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RIVER CLIFF REINFORCEMENT EFFORTS BY APPLICATION OF COMBINATION OF DAM STONE, GABION, TETRAPOD, AND BAMBOO FLOW ALIGNER

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ABSTRACT

The purpose of research : (1) determine the ratio between the combination of retrofitting tetrapod-bamboo alignment-tetrapod (FP1); bamboo flow aligner-tetrapod-bamboo flow aligner (FP2); Check Dam Stones-Gabion-Check Dam Stones (FP3); Gabion-Check Dam Stones-Gabion (FP4)? (2) The effectiveness of the combination of strengthening the tetrapod-bamboo aligner-tetrapod (FP1); bamboo flow aligner-tetrapod-bamboo flow aligner (FP2); Check Dam Stones-Gabion-Check Dam Stones (FP3); Gabion-Check Dam Stones-Gabion (FP4)?

Using the experimental method by creating a Labolatorium scale river model. Testing using clay and sand. The test model is a cliff without reinforcement and cliff with a combination of reinforcement between tetrapods; bamboo flow aligner; check Dam stones and Gabions. Testing by flowing water for 180 minutes/3 hours with a constant discharge of 7.07 liters/second, the installation of reinforcement is 51 cm apart.

The results showed that (1) In general, the effect of the FP1 reinforcement installation was the variation of the combination that was considered the best in reducing scouring on the cliffs and riverbeds. (2) Variation of the combination of FP1, is more effective in reducing the scouring that occurs. At the beginning of the channel turns from STA 00-06 effectively used tetrapod installation, with scours that occur as big as -5 cm, in the middle of the STA channel 06-16 effectively using the installation of bamboo flow aligner, scours that occur as much as -1.5 cm, whereas at At the end of the turn, STA 17-24 used tetrapod installation, scouring by -3.8cm.

Keyword: *scouring, bamboo flow aligner, tetrapod.*

I. INTRODUCTION

1.1. Background

The flow of water that moves quickly at the river bends so that over time the cliffs at the bends experience landslides. One of the rivers that experienced landslides is Bedog River. Bedog River is one of the rivers located extending from the slopes of Mount Merapi to the downstream area of the Indian Samdera Beach in Bantul Regency, DI Province. Yogyakarta. This river has a length of about 67 km.

The morphology of the Bedog River, which consists of several rather steep river cliffs, has sandy clay soil type and there is no strong barrier such as vegetation in the Pajangan, Bantul area, so that there is the potential for landslides in the case of heavy rain. Scouring (scouring) is a natural process that occurs in rivers as a result of the influence of river morphology in the form of curves or narrowing sections of river flow or the presence of water structures (hydraulic structures) such as bridges, dams , floodgates, and others. The shape of the river is one of the determining factors in the process of scouring. This is due to the open channel flow having a free surface. The condition of open channel flow based on the position of the free surface tends to change according to time and space, besides that there is a relationship of dependence between the depth of the flow, the flow of water, the basic slope of the channel and the surface of the free channel itself.

The river flow can cause erosion. Erosion that occurs in rivers is erosion on river banks (river bank erosion). This erosion occurs as a result of erosion of river banks by water flowing from the top of the cliff or by the brunt of a strong river flow at a river bend. Just as when there is a flood in a river there is an increase in energy in the flow of water so that the flow of water erodes the soil or river bank. If the rocks making up the river bank are not compact, then soil erosion is very easy to occur. Therefore it is necessary to protect the river bank so that it does not become siltation due to scouring by water on the river bank such as gabions, concrete walls and so on.

According to Melody, et al (2018) which examines the effect of variations in the distance of tetrapod and crib installation at river curves. Results of the study showed that retrofitting tetrapod effectively used at the beginning and end of the curve, while in the middle of the effective use of crib . According to Wibowo, DE, et al (2019) studied the effect of strengthening the river wall mounting using c heck d am stones and gabion with variations within the river bends in the river using model test laboratory. Research shows that check dam stones are more effective in the middle of turns, whereas at the end of turns it is most effective using gabion reinforcement.

In this study, river bank in the bend area has a condition where the cliff damage occurs due to the swift river flow, which results in a river bank slump. So the researchers tried to use a combination construction, which would use check dam stones, terapapods , gabions and align bamboo currents by making a river-scale, laboratory model.

1.2. Scope of Problem

1. In carrying out this research, for the strengthening of the river bank, a combination of check dam stones, terrapod, gabion and bamboo current alignment is used as the main reference for the variable structure of the river bank protector,
2. Tetrapod that will be used is tetrapod with steel material diameter of 6 mm, length of 1cm x 1 cm x 1 cm x 1 cm and soil nailing using skewers and gabions from gravel diameter passed through sieve no. 4, as a river bed of un scaled sand.
3. Testing is carried out with a constant discharge of 7.07 liters/second for 3 hours. The angular position for aligning bamboo and tetrapod currents is 30º with a distance of 51 cm, while the check dam stones, gabions angle position 900, with a distance of 51 cm.
4. As soil sampling and case studies are the Bedog River Basin, Pajangan, Bantul, D. I. Yogjakarta.
5. Testing is carried out by a laboratory scale method, using a flump found in the JPTSP FT UNY Hydraulics Laboratory.
6. The testing of this model only reviews the scouring that occurs on the outer bank of the bends and the decrease in the river bed as the effect of the installation of the crib with the angular variations in the position of the installation of the distance between the cribs are made equal and a constant discharge, of 7.07 m^3/ s.

1.3. Formulation of The Problem

In accordance with the background of the research, problems related to river bank protection can be described as follows:

1. How do you compare the effectiveness of using check dam stones, terapapods, gabions and aligning bamboo currents as a barrier to riverbanks from landslides and erosion caused by erosion of river water flow?
2. What is the pattern of flow and scouring due to the installation of reinforcement on the cliff and riverbed model at the river bend with an angle of 30, in the form of installing check dam stones, terapapods, gabions and bamboo tides?
3. How is the effectiveness of placing check dam stones, terapapods, gabions and bamboo tides, and to reduce erosion on riverbanks?

1.4. Research Purposes

The objectives to be achieved through this research are:

1. Know the comparison of the effectiveness of installing check dam stones, terapapods, gabions and aligning bamboo currents as a barrier to riverbanks from the danger of landslides and erosion caused by erosion of river water flow.
2. Knowing the flow patterns and scouring caused by mounting reinforcement on cliffs and river bed models at river bends, in the form of a combination of check dam stones, terrapods, gabions and bambo flow aligners with angular positions to align bamboo and tetrapod currents is 30º with a distance of 51 cm, while check dam stones, gabion angular position 900, with a distance of 51 cm.

1.5. Benefit of Research

The virtues that can be obtained through conducting research at this stage are as follows:

a. The development of science, especially in the field of construction technology, can functionally stabilize river slopes or riverbanks from scours on river bank side curves that occur due to river flow.
b. In this research, it is expected to provide general scientific input relating to the problem of the structure of the current breaker. In addition, this research can be used as a reference for further research, particularly those relating to the handling of river bank erosion against landslide case studies.
c. Being considered by related parties as an alternative solution to repair or protect the river bank.
d. Providing solutions to reduce the problem of landslides or river slopes as well as improving the quality and safety of infrastructure in river areas.

II. LITERATURE REVIEW

2.1. Clay

Definition of Clays

The definition of clay soil according to some experts is as follows:

1. Clay soil is a part of soil consisting mostly of microscopic and submicroscopic particles (cannot be seen clearly if only with ordinary microscopic) formed flat plates and is particles of mica, clay minerals (clay minerals), and other very fine minerals. Clay forms hard lumps when dry and sticky when wet with water and has strong elastic properties. Clays also shrink when dry and expand when wet. Because of this behavior, several types of soil can form dry or "broken" fragments, say dry (Das, 1995).
2. The properties possessed from clay soils include small grain size smaller than 0.002 mm, low permeability, high capillary water rise, highly cohesive nature, high rate of shrinkage and high slow consolidation process. With this knowledge of soil minerals, an understanding of clay soil behavior can be observed. (Hardiyatmo, 1992).

Nature of Clay Soils

The properties possessed by clay are as follows (Hardiyatmo, 1992):

1. Fine grain size, which is less than 0.002 mm.
2. Low permeability.
3. High capillary water rise.
4. Very cohesive.
5. High levels of shrinkage.
6. The process of consolidation is slow.

2.2. Slope Stability

A slope is said to be stable if the slope does not experience movement and is not likely to experience movement, that is, if the magnitude of the retaining force component on the slope is greater than the slope mover component. The slope classification is presented in **Table 2.1**.

Table 2.1. Classification of slope according to SNI 03-1997-1995, as follows:

Slope angle (…°)	Condition
45	Medium
60	Steep
90	Steep

(Source: SNI-03-1997-1995)

2.3. Flow Behavior at Turn

Rivers that have more or less regular turns are usually called meanders. River meanders generally have a very gentle slope. The riverbed on the outside side of the bend will generally be deeper because of the greater velocity on the outside side of the bend. The centrifugal force at the bends will cause river crossing which then together with the main flow will form a helicoidal flow. The magnitude of the speed of this transverse current ranges between 10% -15% of the speed of the main direction of flow (Legono, 1986). Flow on the channel that experiences a bend and transverse direction slope (superelevation) will occur grinding on the outside side of the bend, especially the downstream of the bend and sedimentation occurs on the inside of the bend, starting from the middle to the downstream bend (Daoed, et al 2009).

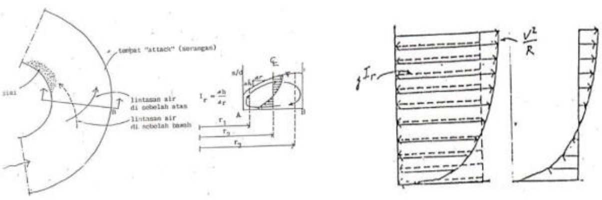

Figure 2.1. Schematic style of flow at curves and formation of helicoids flow

2.4. Scour

(Syarvina, 2013) the depth of scours that occur around water structures, bridges and water constriction are influenced by several factors including:

1. Flow velocity in river channels
   The average maximum local scour depth around the pillar is highly dependent on the relative value of the river flow velocity (the ratio between the average flow velocity and shear velocity), grain diameter values (uniform / non-uniform grain) and pillar width. Thus, the maximum local scour is the maximum local scour in equilibrium conditions.
2. Sedimentation Gradiation
   Gradation of sediments from transport sediments is one of the factors that influence the depth of scour in clear water conditions. From **Figure 2.2**, the scour depth (ys/b) has no dimension as a function of the gradation characteristics of basic material sediments (σ/d50). Where σ is the standard deviation for grain size and d50 is the average particle size. The critical value of σ/d50 to protect it can only be achieved with a base plane, but not with scour holes where the local strength in the granules is high due to increased whirlpools.

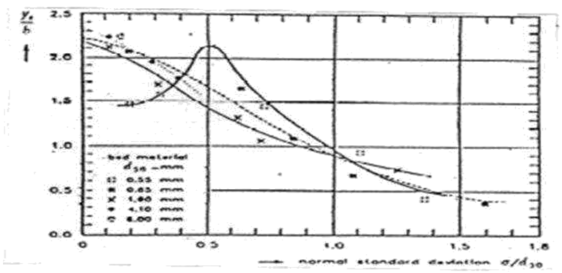

Figure 2.2. The depth of the scour is equilibrium around the pillar function of grain size relative to the condition of clean water flow

2.5. Channel Discharge Size

According to SNI 8137: 2015 debit measurement is a process of measuring and calculating to find out the amount of discharge in an open channel. The shape of a sharp threshold section is triangular shaped overflow. The triangle sharp threshold is a simple measuring building that can be used to measure flow discharges in open channels easily and fairly thoroughly. By applying the design of the appropriate runoff section, based on the results of the experiment can be determined a large range of measurement discharges, namely as follows. Furthermore, the shape of the cross section can be considered in **Figure 2.3** and **Figure 2.4.**

1) The shape of the threshold with a gap angle θ = 90° or tan θ/2 = 1, Having a measurement discharge range from 0.802 l/s to 122,940 l/s.
2) The shape of the threshold with a gap angle θ = 52.12° or tan tan θ/2 = 0.5. Measuring discharge range from 0.406 l/s ≤ Q ≤ 62.150 l/s.
3) The shape of the threshold with a gap angle θ = 28.07° or tan θ/2 = 0.25. has a measuring discharge range of 0.215 l/s ≤ Q ≤ 21.477l/s.

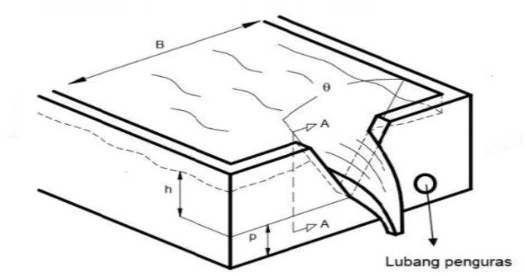

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Figure 2.3. Sharp triangle cross section
(Source: SNI 8137: 2015)

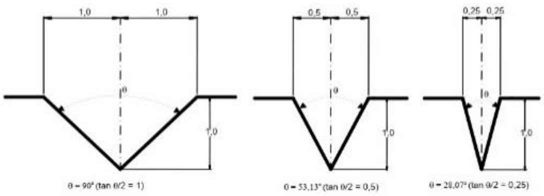

Figure 2.4. Sharp triangle slit angle
(Source: SNI 8137: 2015)

High in effective energy, Hef is given by the equation:

$H_{ef} = h + \delta Ht$………........……………..…… {1}

δHt is a correction of the effect of the combination of viscosity and surface tension for water temperatures of 4° C ~ 20° C, large values of δHt for various slit angles are given in **Figure 2.5**.

Table 2.2. Correction of imperfect flow conditions

Ratio Submerged h/p	Qs/Q 90° Triangle Bend
0	1
0.1	0.999
0.2	0.992
0.3	0.981
0.4	0.981
0.5	0.928
0.6	0.882
0.7	0.816
0.8	0.721
0.9	0.569

(Source: SNI 8137:2015)

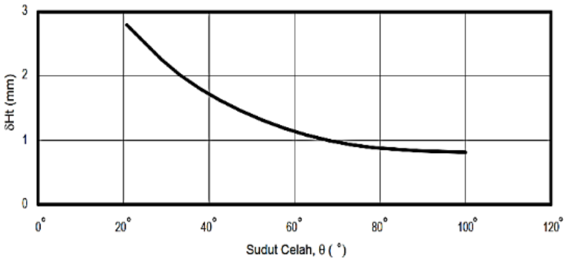

Figure 2.5. The high energy correction δHt, for the sharp threshold of triangles with various slit angle states (Source: SNI 8137: 2015).

If the flow condition that occurs is full contraction, the value of the effective discharge coefficient, Cef depends only on the angle of gap of the triangle threshold, θ, so the value of the discharge coefficient, Cd, for the state of full contraction at the sharp threshold of the triangle, is determined based on the graph shown in **Figure 2.6**.

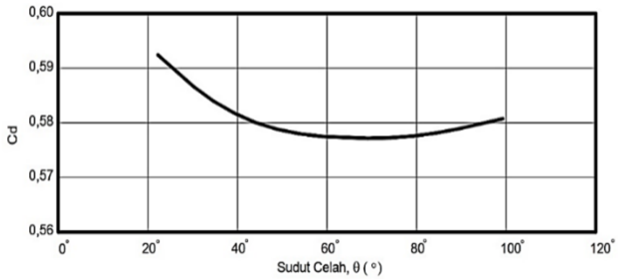

Figure 2.6. Discharge coefficient, Cd sharp triangle threshold for full contraction conditions (Source: SNI 8137: 2015).

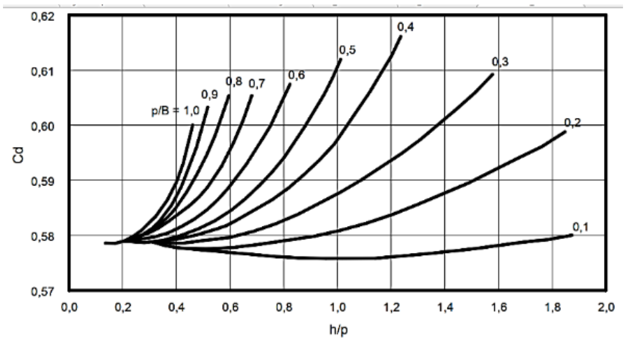

Figure 2.7. Discharge coefficient graph, Cd as a function of h / p and p / B for the sharp threshold of a triangle with a bend angle of 90° (Source: SNI 8137: 2015).

According to Triatmodjo (1993) in Hayyi (2015) for flow outflow from a triangle boiler can be calculated using the triangle boiler formula:

$$Q = \left(\frac{8}{15}\right).\sqrt{2.g}.C_d.\tan\left(\frac{\alpha}{2}\right).H^{5/2} \quad ………… \{2\}$$

If the angle α = 90°, Cd = 0,6 and acceleration of gravity = 9,81 m²/d the discharge:

$Q = 1{,}417\ H^{5/2}$……………………................…. {3}

With:

Q : Discharge (m^2/s)
g : Acceleration of gravity (m/s^2)
H : Water level above threshold (m)
C_d` : Coefficient of discharge
α : Boiler angle

III. METHODOLOGY

3.1. Experimental Design

The experimental design in this study is as follows:

1. **The Place**
   This research was conducted in 2 laboratory places, to examine the soil properties of the Soil Mechanics Laboratory, Department of Civil Engineering and Planning Education, Faculty of Engineering, Yogyakarta State University. As for the manufacturing test activities carried out in Tests carried out by a laboratory scale method, using a flump contained in the JPTSP FT UNY Hydraulics Laboratory.

2. **Research Design**
   The study was conducted in an open channel with a river flume with a bend length of 5 m, width in 0.8 m, and height of 0.5 m. Trapezoid-shaped channel with a bend angle of 90o, and water does not sediment. Observations were made with a constant discharge of 7.07 liters / second for 3 hours. The angular position for aligning bamboo and tetrapod currents was 30º with a distance of 51 cm, while the check dam stones, gabion angular position 900, with a distance of 51 cm. Each flood discharge generated through variations in the slope of the longitudinal channel, then carried out an examination of the check dam stones, tertrapods, gabions and alignment of bamboo currents on the scour pattern and river wall collapse at the bends.

   The gabions and tetrapods are placed in a height of 4 cm and varying the installation angle of 300 in the same direction as the flow of water, while for the flow alignment with bamboo made of skewers, assembled at a distance of 1 cm with a height of 4 cm, mounted perpendicular to the transverse direction of the river model. Tetrapod, current aligners and gabions are mounted transversely in the direction of the river model with a length of 10 cm with a distance of installation with a certain distance extending the model from the beginning of the curve to the end of the river model.

3.2. Research Procedure

In accordance with its objectives, this research was conducted by an experimental method, with a laboratory-scale method in which the research was modeled as a snippet of the situation in the Bedog River Basin, Pajangan, Bantul, DI Yogyakarta. The data used are further in the form of primary data obtained from the results of measurements in the experiments conducted.

3.3. Materials, Tools, and Sampling

1. Materials

The material used in this study is soil material taken from the Bedog River Basin, Pajangan, Bantul, DI Yogyakarta. As for making the specimen as follows:

a. Gabions and check dam stones made of gravel are selected broken stones so that they are closer to the actual condition of the size of the filter no. 4 . Gabion elements are made 2.5 x 2.5 x 5 cm per unit which is veiled with a network of wires, then arranged each of 3 layers horizontally and vertically. For the arrangement of the elongated direction carried out like a brick arrangement.

b. Tetrapod made from reinforcement diameter 6 cut 2 cm then put together using welding.

c. Bamboo flow aligner is made of skewers and installed a distance of 1 cm pliers are anchored into the cliff soil model with a depth of 5 cm.

2. Tools

With a river flume with a bend length of 5 m, width in 0.8 m, and height of 0.5 m. Trapezoid-shaped channel with a bend angle of 90º , and water does not sediment. **Figure 3.1.**

3. Sampling

As for taking a sample of observation in this experiment was taken to vary the position and location of the riverbank reinforcement methods. The details are presented in **Table 3.1**.

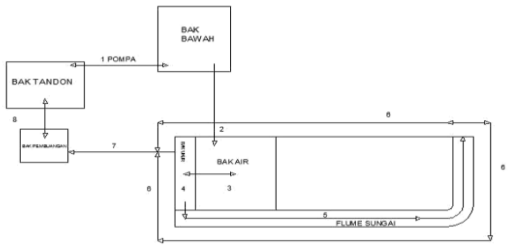

Figure 3.1. The design of the Labolatory model

Table 3.1 Plans for sampling observations

No	Flow	Reinforcement Type	River Observation Side	Point of Observation
1	7,07 liters/second	Tetrapod-bamboo flow aligner-tetrapod (FP1)	Outer side of the turn	• Early turn • Middle turn • End of turn
2	7,07 liters/second	bamboo flow aligner-tetrapod-bamboo flow aligner (FP2)	Outer side of the turn	• Early turn • Middle turn • End of turn
3	7,07 liters/second	Tetrapod-bamboo flow aligner-tetrapod (FP1)	Riverbed	• Early turn • Middle turn • End of turn
4	7,07 liters/second	bamboo flow aligner-tetrapod-bamboo flow aligner (FP2)	Riverbed	• Early turn • Middle turn • End of turn
5	7,07 liters/second	Check Dam Stones-Gabion-Check Dam Stones (FP3)	Outer side of the turn	• Early turn • Middle turn • End of turn
6	7,07 liters/second	Gabion-Check Dam Stones-Gabion (FP4)	Outer side of the turn	• Early turn • Middle turn • End of turn
7	7,07 liters/second	Check Dam Stones-Gabion-Check Dam Stones (FP3)	Riverbed	• Early turn • Middle turn • End of turn
8	7,07 liters/second	Gabion-Check Dam Stones-Gabion (FP4)	Riverbed	• Early turn • Middle turn • End of turn
9	7,07 liters/second	No Reinforcement (TP1 and TP2)	Outer side of the turn	• Early turn • Middle turn • End of turn
10	7,07 liters/second	No Reinforcement (TP1 and TP2)	Riverbed	• Early turn • Middle turn • End of turn

3.4. Research Stage

The framework for thinking in this research framework is illustrated in the following flowchart:

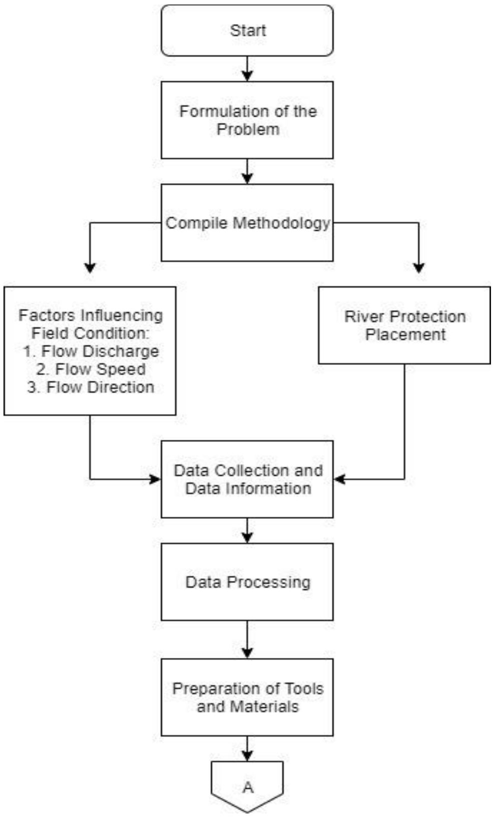

Figure 3.2 Flowchart of Research Stages

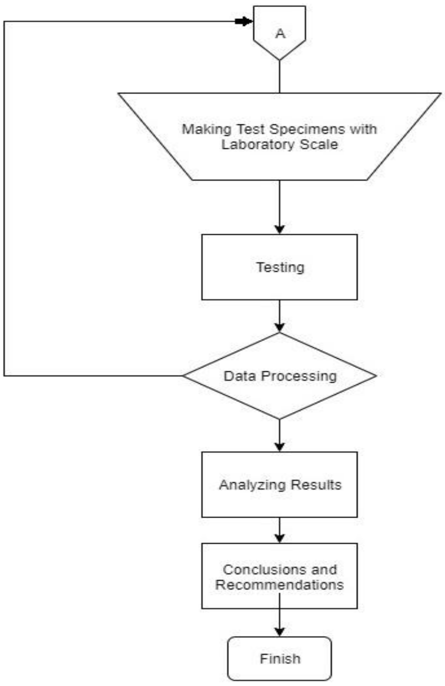

Figure 3.3. Research Stages Flow Chart (continued)

IV. RESULT AND DISCUSSION

4.1. Observation Result

The results of the laboratory scale scour test were carried out for 3 hours with a constant discharge of 7.07 liters/second, resulting in several scouring results that occurred in the early minutes experienced considerable scouring because the flow conditions were still unstable. At the last minute there is no scour or can be considered stable because the scour has reached balance.

4.2. Data Processing

As has been written in the purpose of the problem discusses the effect of variations in the installation of river bank reinforcement modeling, to reduce scouring using the same distance, depth of flow and discharge. In scouring tests of laboratory scale river models with a combination of FP1 loading FP2; FP3 and FP4 produce maximum scouring as follows:

1. Comparison of Strengthening of Tetrapod and Bamboo Flow Aligner

To facilitate the reading of the results of the study, it is presented in **Table 4.1**. From Table 4.1 it can be seen that in FP1 scour drops occur, for STA 03 TP scours occur by -5 cm after being given FP1 reinforcement to -5 cm or a decrease of 100%, whereas for river bank cliffs where when scour TP is -4, 5 cm after being given FP1 reinforcement to -2.6 cm, which means a decrease in scour that occurs by -1.9 cm or 42.2%. For STA 10 there is a decrease from the original TP of -2.5 cm after being given reinforcement to -1.5 cm, which means a decrease in scouring that occurs by -1 cm or a decrease of 40% and for a decrease in the cliff from -4.7 cm when TP becomes -2.3 cm or 51.1%. Similarly, for STA 21 the decrease occurred by -4 cm after being given FP1 reinforcement to -3.8 cm or a decrease of 5%. For the scour river scour model occurs -4.2 cm to -2.4 cm or 42.9%.

From Table 4.1 we can see that in FP2 scours decrease, for STA 03 of scour TP it occurs -5 cm after being given FP1 reinforcement to -5 cm or decreases by 100% while for scour river model walls in TP it is -4, 5 cm after being given FP2 reinforcement to -2.4 cm, which means a decrease in scour that occurs by -2.1 cm or by 46.7%. For STA 10 there was a decrease from the original TP of -2.5 cm after being given FP2 reinforcement to -

1.6 cm, which means a decrease in scour that occurred by -0.9 cm or a decrease of 36% and for a decrease in the cliff from - 4.7 cm when TP becomes -2.7 cm or 42.6%. Likewise for STA 21 TP, scouring that occurs is -4 cm. After being given FP2 reinforcement, scoured to -3.8 cm or a decrease of 5%. For the scour model river scour occurs by -4.2 cm to -3 cm or by 28.6%.

Based on Table 4.1, it can be concluded that FP1 is more effective in reducing scouring than FP2. The scour that occurs at the beginning of the turns of FP1 and FP2 at STA 03 and STA 21 occurs the same scour by 100%, because the sand at the bottom of the river model is washed away by water. Whereas in the middle of the turn, the STA 10 percutaneous FP1 is more efficient than the strengthening of FP2.

2. Comparison of Check Dam Stones and Gabions Strengthening

To facilitate the reading of research results, it can be seen from the presentation of research results in the **Table 4.2**.

Table 4.1 Observation Result

No	Installation	STA	Scour (cm)		Reduction (cm)		Percent (%)	
			Base	Cliff	Base	Cliff	Base	Cliff
1	Without Reinforcement (TP1)	STA 03	-5	-4,5	0	0	100	100
		STA 10	-2,5	-4,7	0	0	100	100
		STA 21	-4	-4,2	0	0	100	100
2	Tetrapod Bamboo Flow Aligner Tetrapod (FP1)	STA 03	-5	-2,6	-5	-1,9	100	42,2
		STA 10	-1,5	-2,3	-1	-,4	40	51,1
		STA 21	-3,8	-2,4	-0,2	-1,8	5	42,9
3	Bamboo Flow Aligner *Tetrapod* Bamboo Flow Aligner (FP2)	STA 03	-5	-2,4	-5	-2,1	100	46,7
		STA 10	-1,6	-2,7	-0,9	-2	36	42,6
		STA 21	-3,8	-3	-0,2	-1,2	5	28,6

Table 4.2. Observation Results

No	Installation	STA	Scour (cm)		Difference (cm)		Percent (%)	
			Base	Wall	Base	Wall	Base	Wall
1	Without Reinforcement (TP2)	STA 01	-4,4	-4,8	0	0	100	100
		STA 11	-0,8	-3,8	0	0	100	100
		STA 19	-2,2	-2,1	0	0	100	100
2	Check Dam Stones-Gabion- Check Dam Stones (FP3)	STA 01	-0,8	-2,8	-3,6	-2	81,8	41,7
		STA 11	-0,4	-3,7	-0,4	-0,1	50,0	2,6
		STA 19	-2,1	-3,4	-0,1	-1,3	4,5	61,9
3	Gabion-Check Dam Stones-Gabion (FP4)	STA 01	-2,8	-2,8	-1,6	-2	36,4	41,7
		STA 11	-3,7	-6,2	-2,9	-2,4	362,5	63,2
		STA 19	-2,8	-3,2	-0,6	-1,1	27,3	52,5

From Table 4.2 it can be seen that in FP3 for STA 01, there was a decrease in scouring of TP2, where TP2 experienced scouring of -4.4 cm, after being given FP3 scouring strength to -0.8 cm, or a scouring decrease of -3.6 cm or 81.8%, while on the outer wall of the channel, where TP2 experiences scouring of -4.8 cm, after being given FP3 reinforcement, the outer wall of the channel has decreased scouring by -2 cm or by 41.8%.

In STA 11, scour decreased against TP2, where TP2 experienced scouring of -0.8 cm, after being given scouring FP3 scouring.

V. CONCLUSION AND RECOMENDATION

5.1. Conclusion

Based on the results of research conducted, and discussion, about variations in the installation combination of tetrapod-bamboo flow aligner-tetrapod (FP1); bamboo flow aligner-tetrapod-bamboo flow aligner (FP2); Check Dam Stones-Gabion-Check Dam Stones (FP3); Gabion-Check Dam Stones-Gabion (FP4), can be concluded as follows:

1. In general, the effect of installing a combination of tetrapod reinforcement and bamboo flow adjusting (FP1) is the variation of the combination considered to be the best in reducing scouring on cliffs and riverbeds.
2. Variation of the combination of tetrapod installation of tetrapod bamboo currents is more effective to reduce scouring that occurs in the channel. At the beginning of the channel bends from STA 00-06 effectively used tetrapod installation, with scours that occur as big as -5 cm, in the middle of the channel bends from STA 06-16 effectively used the installation of bamboo current attuners, scours that occur by -1.5 cm, while At the end of the channel bends from STA 17-24 a tetrapod was installed, which was scoured by -3.8cm.

5.2. Recomendation

Based on testing that has been done, the authors recommend the following suggestions:

1. Installation of reinforcement buildings can alternately on river banks.
2. The use of basic materials in laboratory tests is made as closely as possible to the conditions in the field.

VI. REFERENCES

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