International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 31 No. 2 March 2022, pp. 409-421

# *2D Physical Model Of The Sheet-Pile Building Of The Komering River At Sugih Waras Village, Ogan Komering Ilir Regency*

Yogi Adinata[1] and Achmad Syarifudin[2]

[1]Post Graduate of Civil and Environment Engineering FacultyUniversitas Bina Darma Palembang Indonesia

[2]Assoc. Prof. Of Civil and Environment Engineering FacultyUniversitas Bina Darma Palembang Indonesia



**Abstract— The conditions on the slopes of Komering river have a soft soil layer (back fill) and less strong soil reinforcement with a depth ranging from 20 m to 25 m, with the presence of a soil layer like this, plus a soil reinforcement that is less supportive to withstand the loads that are above it, so if there is a disturbance or the maximum load occurs on the slope soil surface, it will cause landslides.This study aims to draw and produce how much erosion and sedimentation that occurs in the river bends with sheet-pile with a physical model approach in the laboratory and dimensional analysis using the Langhaar method.The results of the study, the depth of erosion around the sheet-pile building with a relative erosion (ds/t) of 0.068. This means that there is an increase in the depth of erosion within 15 minutes of 1.02 cm in the model or with a scale in the field of 1:100, there is an erosion depth of 1.02 m. When the experiment lasted for 30 minutes, it was seen that the maximal relative sedimentation (ds/t) of 0.02 occurred at a relative speed (v/t) of 0.0012. This means that the sediment accumulation that occurs around the sheet-pile building in the model within 30 minutes is 0.6 cm or on a 1:100 scale in the prototype there will be sedimentation of 0.6 m.**

**Keywords: river cliffs, dimensional analysis, Langhaar method, erosion and Sedimentation**

## I. Introduction

The river is one of the aquatic ecosystems that is influenced by many factors, both in natural activities and human activities in the watershed (DAS). In the management of a watershed, it is necessary to pay attention to the water body of the watershed. Wrong watershed management will have an impact on the sustainability of river water bodies, namely very high water discharge fluctuations and reduced river capacity. (Paimin et al, 2012)

The water level in the river (river stage) is the elevation of the water level at a station above the datum line (normal height). Sometimes the normal water level is taken to be equal to the mean sea level, but more often it is taken slightly below the zero pointof river flow. (Yandi Hermawan, 1996).

The Komering River has many meanders, especially on the riverbanks, there are roads that really need to be considered so thatthere is no material collapse and the road can be damaged and even cannot be passed by vehicles.

For cohesive soil slopes under short term conditions, total analysis and effective stress analysis should be used. For long term conditions, only effective stress analysis is used. The definition of short term (short term) is the implementation condition at the time of implementation (now) in an undrained condition, while the long term condition is a drained condition in a relatively longertime which is reviewed at the last time. construction and after.

**Corresponding Author:** Achmad Syarifudin

Slopes with material in the form of non-cohesive soil, it is sufficient to use effective stress analysis both for the short term and long term if the load conditions are static.

As it was previously known that the conditions on the slopes under review have a soft soil layer (back fill) and less strong soil reinforcement with a depth ranging from 20 m to 25 m, with the presence of a layer of soil like this, plus soil reinforcement that isless supportive to withstand the load. which is above it, then if there is a disturbance or the maximum load occurs on the surface ofthe slope soil, it will be able to cause a landslide.

The condition of the land located on the banks of the Musi River is soil consisting of sand and mud which is at risk of soil movement and causes landslides. Efforts to prevent landslides can be carried out by several methods that can be used, one of which is using sheet piles as soil retainers. Sheet pile is a construction in the form of a continuous wall made by connecting interlocking pieces / sections which aim to withstand horizontal pressure due to soil and water. The type of sheet pile that will be discussed is sheet pile with reinforced piles.

To avoid damage and collapse, single or group pile foundations must have a strong bearing capacity to carry the construction load on them. In order for the pile that interacts with the soil to have an accurate bearing capacity, it is necessary to carry out an accurate soil investigation as well. Furthermore, research was carried out based on soil conditions to obtain erosion andsedimentation in sheet-pile buildings through hydraulic model testing in the laboratory..

## II. RESEARCH METHODS

### 2.1. Research sites

Fig. 1. Research location

Fig. 2. Sketch of a river model in the Hydraulics Laboratory of Bina University Darma.(Achmad Syarifudin, 2018)

### 2.2. Dimension Analysis

To determine the dimensionless number can be done by dimensional analysis. Dimensional analysis to determine thedimensionless number there are several ways, including by:

a. Basic echelon matrix

b. Buckingham (phi.theorem)

c. Rayleigh

d. Stepwise,
and
e.Langhaar

How to Basic Echolen Matrix

The principle of determining dimensionless numbers using the "basic echelon matrix" is to choose a "repeating variable" with the appropriate number of basic elements (dimensions) used (for example, three for the dimensions used in the problem, namely L, T, and M) and variables the rest is compiled using the "repeating variable". The way of preparation is using the increasing order (echelon) and the "repeating variable" matrix.

- The Buckingham Way (phi theorem)

If an event or phenomenon can be described with n parameters, and those parameters are composed of m basic elements (dimensions), then the number of dimensionless number products that can be generated or derived is (n-m).

By determining a number of "repeating variables" with basic elements (dimensions), each of these dimensionless number productscan be compiled and analyzed to obtain their magnitude.

- Rayleigh Way

This method is usually used for relatively simple problems. Dimensionless numbers are directly derived from the existingparameter relationships. If this method is applied to complex problems and with a large number of parameters, it will be difficult.

- Stepwise Way (Stepwise Procedure)

The stepwise method is a way to get a dimensionless number by eliminating (eliminating) the dimensions step by step. The first step is to determine the mass dimension (M) by using a variable containing the mass dimension, for example the density

(M/L3).

The next step is to determine the time dimension (T) by using a variable that contains a time dimension, such as velocity V (L/T).

The last stage is the determination of the length dimension L by using a variable that "only" contains a length dimension, forexample with a depth of d (L). There are two stepwise ways, namely:

a. “Basic stepwise procedure” and

b. "Dimensional matrix stepwise".

These two methods have the same principle, only the difference is in the arrangement of the order of the variables to be analyzed. In the first way the order of variables is independent, while in the second way the order of variables is arranged in such away that "repeating variables form a matrix" at the beginning of the variable arrangement.

- The Langhaar Way

If the hydraulic phenomenon/event can be explained by n parameters Pi with i = 1,2, 3,.................... , n and if the parameter is composed of m principal elements, then the product of dimensionless numbers that can be derived number (n-m). For hydraulicengineering purposes, there are usually 3 main elements, namely: mass (M), length (L), and time (T).

j = P1k1. P2k2. first aid.............. P, where

jnkn = product of dimensionless numbers with j = 1, 2, 3

If Pi has dimension M, then the dimensions can be written as follows:

= (Mα1 Lβ1 Tτ1)k1 * (Mα2 Lβ2 Tτ2)k2 * .......... (Mαn Lβn Tτn)kn

= [M(α1k1+α2k2 +........+αnkn)]*[Lβ1k1 +β2k2+.......+βnkn ]*[Tτ1k1+τ2k2 +. .........+τnkn]

is a dimensionless number if: 1
k1+ 2 k2 +. ........+ n kn = 0

1 k1 + 2 k2+. ......+ n kn = 0

1 k1 + 2 k2 +.......+ n kn = 0

coefficients i, i and i can be known from the related parameters Pi.

### 2.3. Research Materials and Tools

Table I. The Materials And Tools Used In This Study

| No. | Tools Name | Amount | Uses |
|---|---|---|---|
| 1 | River scale model | 1 set | tool for writing data recording results |
| 2 | Pump | 1 unit | sists the movement of flow in the model |
| 3 | Sheet-pile Model | 1 unit | Simulation Tool |
| 4 | River bed materials | Sieve analysis result | Simulation Material |
| 5 | Water | suitable for storage | Flow simulation |

### 2.4. Research Stages

In accordance with the research objectives, the following stages are required:

1. The first stage is to collect references from journals, books, and other secondary data sources.
2. The second stage is conducting a field orientation survey to obtain the current (existing) field conditions, taking photos of the field (site) so that it can be used as initial research data.
3. The third stage is to design the river with a model scale from prototype to model with a maximum storage capacityof 1000 liters, consisting of 2 circulation tanks located upstream and downstream of the river model with dimensions of length 500 cm, width 20 cm with a wall slope ratio of 1 : 0.005.
4. The fourth stage, conducting initial simulation trials to see the readiness of the river model and calibrating so that the model is in accordance with the conditions from prototype to model.
5. The fifth stage is to test the model by placing the sediment base material from the sieve analysis by taking the average diameter (d50) with the assumption that the base material corresponds to that in the river prototype. Followed by the installation of the sheet-pile model position at the river bend as much as 3 points (beginning of theturn, middle and end of the turn).
6. The sixth stage is to do a trial with a running time of 60 minutes every 15 minutes. Observations and recordings oferosion and sedimentation patterns were carried out in each scenario of the sheet-pile model installation.
7. The seventh stage, discusses the results of observations that occur in the sheet-pile model and makes research conclusions and provides suggestions for further research by other studies.

The equipment used in this research is a hydraulics laboratory facility, Master of Civil Engineering, Postgraduate Program atBina Darma University.

The specifications of the tool are as follows:

1. River model with its turns:

   Wall material: made of ordinary mixed cementEffective length: 600 cm

   Width: 25 cm

   Depth: 20 cm
2. Measuring depth of scour
3. Meter, to measure the location of scour
4. Photo camera to take pictures during the experiment
5. Video recorder to record the execution of the experiment.

### 2.5. Research Preparation

This research was conducted using a laboratory approach with various variations in flowrate, velocity and time. The standardflume is mostly made of glass and has the following important parts:

- River model with bends as the main place in this experiment, to drain water with a size of 600 x 25 x 20 cm. This rivermodel is placed in the open.
- A reservoir that functions to accommodate water that will be flowed into the river model or out,
- Water pump, serves to pump water so that it can be distributed along the gutters. This pump is equipped with anautomatic on/off switch for 220/240 V, 50 Hz,
- Discharge faucet, is a faucet that functions to regulate the size of the discharge coming out of the pump.

Has adischarge opening scale of 6-9 range,

- This bed slope has a scale for a maximum positive bed slope of + 3.0 % and a maximum negative bed slope of - 1.0%..

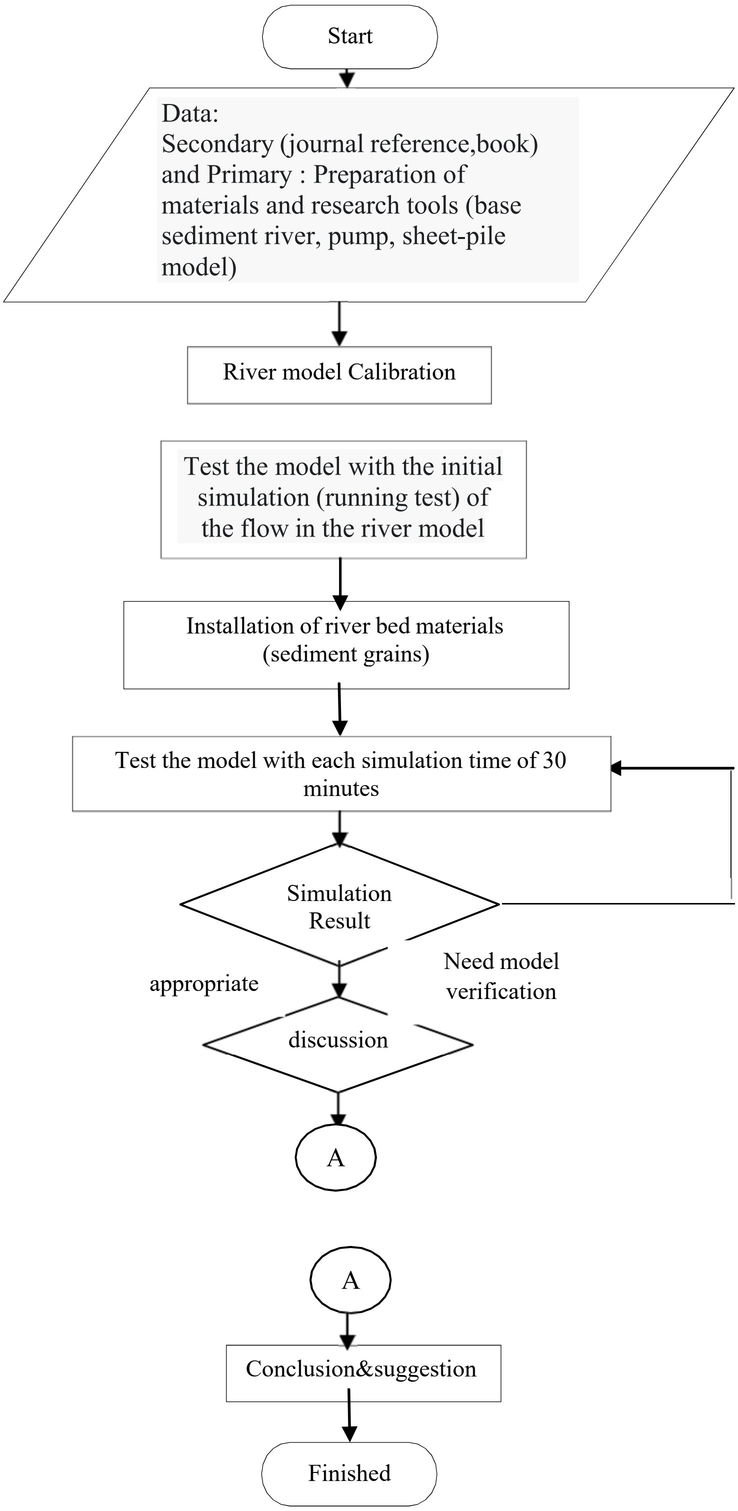


Fig. 3. Flowchart of the calculation of rainfall frequency analysis

## III. Research Result And Discussion

### 3.1 Dimension Analysis

Langhaar's theorem is used in analyzing the parameters related to this research because this theorem is considered more in accordance with the conditions of the existing data and in accordance with the research because the parameters are relatively few. Dimensional analysis follows the following steps:

1. In the formulation of the problem, it is stated that the parameters that affect the erosion of riverbanks include flowvelocity (v), depth of erosion and sedimentation (ds), time (t) and acceleration of gravity (g), and water mass density (ρw). ).
2. The parameters are grouped into:

- Dependent parameter: v
- Parameters changed during the experiment: ds, x and t
- Other parameters: g and w

3. The prices of α1, β1 and γ1 are determined as shown in table 2 below:

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

Table II. Determination Of Dimensional Analysis

| **Grup** | **1** | | **2** | | **3** | | **Ket** |
|---|---|---|---|---|---|---|---|
| **Parameter** | **v** | **ds** | **x** | **t** | **ρ** | **g** | |
| M | 0 | 0 | 0 | 0 | 1 | 0 | α1 |
| L | 1 | 1 | 1 | 0 | -3 | 1 | β1 |
| T | -1 | 0 | 0 | 1 | 0 | -2 | γ1 |
| | k1 | k2 | k3 | k4 | k5 | k6 | ki |

Equations related to parametersk5 = 0

k1 + k2 +k3 -3k5+k6 = 0

-k1 + k4 – 2k6 = 0

eliminasi k5

k1 + k2 + k3 + k6 = 0k1+k4 + k6 = 0

k2 + k3 + k4 = 0

Determination of dimensionless numbers as in table 3.

Table III. Dimensionless Numbers

| Ki | k1 | k2 | k3 | k4 | k5 | k6 |
|---|---|---|---|---|---|---|
| **Parameter** | **v** | **$d_e$** | **x** | **t** | **ρ** | **g** |
| π1 | 1 | 0 | 0 | -1 | 0 | 0 |
| π2 | 0 | 1 | 0 | -1 | 0 | 0 |
| π3 | 0 | 0 | 1 | -1 | 0 | 0 |
| π4 | 0 | 0 | 0 | 1 | 0 | 1 |

π1 = v/t (1)

π2 = ds/t (2)

π3 = x/t (3)

π4= √ g x t (4)

(x/t) x (√gt)

(x/t) x (g1/2 t1/2) together with v = √2gtf (v/t ; ds/t; v)= 0 (v ≈ 0)

(v/t) = f (ds/t) focus on erosion near sheet-pile

### 3.2 Experiment Results

Table IV. The following are the experimental results for the river bend model installed by sheet-pile buildings as follows:

Table IV. Experimenttal Result With The Sheet-Pile Model At River Bends

| v (m/det) | ds (cm) | t (detik) | v/t | ds/t |
|---|---|---|---|---|
| 0.006 | 0.2 | 5 | 0.0012 | 0.040 |
| 0.006 | 0.05 | 5 | 0.0012 | 0.010 |
| 0.006 | 0.05 | 5 | 0.0012 | 0.010 |
| 0.006 | 0.05 | 5 | 0.0012 | 0.010 |
| 0.006 | 0.02 | 5 | 0.0012 | 0.004 |
| 0.006 | 0.04 | 10 | 0.0006 | 0.004 |
| 0.006 | 0.02 | 10 | 0.0006 | 0.002 |
| 0.006 | 0.04 | 10 | 0.0006 | 0.004 |
| 0.006 | 0.01 | 10 | 0.0006 | 0.001 |
| 0.006 | 0.08 | 10 | 0.0006 | 0.008 |
| 0.006 | 0.01 | 15 | 0.0004 | 0.001 |
| 0.006 | 0.01 | 15 | 0.0004 | 0.001 |
| 0.006 | 0.01 | 15 | 0.0004 | 0.001 |
| 0.006 | 0.01 | 15 | 0.0004 | 0.001 |
| 0.006 | 0.01 | 15 | 0.0004 | 0.001 |

| | | | | |
|---|---|---|---|---|
| 0.006 | 0.02 | 20 | 0.0003 | 0.001 |
| 0.006 | 0.05 | 20 | 0.0003 | 0.003 |
| 0.006 | 0.02 | 20 | 0.0003 | 0.001 |
| 0.006 | 0.01 | 20 | 0.0003 | 0.001 |
| 0.006 | 0.02 | 20 | 0.0003 | 0.001 |
| 0.006 | 0.01 | 25 | 0.00024 | 0.000 |
| 0.006 | 0.01 | 25 | 0.00024 | 0.000 |
| 0.006 | 0.02 | 25 | 0.00024 | 0.001 |
| 0.006 | 0.02 | 25 | 0.00024 | 0.001 |
| 0.006 | 0.02 | 25 | 0.00024 | 0.001 |
| 0.006 | 0.02 | 30 | 0.0002 | 0.001 |
| 0.006 | 0.03 | 30 | 0.0002 | 0.001 |
| 0.006 | 0.05 | 30 | 0.0002 | 0.002 |
| 0.006 | 0.01 | 30 | 0.0002 | 0.000 |
| 0.006 | 0.01 | 30 | 0.0002 | 0.000 |

Source: Analysis results, 2021

### 3.3 Discussion

Erosion on sheet-pile model at river bend for 30 minutes

The following picture shows the erosion that occurred on the river bank with sheet-pile installed for 30 minutes

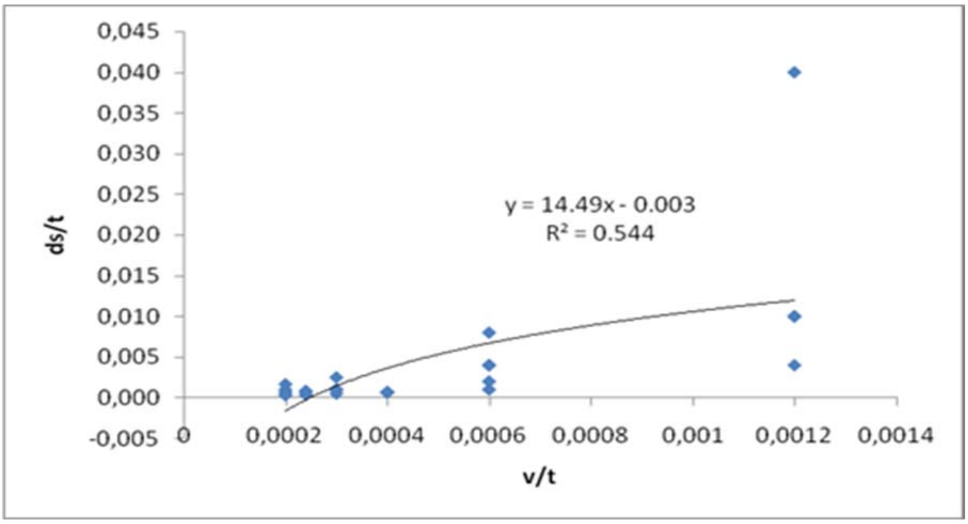


Fig. 4. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 30 minutes

In fig. 4. When the experiment lasted for 30 minutes, it was seen that the relative sedimentation (ds/t)max of 0.02 occurredat a relative velocity (v/t) of 0.0012.

It means that the accumulation of sediment that occurs around the sheet-pile building in the model within 30 minutes is 0.6cm or on a 1:100 scale in the prototype there will be sedimentation around the sheet-pile of 0.6 m.

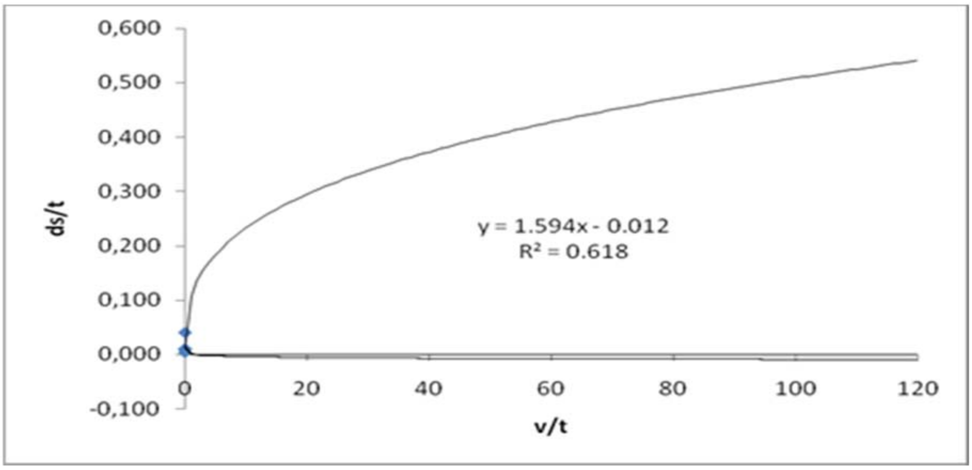


Fig. 5. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 5 minutes

In fig. 5. shows that when the experiment lasted for 5 minutes, the maximum relative sedimentation decrease (ds/t)max of 0.008 occurred at a constant relative velocity (v/t) of 0.0012.

It means that around the sheet-pile building there has been sedimentation of 0.04 cm or on a scale of 1:100 in the prototype there will be accumulation around the sheet-pile of 0.04 m.

When the experiment was carried out for 10 minutes, there was only erosion around the sheet-pile building on the river bank, which was about a relative erosion depth (ds/t) of 0.045, this means that in the field there was an erosion of 0.045 cm. Asshown in Fig. 6 below

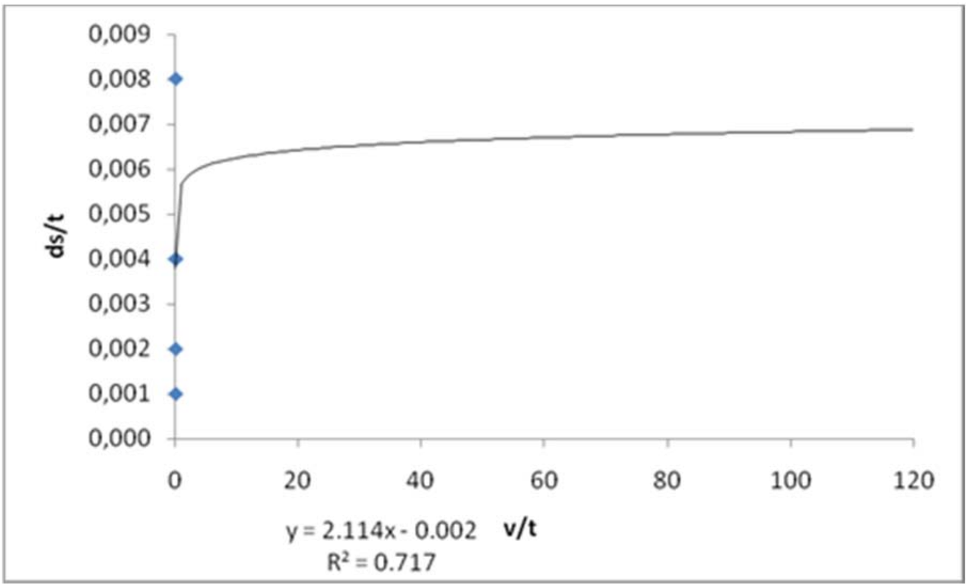


Fig.6. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 10 minutes

During the 15-minute experiment, it was seen that there was an increase in the depth of erosion around the sheet-pile building with a relative erosion (ds/t) of 0.068. It means that there is an increase in the depth of erosion within 15 minutes by 1.02 cm in the model or with a scale in the field of 1:100 there is an erosion depth of 1.02 m.

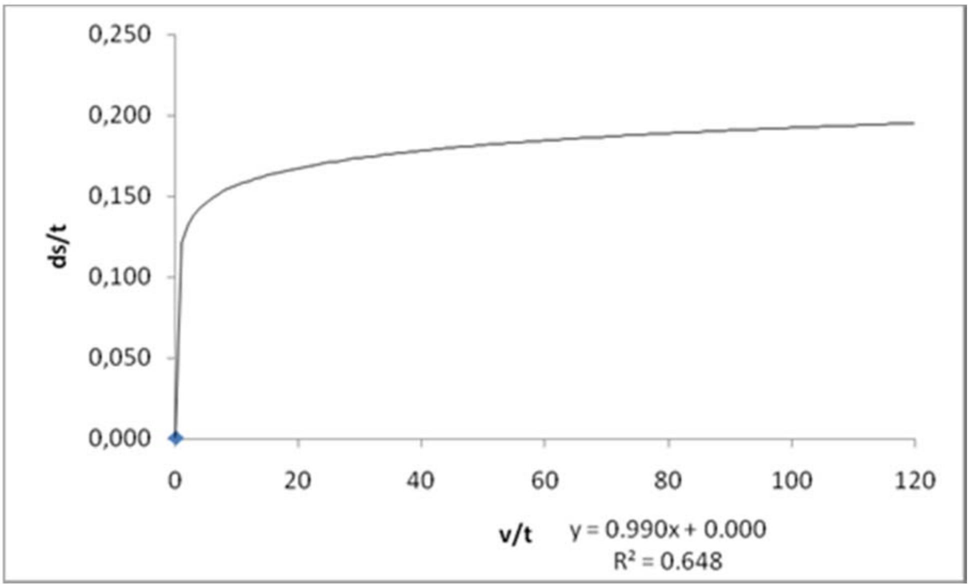


Fig. 7. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 15 minutes

Then in Fig.8. The following shows that the maximum relative sediment accumulation (ds/t)max occurred again when the experiment lasted for 20 minutes, which was 0.0075. This means that during the 20 minute experiment there was no erosion butsedimentation around the sheet-pile building. Sedimentation occurs by 0.15 cm in the model and if in the field with a scale of 1:100 then there is a buildup of 0.15 m of sedimentation.

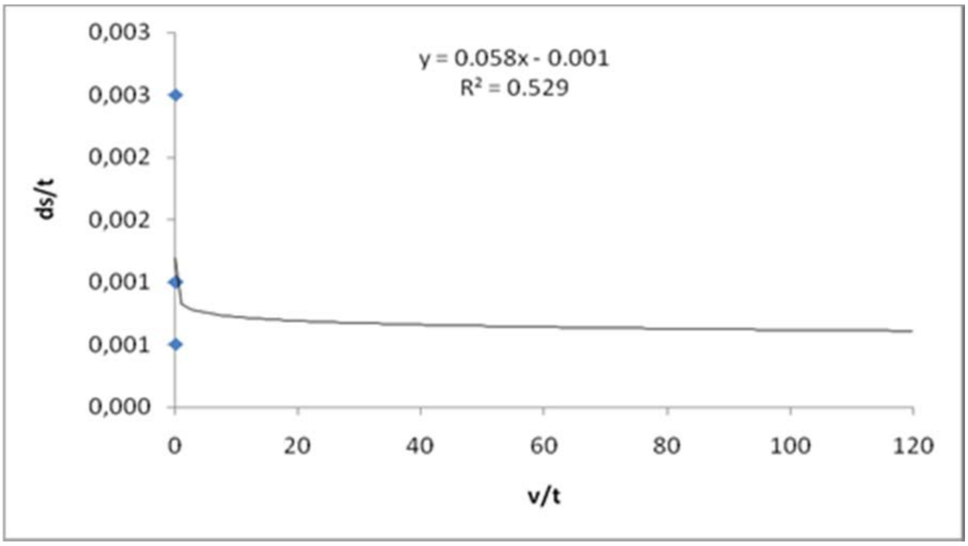


Fig. 8. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 20 minutes

In fig. 9. The following shows the phenomenon of erosion and sedimentation events (sediment transport) that occurred during the experiment in the model for 25 minutes. Sugih Waras Village, Kab. Ogan Komering Ilir. There is no erosion or sedimentation seen as shown in Fig. 6. following.

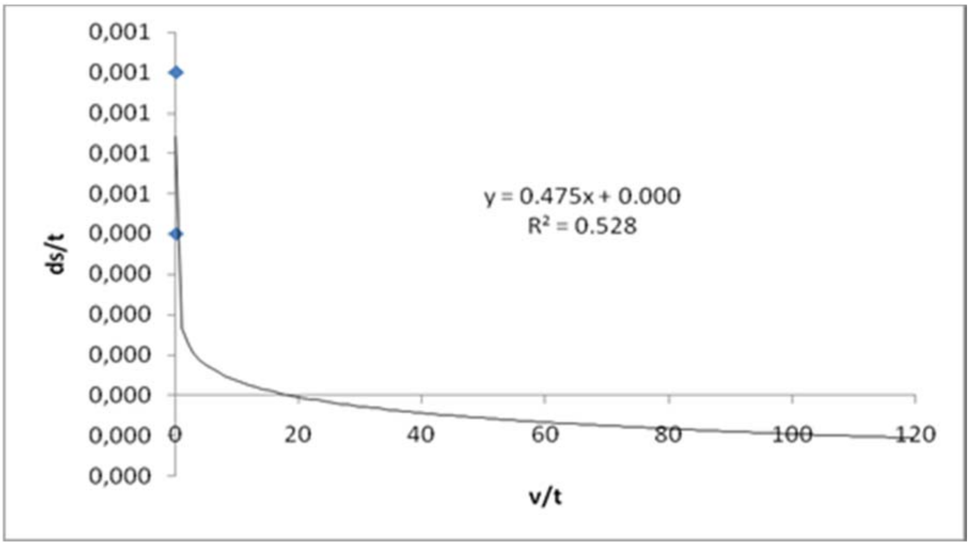


Fig. 9. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 25 minutes

In fig. 10. The following shows the experimental conditions for 30 minutes, where it appears that conditions have occurredwhich are almost the same as the experimental time for 30 minutes, there is no erosion or sedimentation in the river model withsheet-pile buildings, meaning that when it lasts more than 30 minutes there is no erosion and sedimentation .

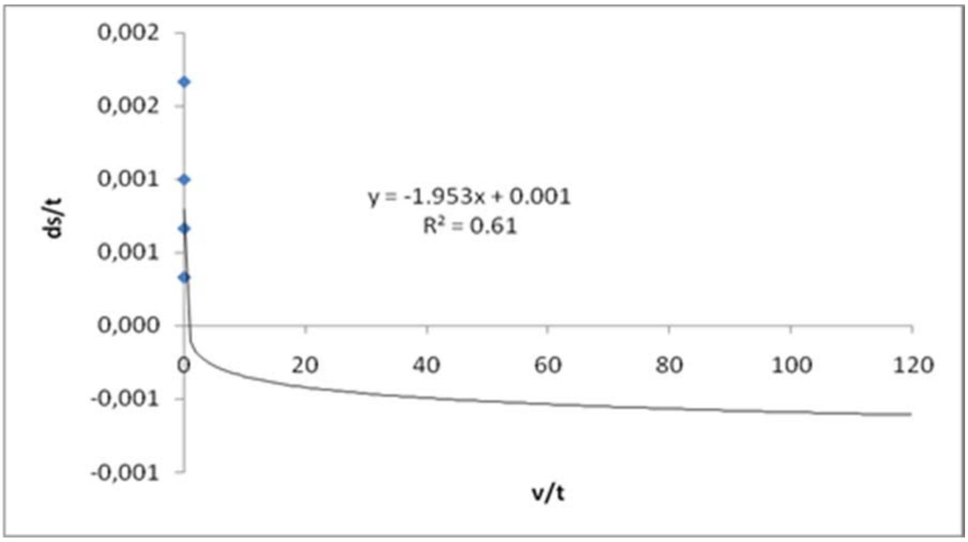


Fig.10. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 30 minutes

It is possible that in the field it can be seen that the maximum sedimentation value is 0.6 m, while the maximum erosion value that occurs is 1.02 m.

## IV. Conclusions

Based on the results of dimensional analysis and discussion, it can be concluded in this study as follows:

1. The depth of erosion around the sheet-pile building obtained a relative erosion depth (ds/t) of 0.068. It means that there is anincrease in the depth of erosion within 15 minutes by 1.02 cm in the model or with a scale in the field of 1:100 there is an erosion depth of 1.02 m.
2. When the experiment lasted for 30 minutes, it was seen that the relative sedimentation (ds/t)max of 0.02 occurred at a relativevelocity (v/t) of 0.0012. It means that sediment buildup occurred around the sheet-pile building in the model within 30 minutes. minutes is 0.6 cm or on a scale of 1:100 in the prototype there will be sedimentation of 0.6 m.

## REFERENCES

[1] Paimin et al, 2012, Watershed Management Planning System, Research and Development Center for Conservation and Rehabilitation (P3KR), Bogor,

Indonesia

[2] Holdani Kurdi et al, 2019, Model Hidrolika, Lambung Mangkurat University Press

[3] Achmad Syarifudin and Dewi Sartika, A Scouring Patterns Around Pillars of Sekanak River Bridge, Journal of Physics: IOP Conference Series, volume 1167, 2019, IOP Publishing

[4] Achmad Syarifudin., 2018, Hidrologi Terapan, Andi Offset, Yogyakarta

[5] Achmad Syarifudin., 2018, Drainase Perkotaan Berwawasan Lingkungan, Andi Offset, Yogyakarta

[6] Ahmed SMU, Hogue MM and Hossain S, 1992, "Floods in Bangladesh: A Hydrological Analysis," Final Report R01/92, Institute of Flood Control and Drainage Research (IFCDR), Bangladesh University of Engineering and Technology (BUET), Dhaka, pp.1-5

[7] Cahyono Ikhsan., 2017, The effect of variations in flow rate on the bottom of an open channel with uniform flow, Civil Engineering Media.

[8] Chow V.T., D.R. Maidment and L.W. Mays., (1988), Applied Hydrology. Mc. Graw Hill co. Department of Public Works., Guidance for Landslide Management Planning, SKBI - 2.3.06., 1987, PU Publication Agency Foundation

[9] Directorate General of Human Settlements, Ministry of Public Works. 2010. Procedures for Making Retention Ponds and Polders With Main Channels. Directorate General of Human Settlements, Ministry of Public Works. Jakarta.

[10] Department of Public Works., Guidance for Landslide Management Planning, SKBI - 2.3.06., 1987, PU Publication Agency Foundation Islam MZ

[11] Istiarto, 2012, Teknik Sungai, Transpor Sedimen, Gadjahmada University, Yogyakarta

[12] Istiarto, 2012, Teknik Sungai, Gadjahmada University, Yogyakarta

[13] Mc. Cuen R.H., (1982), A Guide to hydrologic analyses using SCS methods. Prentice Hall Publication.

[14] Okubo K, Muramoto Y, and Morikawa H, 1994, "Experimental Study on Sedimentation over the Floodplain due to River Embankment Failure," Bulletin of the Disaster Prevention Research Institute, Kyoto University, 44 (2), pp. 69- 92

[15] Achmad Syarifudin., 2017, The influence of Musi River Sedimentation to The Aquatic Environment DOI: 10.1051/matecconf/201710104026, MATEC WebConf, 101, 04026, , [published online 09 March 2017]

[16] Robert. J. Kodoatie, Sugiyanto., 2002, Flood causes and methods of control in an environmental perspective, Yogyakarta

[17] Syarifudin A, HR Destania., IDF Curve Patterns for Flood Control of Air Lakitan river of Musi Rawas Regency, IOP Conference Series: Earth and Environmental ScienceVolume 448, 2020, The 1st International Conference on Environment, Sustainability Issues and Community Development 23 - 24 October 2019, Central Java Province, Indonesia

[18] Van Rijn, L.C., 2007, Unified View of Sediment Transport by Currents and Waves II: Suspended Transport. Journal of Hydraulic Engineering, Vol. 133, Issue 6, , pp. 668-689.

[19] Wanshun Zhang, Yanhong Xu, Yanru Wang, and Hong Peng, 2014. Modeling Sediment Transport and River Bed Evolution in River System, Journal of Clean Energy Technologies, Vol. 2, No. 2, April 2014

[20] Yang, C.T., Sediment Transport: Theory and Practice. McGraw-Hill, Singapore, 1996.