

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

*by Achmad Syarifudin, Yogi Adinata*

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

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**Abstra** 10- The conditions on the slopes of Komerling 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

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## **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 point of river flow. (Yandi Hermawan, 1996).

The Komerling River has many meanders, especially on the riverbanks, there are roads that really need to be considered so that there 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 longer time which is reviewed at the last time. construction and after.

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 is less supportive to withstand the load, which is above it, then if there is a disturbance or the maximum load occurs on the surface of the 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 and sedimentation in sheet-pile buildings through hydraulic model testing in the laboratory..

## II. RESEARCH METHODS

### 2.1 Research sites

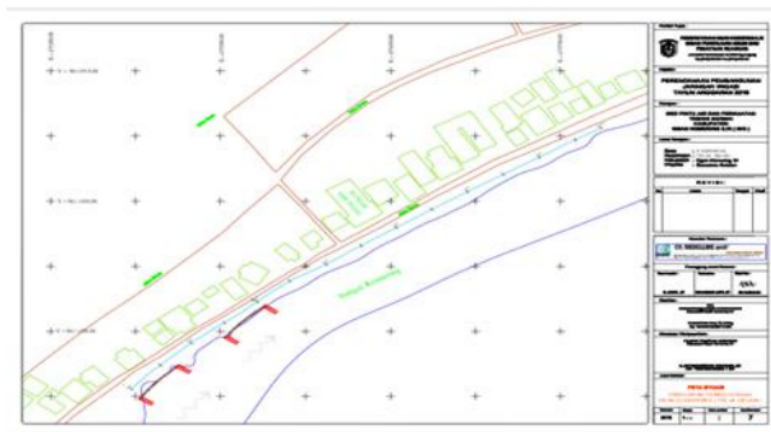


Fig. 1. Research location



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 the dimensionless number there are several ways, including by:

- Basic echelon matrix
- Buckingham (phi.theorem)
- Rayleigh
- Stepwise, and
- Langhaar

### How to Basic Echelon 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 products can 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 existing parameter 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/L<sup>3</sup>).

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, for example with a depth of d (L). There are two stepwise ways, namely:

- "Basic stepwise procedure" and
- "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 a way 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  $P_i$  with  $i = 1, 2, 3, \dots, n$  and if the parameter is composed of m principal elements, then the product of dimensionless numbers that can be derived number (n-m). For hydraulic engineering purposes, there are usually 3 main elements, namely: mass (M), length (L), and time (T).

$j = P_1^{k_1} P_2^{k_2} \dots P_n^{k_n}$ , where

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

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

$$= (M^{\alpha_1} L^{\beta_1} T^{\tau_1})^{k_1} * (M^{\alpha_2} L^{\beta_2} T^{\tau_2})^{k_2} * \dots (M^{\alpha_n} L^{\beta_n} T^{\tau_n})^{k_n}$$
$$= [M^{\alpha_1 k_1 + \alpha_2 k_2 + \dots + \alpha_n k_n}] [L^{\beta_1 k_1 + \beta_2 k_2 + \dots + \beta_n k_n}] [T^{\tau_1 k_1 + \tau_2 k_2 + \dots + \tau_n k_n}]$$

is a dimensionless number if:

$$\alpha_1 k_1 + \alpha_2 k_2 + \dots + \alpha_n k_n = 0$$

$$\beta_1 k_1 + \beta_2 k_2 + \dots + \beta_n k_n = 0$$

$$1 k_1 + 2 k_2 + \dots + n k_n = 0$$

coefficients  $k_i$ ,  $i$  and  $i$  can be known from the related parameters  $P_i$ .

### 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 capacity of 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 ( $d_{50}$ ) 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 the turn, 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 of erosion 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 at Bina Dharma University.

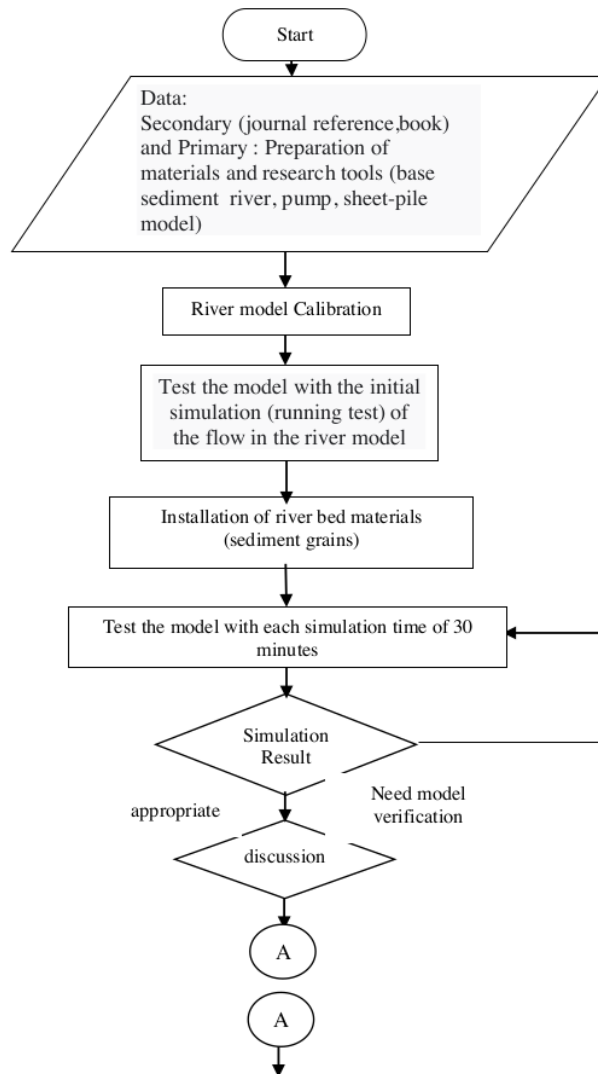
The specifications of the tool are as follows:

1. River model with its turns:
  - Wall material: made of ordinary mixed cement
  - Effective 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 standard flume 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 river model 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 an automatic 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 a discharge 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%..



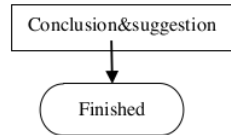


Fig. 3. Flowchart of the calculation of rainfall frequency analysis

### 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 flow velocity ( $v$ ), depth of erosion and sedimentation ( $ds$ ), time ( $t$ ) and acceleration of gravity ( $g$ ), and water mass density ( $\rho$ ). ).
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  $\alpha_1$ ,  $\beta_1$  and  $\gamma_1$  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	$v$	$ds$	$x$	$t$	$\rho$	$g$	
M	0	0	0	0	1	0	$\alpha_1$
L	1	1	1	0	-3	2	$\beta_1$
T	-1	0	0	1	0	-2	$\gamma_1$
	$k_1$	$k_2$	$k_3$	$k_4$	$k_5$	$k_6$	$k_i$

Equations related to parameters

$$k_5 = 0$$

$$k_1 + k_2 + k_3 - 3k_5 + k_6 = 0$$

$$-k_1 + k_4 - 2k_6 = 0$$

eliminasi  $k_5$

$$k_1 + k_2 + k_3 + k_6 = 0$$

$$k_1 + k_4 + k_6 = 0$$

$$k_2 + k_3 + k_4 = 0$$

Determination of dimensionless numbers as in table 3.

TABLE III. DIMENSIONLESS NUMBERS

$K_i$	$k_1$	$k_2$	$k_3$	$k_4$	$k_5$	$k_6$
-------	-------	-------	-------	-------	-------	-------



Parameter	v	d <sub>e</sub>	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

$$\pi_1 = v/t \quad (1)$$

$$\pi_2 = ds/t \quad (2)$$

$$\pi_3 = x/t \quad (3)$$

$$\pi_4 = \sqrt{g} \times t \quad (4)$$

$$(x/t) \times (\sqrt{gt})$$

$$(x/t) \times (g/2 \ t/2) \text{ together with } v = \sqrt{2gt}$$

$$f(v/t; ds/t; v) = 0 \quad (v \approx 0)$$

$$(v/t) = f(ds/t) \text{ focus on erosion near sheet-pile}$$

### 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. EXPERIMENTAL RESULT WITH THE SHEET-PILE MODEL AT RIVER BENDS				
v (m/detik)	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

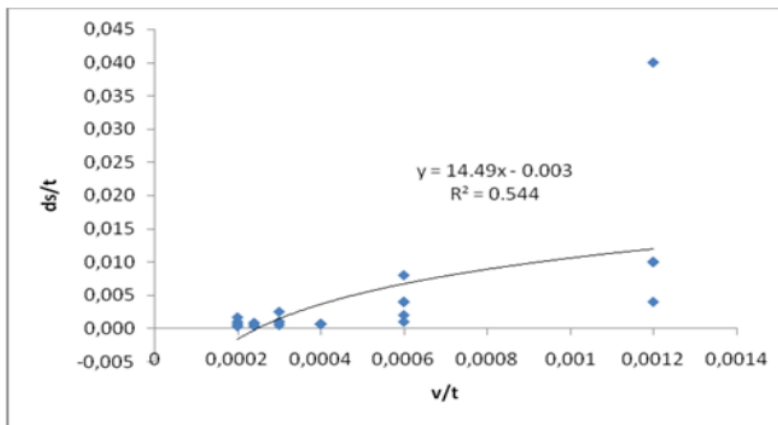


Fig. 4. Graph ( $v/t$ ) vs ( $ds/t$ ) on a sheet-pile on a riverbank for 30 minutes

In fig. 4. When the experiment lasted for 30 minutes, it was seen that the relative sedimentation ( $ds/t$ )max of 0.02 occurred at 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 0.6 cm or on a 1:100 scale in the prototype there will be sedimentation around the sheet-pile of 0.6 m.

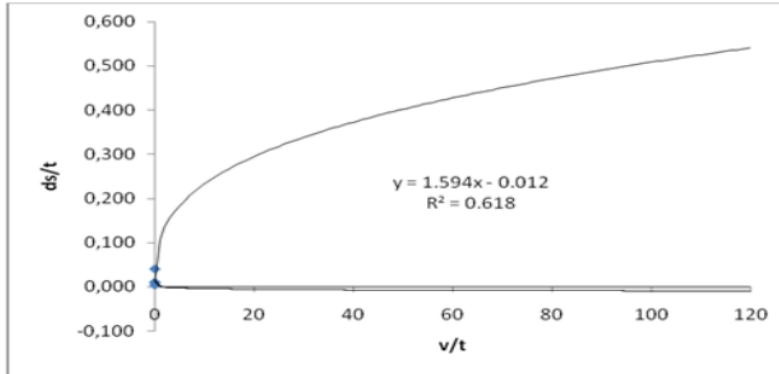


Fig. 5. Graph ( $v/t$ ) vs ( $ds/t$ ) on a sheet-pile on a riverbank for 5 minutes

In fig. 5. shows that when the experiment lasted for 5 minutes, the maximum relative sedimentation decrease ( $ds/t$ )<sub>max</sub> 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. As shown in Fig. 6 below

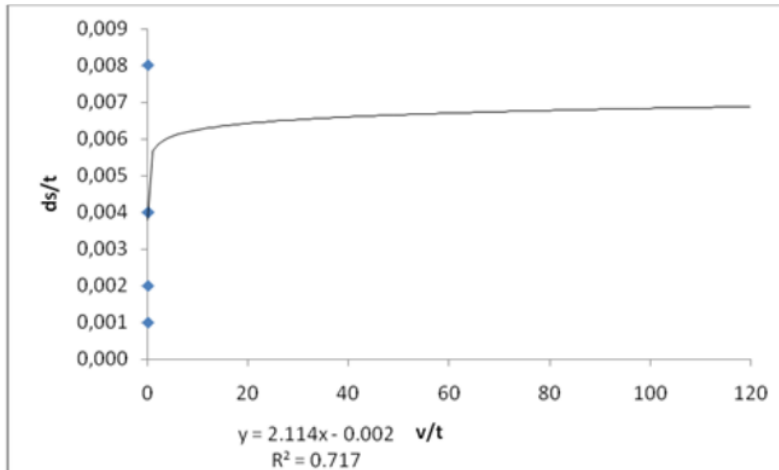


Fig.6. Graph ( $v/t$ ) vs ( $ds/t$ ) on a sheet-pile on a riverbank for 10 minutes

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.

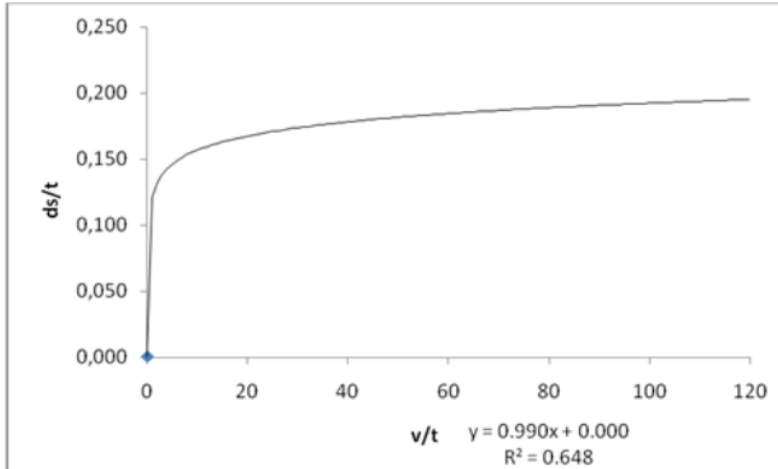


Fig. 7. Graph ( $v/t$ ) vs ( $ds/t$ ) on a sheet-pile on a riverbank for 15 minutes

Then in Fig.8. The following shows that the maximum relative sediment accumulation ( $ds/t$ )<sub>max</sub> 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 but sedimentation 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.

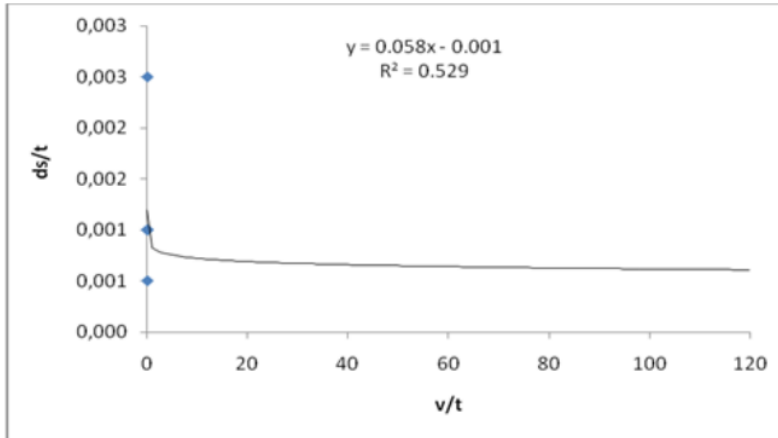


Fig. 8. Graph ( $v/t$ ) vs ( $ds/t$ ) on a sheet-pile on a riverbank for 20 minutes

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.

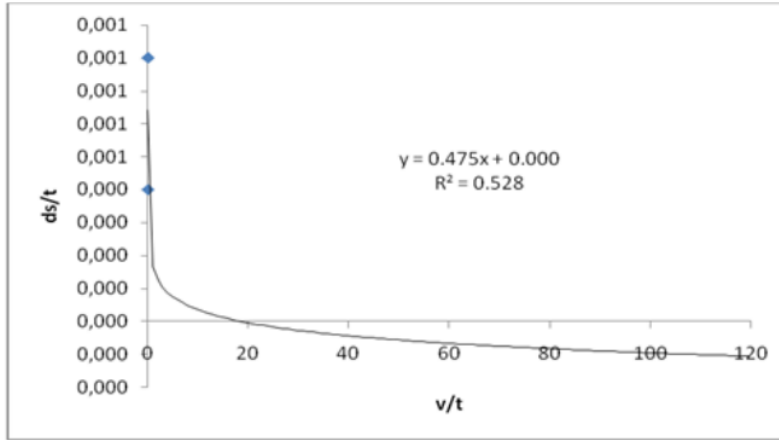


Fig. 9. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 25 minutes

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

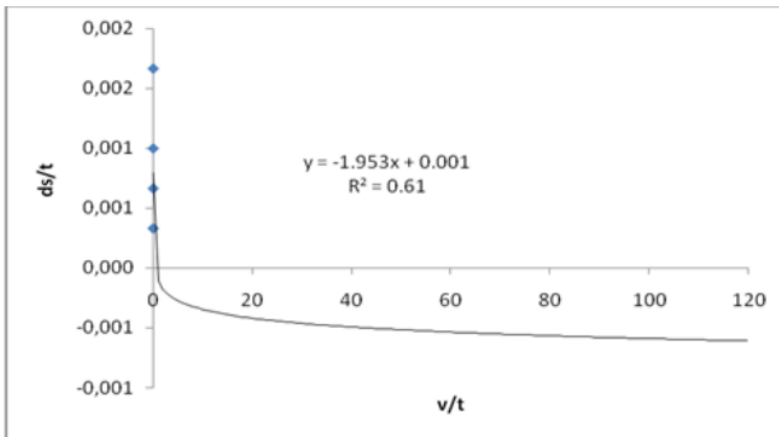


Fig.10. Graph (v/t) vs (ds/t) on a sheet-pile on a riverbank for 30 minutes

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 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.
2. When the experiment lasted for 30 minutes, it was seen that the relative sedimentation (ds/t)max of 0.02 occurred at a relative velocity (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.

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