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Analysis of Sediment Movement Around Gabion Buildings as River Bank Protectors

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Abstract— Urban areas that have developed, if not managed properly, will cause a lot of problems in the future, which not only bring good effects but also bad influences that will disrupt natural conditions and the environment itself. Rivers as one of the potential water resources can contribute to human, animal and plant life. Therefore, there must be a balance between water availability and water demand. The factor that affects the reduced availability of water is due to the sediment that settles at the bottom of the river. The decrease in the river's carrying capacity causes sedimentation on the banks of the river or in the middle of the river channel. Sediment occurs due to an imbalance in the flow velocity in the river. Flow velocity every year can affect the distribution of sediment which is dominated by sediment with fine grain size and sand. To keep the river channel from changing, it is necessary to strengthen it, especially at river bends, namely by making gabion walls. Gabion is a construction made of crushed stone arranged by woven wire. To get a high level of confidence, research and research is carried out using a hydraulics model which in making the model is determined based on the relationship between parameters expressed in dimensionless numbers or using dimensional analysis.

Keywords— Flow velocity; hydraulics model; gabion; dimensional analysis.

I. INTRODUCTION

The development of urban areas today, has a good impact if managed carefully and well, but can also have a bad impact on the preservation of nature and the environment. The river as a place for various activities of natural ecosystems as well as human activities must be maintained for its sustainability. For this reason, it is necessary to manage it as a watershed. Watershed management is an important part of regional planning in Indonesia, but if it is not properly maintained, watersheds will affect the amount of water available. The reduced availability of water is caused by the presence of sediment (sedimentation) at the bottom of the river. Strong flow velocity will also cause landslides on the cliff walls. Gabions as a way to protect riverbanks are indispensable, especially at bends or bends in river flow. In a water structure planning, there are many problems that cannot be solved only by existing formulas. Therefore, assistance in hydraulic models in solving problems is very useful.

There are three activities in modeling :

1. Modelization, namely the process of imitating problems with smaller scale prototypes

2. Problem solving, which is an attempt to solve the problems that exist in the model

3. Interpretation, which is an attempt to transfer the results of the solutions carried out in the model

To simplify a physical model, it is done by using dimensional analysis which is expected to provide the law of scaling data from a small model to large prototype design information.

This modeling research was carried out in a 40x40 cm channel, a flow length of 1.280 cm and a bend length of 150 cm with a bend angle of 120^0.

II. Research Methods

2.1 Research site

This research was conducted at the Hydrology and Hydraulics laboratory, Universitas Bina Darma, Palembang.


Figure 2.1. River bend design model (syarifudin, A. 2020)

2.2 Material and Tools

- Scalable river model (1 set), A tool for writing data recording results,
- Pump (1 units), Assists the movement of flow in the model,
- Gabion model (1 units), Simulation tool,
- River bed materials (Filter analysis results), Simulation material,
- Water (according to accommodation), Flow simulation.

2.3 Research Stages

1. The first stage, Collecting references from journals, books, and other secondary data sources,
2. The Second stage, conducting field orientation surveys to obtain the current (existing) field conditions, taking field photos (sites) so that they 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 (d50) with the assumption that the base material corresponds to that in the river prototype. Followed by the

installation of the position of the gabion model at the bend of the river as many as 3 multilevel gabion models with various placements on the model.

6. The sixth stage is to conduct a trial with a running time of 60 minutes with every 15 minutes observing both 3 and 5 tiers of the oval model. Observations and recordings of erosion and sedimentation patterns were carried out in each scenario of the installation of the gabion model.

7. The seventh stage, discusses the results of observations that occur in the gabion model and makes research conclusions and provides suggestions for further research by other studies.

III. RESULTS AND DISCUSSION

3.1 Dimension Analysis

Dimensional analysis is one way to compare the relationship between parameters related to this research. The method used is the Langhaar method and the dimensional analysis steps are as follows :

1. In the problem formulation, it is stated that the parameters that affect the erosion around the gabion include river depth (h), flow velocity (v), erosion and sedimentation depth (ds), time (t) and acceleration of gravity (g), and the density of water (ρw),

2. The parameters are grouped into:

   a. Dependent parameter: v

   b. Parameters changed during the experiment: de, h and t

   c. Other parameters: g and ρw

3. The prices of α1, β1 and γ1 are determined by tabulation as follows :

Table 3.1. Determination of α1, β1 and γ1

Group	1	2				3		Note
Parameter	**v**	**d_e**	**dd**	**H**	**t**	**ρ**	**g**	
M	0	0	0	0	0	1	0	α1
L	1	1	1	1	0	-3	1	β1
T	0	0	0	0	1	0	-2	γ1
	k1	k2	k3	k4	k5	k6	k7	ki

Equations related to parameters

$k6 = 0$

$k1 + k2 + k3 + k5 \quad -3k6 + k7 = 0$

$k4 \quad - 2\,k7 = 0 \qquad 2k7 = -k4$

elimination k5

$k1 + k2 + k3 + k4 + k5 + 2k7 = 0$

The determination of the dimensionless number is :

Table 3.2. Dimensionless number

ki	k1	k2	k3	k4	k5	k6	k7
Parameter	**x**	**d_e**	**dd**	**h**	**t**	**ρ**	**g**
π1	1	0	0	0	-1	0	0
π2	0	1	0	0	-1	0	0
π3	0	0	1	0	-1	0	0
π4	0	0	0	1	-1	0	2

$\pi 1 = x/t$

$\pi 2 = d_e/t$

$\pi 3 = d_d/t$

$\pi 4 = h/t$

$(x/t) \times (2gt) = (x/t) \times \sqrt{(gt)}$; $\sqrt{(gt)} = v \approx 0$

$f(x/t; d_e/t; d_d/t; h/t) = 0$

$(x/t) = f(d_e/t)$ (focus erosion depth)

$(x/t) = f(d_d/t)$ (sedimentation focus)

$(x/t) = f(h/t)$ h considered constant

3.2. Simulation results and discussion

Table 3.3. The relationship between dimensionless parameters

v (cm/sec)	de (cm)	dd (cm)	t(minute)	v/t	de/t	x/t
0.006	0.03	0	5	0.0012	0.006	4.800
0.006	0.03	0	5	0.0012	0.006	5.000
0.006	0.04	0	5	0.0012	0.008	5.200
0.006	0.04	0	5	0.0012	0.008	4.800
0.006	0.03	0	5	0.0012	0.006	4.800
0.006	0.02	0	10	0.0006	0.002	2.400
0.006	0.02	0	10	0.0006	0.002	2.400
0.006	0.02	0	10	0.0006	0.002	2.400
0.006	0.02	0	10	0.0006	0.002	2.400
0.006	0.02	0	10	0.0006	0.002	2.400
0.006	0.05	0	15	0.0004	0.003	1.600
0.006	0.05	0	15	0.0004	0.003	1.600
0.006	0.05	0	15	0.0004	0.003	1.600

0.006	0.05	0	15	0.0004	0.003	1.600
0.006	0.05	0	15	0.0004	0.003	1.600
0.006	0.08	0	20	0.0003	0.004	1.200
0.006	0.08	0	20	0.0003	0.004	1.200
0.006	0.08	0	20	0.0003	0.004	1.200
0.006	0.08	0	20	0.0003	0.004	1.200
0.006	0.08	0	20	0.0003	0.004	1.200
0.006	0.06	0	25	0.0002	0.002	0.960
0.006	0.06	0	25	0.0002	0.002	0.960
0.006	0.06	0	25	0.0002	0.002	0.960
0.006	0.06	0	25	0.0002	0.002	0.960
0.006	0.06	0	25	0.0002	0.002	0.960

3.3. Graph of relationship between (v/t) and (de/t)

The relationship between the parameters v, de and t is presented in the figure below :

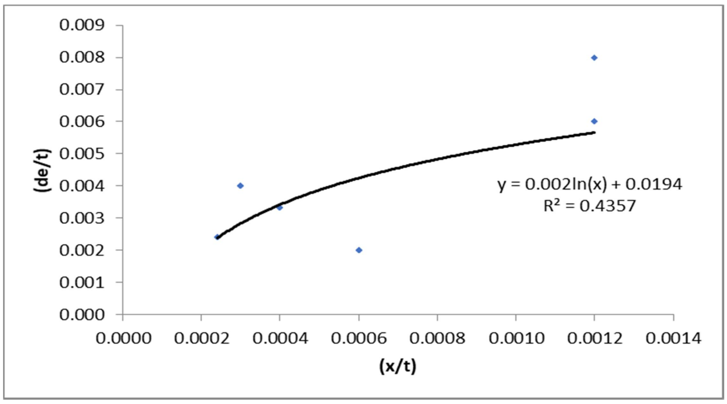

Figure 3.1 Graph of the relationship between (v/t) and (de/t) for 25 minutes

In Figure 3.1 it can be said that with a maximum relative velocity (v/t)max there is a maximum relative erosion depth (de/t)max of 0.0058, meaning that there is an erosion depth value of 0.145 cm (in the model).

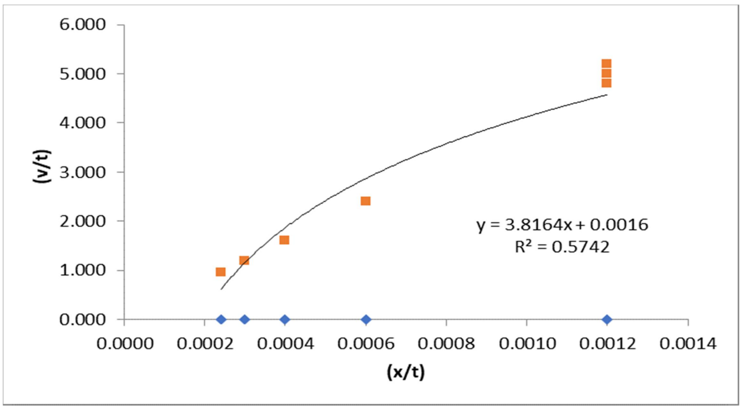

Figure 3.2 Graph of the relationship between (x/t) and (v/t) for 25 minutes

In Figure 3.2 it can be seen that at the maximum relative distance (x/t)max of 4.5 getting the maximum relative speed (v/t)max of 0.0013.

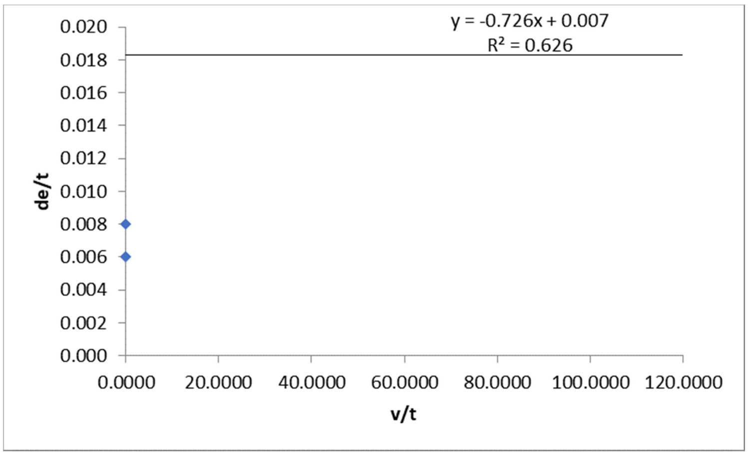

Figure 3.3 Graph of the relationship between (v/t) and (de/t) for 5 minutes.

In Figure 3.3 it can be said that with the maximum relative velocity (v/t)max there is a maximum relative erosion depth (de/t)max of 0.0068, meaning that the erosion depth value is 0.034 cm (in the model).

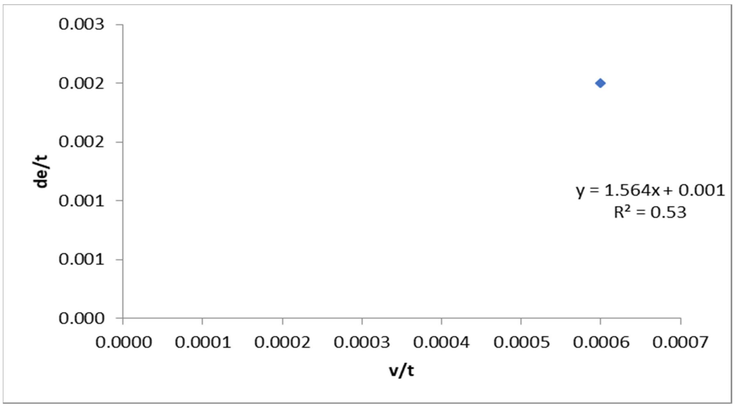

Figure 3.4 Graph of the relationship between (v/t) and (de/t) for 10 minutes.

In figure 3.4 it can be said that with a relative velocity (v/t) of 40, there is no erosion in the river and then at the maximum relative velocity there is a maximum relative sedimentation (dd/t) of 0.0005, meaning that for 10 minutes there is sedimentation of 0.005 cm (on models).

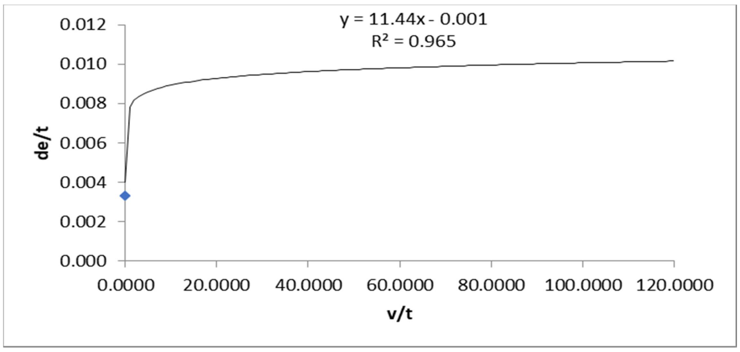

Figure 3.5 Graph of the relationship between (v/t) and (de/t) for 15 minutes.

In Figure 3.5 the maximum relative erosion depth (de/t)max is 0.75 at the maximum relative velocity (v/t)max 120. Thus, it can be said that within 15 minutes, the erosion depth is 11.25 cm. (on models).

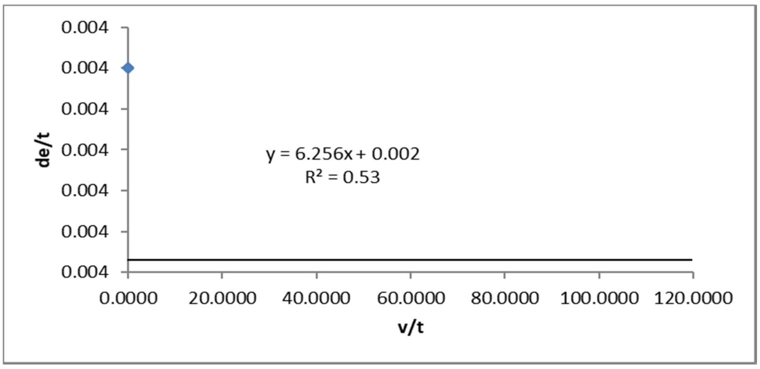

Figure 3.6 Graph of the relationship between (v/t) and (de/t) for 20 minutes.

In Figure 3.6 it is found that the maximum relative erosion depth (de/t)max decreases over a period of 20 minutes, which is 0.0035 at a maximum relative velocity (v/t)max of 120. There has been a decrease in the depth of erosion within 20 minutes, it is obtained the depth of erosion that occurs is only 0.07 cm (in the model).

Thus, it can be said that the flow velocity is stable at 20 minutes when the flow hits the gabion building.

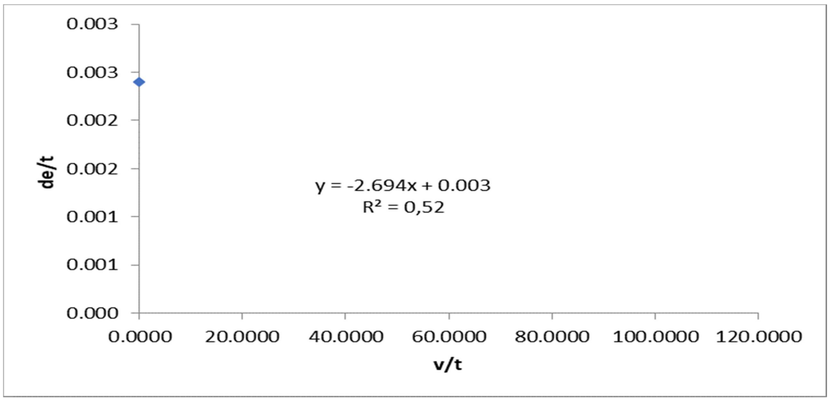

Figure3.7 Graph of the relationship between (v/t) and (de/t) for 25 minutes.

In Figure 3.7 there is a drastic decrease in flow time for 25 minutes, where at a relative distance (v/t) of 20 near the gabion building the flow velocity is stable. Then there was sedimentation at a relative velocity (v/t) of 150, namely a relative sedimentation (dd/t) of 0.001. It can be said that there is no maximum relative erosion (de/t)max but there is sedimentation near the gabion building.

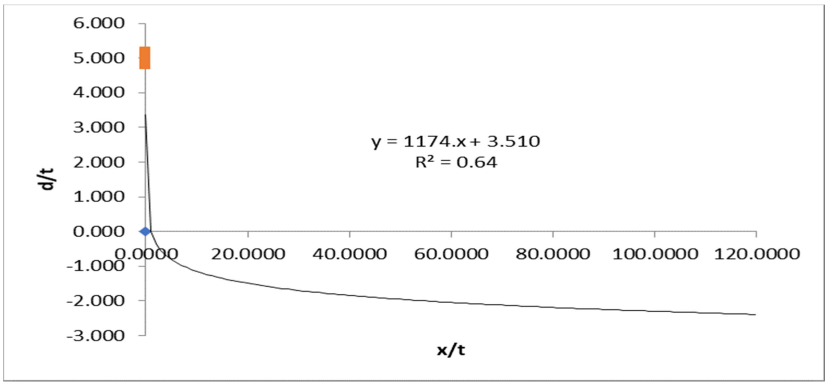

Figure 3.8 Graph of the relationship between (de/t) and (x/t) for 5 minutes.

In Figure 3.8 there is a drastic decrease in the flow time for 25 minutes, where at a relative distance (x/t) of 20 near the gabion building the flow velocity is stable. Then there was sedimentation at a relative velocity (v/t) of 150, namely a relative sedimentation (dd/t) of 0.001. It can be said that there is no maximum relative erosion (de/t)max but there is sedimentation near the gabion building.

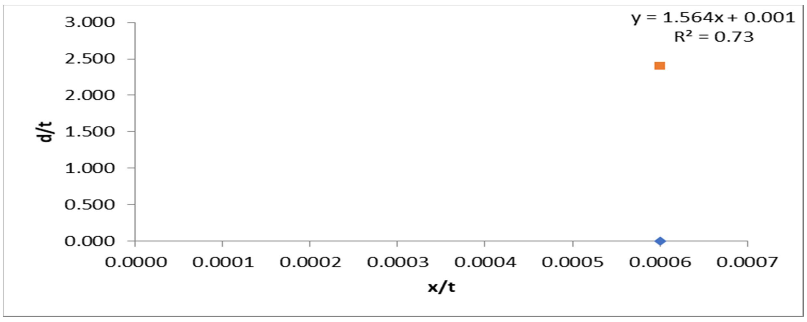

Figure 3.9 Graph of the relationship between (d/t) and (x/t) for 10 minutes.

In the graph of Figure 3.9 at a relative distance (x/t) of 2, there is no change in flow velocity along the flow.

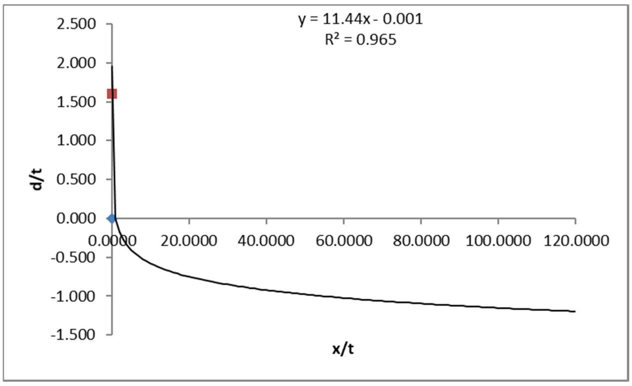

Figure 3.10 Graph of the relationship between (v/t) and (x/t) for 15 minutes.

In Figure 3.10. there is an increase in the relative velocity (v/t) at the time of flow for 15 minutes, where at a relative distance (x/t) of 120 near the gabion building, the flow velocity increases.

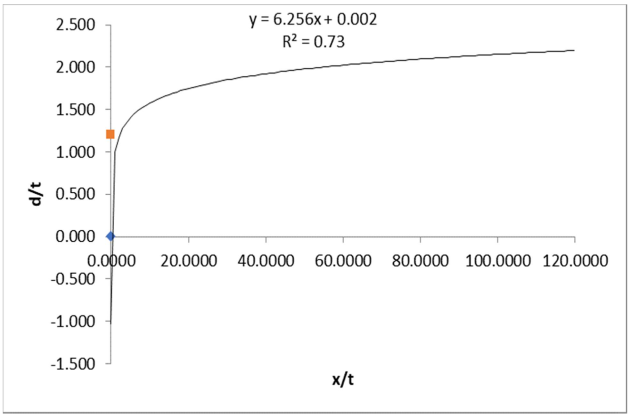

Figure 3.11 Graph of the relationship between (v/t) and (x/t) for 20 minutes.

In Figure 3.11 there is an increase in relative velocity (v/t) again at the time of flow for 20 minutes, where at a relative distance (x/t) of 120 near the gabion building, the flow velocity increases by 5.

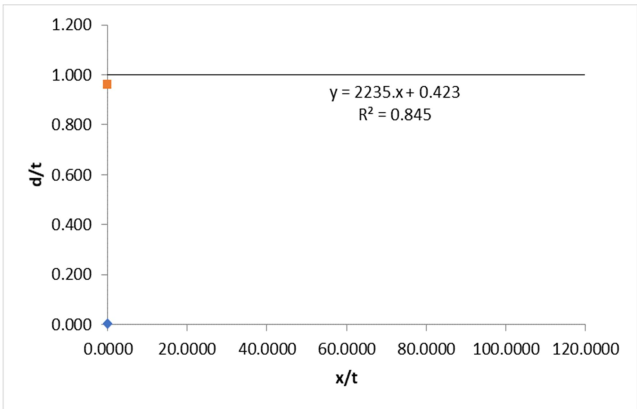

Figure 3.12 Graph of the relationship between (v/t) and (x/t) for 25 minutes.

In Figure 3.12 there is a decrease in relative velocity (v/t) again during the flow time for 25 minutes, where at a relative distance (x/t) of 120 near the gabion building, the flow velocity decreases by 1.2.

IV. CONCLUSION

During 25 minutes there is a maximum relative erosion depth (de/t) max of 0.0058. In the first 5 minutes there was an erosion of 0.0058 meaning there was an erosion depth of 0.145 cm in the model. Meanwhile, during the second 5 minutes (10 minutes) of the experiment there was no erosion in the river and only a maximum relative sedimentation (dd/t) of 0.0005, meaning that within 10 minutes there was sedimentation near the gabion building of 0.0025 cm . In the third 5 minutes (15 minutes) there was an erosion of 0.75, meaning that it resulted in an erosion depth of 11.25 cm in the model. In the fourth 5 minutes (20 minutes) there is a maximum relative erosion depth (de/t)max of 0.0035. Then during the fifth 5 minutes (25 minutes) there was a decrease in the relative depth of erosion (dd/t) of 0.001 but sedimentation occurred near the gabion building.

The pattern of movement of bottom sediment at river bends can be used as a basis for controlling river bank (river bends) the destructive power of water so that it can withstand the rate of cliff erosion from time to time and maintain stable conditions of river flow (stable channels).

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