is red yellow where this organic content cannot be used with sand and must be washed if it is to be used for normal concrete. The coarse aggregate test (gravel) shows the results: water content 8.7%, water absorption 5.45, gravel volume weight 1.32 g/$cm^3$, bulk density: 2.24, SSD density 2.36, apparent density 2.55. The material contained in the Wailawa River is fine aggregate (sand) which indicates that sand can be classified into the light aggregate category, and coarse aggregate (gravel) indicates that this aggregate can be categorized as normal aggregate.

## D. Compressive Strength of Concrete Cubes Using the Wailawa River Material

The compressive strength of concrete increases along with the age of the concrete, [16][17] but the compressive strength of concrete can also decrease along with the increase of aggregate/cement ratio.[18][19] The compressive strength characteristic of concrete is the typical compressive strength of concrete. This shows the class of the concrete itself.[20][21]

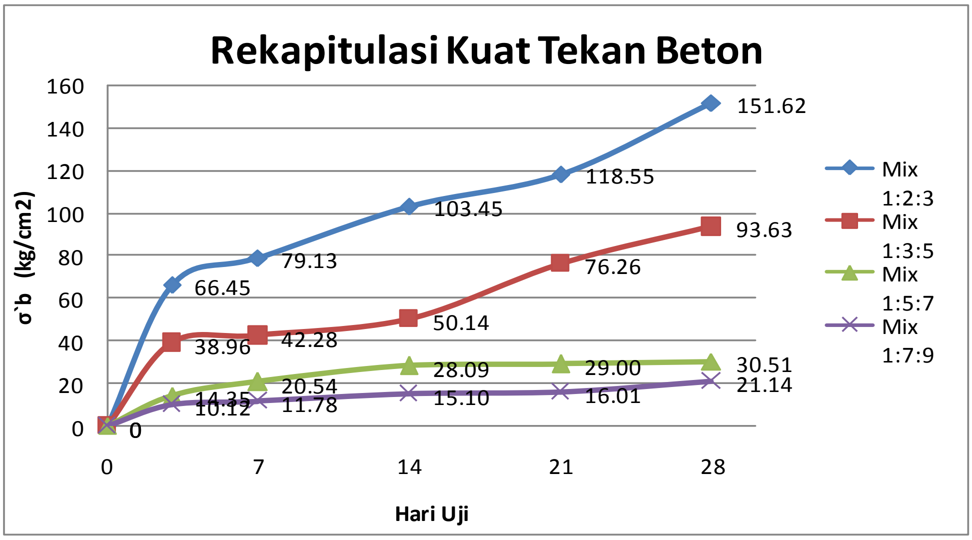


Figure 3. Compressive Strength of Concrete kg/$cm^2$

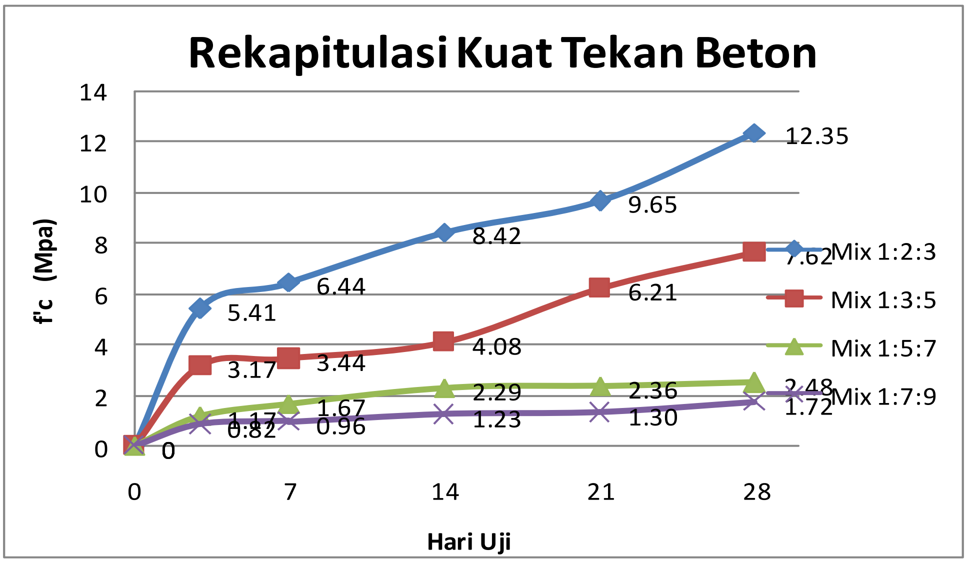


Figure 4. Compressive Strength of Concrete in the conversion to Mpa

The compressive strength test shows that the concrete cube with a mixture of 1: 2: 3 had strength when the concrete was three days old, which was 66.45 Kg/cm$^2$ or 5.41 Mpa and this mixture had strength when the concrete was twenty-eight days old with 151.62 Kg/cm$^2$ or amounting to 12.35 Mpa. The second position is occupied by concrete with a mixture of 1: 3: 5 where the strength of the concrete when it was three days old was 38.96 Kg/cm$^2$ or 3.17 Mpa. The strength of concrete with this mixture increased at the age of twenty-eight days, which was 93.63 Kg/cm$^2$ or 7.62 Mpa. The strength of the concrete which shows the compressive strength in the third position is concrete with a mixture of 1: 5: 7 where at the age of three days the strength of this concrete was 14.35 Kg/cm$^2$ or 1.17 Mpa, while at the age of twenty-eight days the strength of the concrete reached 30.51 Kg/cm$^2$ or 2.48 Mpa. The lowest withstand of compression is shown by a mixture of 1: 7: 9 with the strength of the concrete at three days could reach 10.12 Kg/cm$^2$ or 0.82 Mpa, while on the twenty-eight day it could reach 21.14 Kg/cm$^2$ or 1.72 Mpa.

The average weight volume of concrete owned by concrete with a mixture of 1: 2: 3, 1: 3: 5, 1: 5: 7, and 1: 7: 9 was 2096.99 Kg/cm$^3$, 2073.48 Kg /cm$^3$, 2011.46 Kg/cm$^3$, 1981.23 Kg/cm$^3$, respectively. The weight of the concrete shows that the ability of the concrete not to shift due to the horizontal pressure generated by the landslide is higher than the horizontal pressure of the soil, and this condition can be achieved if the concrete is made with a volume based on the thickness of the concrete walls of fifteen cm.

## IV. Conclusion

The results showed that the volume of material that could be utilized by the community was 1228.67m3 and would increase if heavy equipment was used for collection. Landslides at each location occurred in different times with the volume of landslides at location I part 1 of 1,116 m$^3$ and part 2 of 0.896 m$^3$, while at location II landslide part 1 was 9.8 m3 and part 2 was 2.13 m$^3$. The material characteristic test shows that coarse aggregate can be used for making concrete, but the organic content contained in fine aggregate must be washed if it is to be used in normal concrete. The ability of concrete to withstand compression by a mixture of 1: 2: 3 had the highest strength, which was 151.62 kg/cm$^2$ or equivalent to 12.35 Mpa, and the concrete with the lowest strength was shown by the concrete with a mixture of 1: 7: 9 which had the minimum strength of concrete amounting to 10.12 kg/cm$^2$ or equivalent to 0.82 Mpa. The concrete weight for each cubic is greatly influenced by the amount of cement in the concrete. This can be seen from the test results that the highest ratio of weight to volume of concrete is shown by a mixture of 1: 2: 3 with an average result of 2096.99 kg/cm$^3$, and the ratio of the lowest weight volume of concrete is shown by a mixture of 1: 7: 9 with the results the average yield was 1,981.23 kg/cm$^3$. The demonstrated ability of concrete indicates that the concrete can withstand the shear forces of the soil

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