Laboratory Test for the Improvement of River Bends Towards the Landslide

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Abstract. The crib is a protective building on the river wall towards the flow rate of the river. The purpose of the study is to determine the effect of crib installation with variation in angle at the river turn towards cliff landslide. The research method used is river modeling, with flume size of 5.00 m long, width in 0.80 m, and height of 0.50 m. The results of the study are: (1) tetra pod installation at the river turn shows an effective gradient pattern at the beginning, middle and end of the turn at the angle installation of 30º, 45º and 30º respectively, while the tetra pod with 60º angle is not effective. (2) installation of gabion crib with angular variation at the river turn can be seen effective gradient pattern at the beginning of entering the turn with 30º crib angle, in the middle of the curve the effective gradient pattern at 45º angle, and at the end of the curve the gradient pattern is effective at 30º, while the gabion crib with 60º angle is not effective to be used at the river turn. (3) aligning the current on the protection and reparation of soil impacting cliff of -5.4 cm, scouring on compacted cliff models of -1.8 cm, and the cliff model protected by crib does not experience scour. The conclusion is that crib protection is more effective than river models with soil improvement (compaction method).

Keywords: river turn, scour, crib

1. Introduction
The stability of the physical shape of the river poses a problem for humans if it significantly changes. This instability occurs naturally and because of many treatments along the river, for example the presence of dam, reservoir, bridge, and because of natural condition that cannot be avoided such as the existence of a river bend. River turn is a very specific phenomenon to be studied, because at river turn it is often encountered problems of scouring or landslides around riverbank and sedimentation. A river is a channel where water flows with free water. At all points along the channel, the pressure on the surface of the water is the same, which is usually atmosphere pressure. Flow variables are very irregular in space and time. These variables are channel latitude, roughness, base slope, turn, flow rate and so on [1].

Scouring is a natural phenomenon that is caused by erosion of the flow of water on the cliff and river base. It is also a process of declining or the deeper depth of the river below the natural surface elevation due to the interaction between the flow with the river base material [2]. In severe condition erosion or avalanche with large masses on the river bank can cause damage to existing infrastructure and change in the river base can cause unstable slope so that the control building needs to be placed to balance the base and cliffs on the river turn. The controlling building in general is a crib building...
which is also a river cliff protection building indirectly from local scouring for example on river cliff that is near potential area that is at the river turn.

Development of river improvement, such as normalization at river turns has been carried out for long, but the construction often does not provide satisfying result, because it is damaged before fulfilling its function. River bank protection building or crib building is functioned as the river flow direction. The crib building is installed across the river cliff with the aim of directing the flow so that it can protect the riverbank from the erosion process and even the deposition process will occur.

According to SNI 2400 about Procedures for Planning Krebs on the River, installation of crib at river turn has a large positive effect if it is constructed correctly [3]. On the other hand, if the crib is poorly constructed, then the cliff opposite it and the part of the river downstream of the crib will experience a destructive effect. In order to obtain maximum result from the installation of crib according to its purpose, it must be studied carefully, especially those concerning the selection of crib type, selection of dimension, and position of crib, length, direction, height, and distance between the crib according to the river condition.

The failure of crib construction can be caused by the presence of water current that is still strong enough around the crib, causing a scour of the base or cliff around the crib. At a certain level of scouring, it can endanger slope stability and stability of the crib itself. This often occurs in crib building at river turn. To resolve the above problems, knowledge is needed about the scour mechanism that occurs in river, especially at turn. Hence we need a hydraulic model test with a physical model. The effect of the installation of the crib distance to the flow characteristics is the change in flow rate so as to change the type of flow in each model, the decrease in speed, can defend the cliff from the scouring process by the speed of water [4].

Modelling of scour on river turn and the effectiveness of water structure as a protector of cliff, especially on cliff protector, is still rarely done, which is mostly done in the field is effort to overcome or repair the damage that has occurred at the river turn due to being hit by floods. There are still rare attempts to predict the scour or landslide of river cliff, and further effort is made to protect river bank with crib building [5].

The focus of this modelling test is to find out how big the effectiveness of the crib building at the river turn towards scour that occurs on the base or river bank due to water flow especially at maximum discharge. The effect of mounting crib with angular variations as an effort to protect river cliff towards scouring or landslide that occur. Thus, it is expected that efforts to protect river cliffs using this crib can protect river bank from heavy water flow and reduce the depth of scour that occurs at the river turn. The objectives to be achieved in this study are as follows:

1. Knowing the comparison of the effectiveness of using tetrapod, directing the flow of bamboo and gabion as a barrier to the river turn from the danger of landslide and erosion caused by erosion of river water flow.
2. Knowing the flow pattern and scour due to the installation of tetrapod, gabion on the cliff and the base of the river model at the river turn with angles of 60°, 45°, and 30° also installing director with bamboo current.
3. Knowing the effectiveness of tetrapod placement, installing director of bamboo current and gabion and to reduce erosion on the cliff of river turn.

2. Material and Method
2.1 Object of Study
The purpose of this modelling test in general is to find out the maximum scouring that occurs at the river turn and the effect of the installation of crib with angular variation. In accordance with its objective, this study is carried out using an experimental method with a laboratory scale method in which this study is modeled as a situation in Progo River, Banjaroyo, Kalibawang, Kulon Progo Regency, Yogyakarta Special Region.

The data used is the primary data obtained from the measurement result in the experiment carried out on this test is by the hydraulic model test in the laboratory using an open channel flume with dimensions with 5 m turn length, 0.8 m in width, and height of 0.5 m. Trapezoidal
channel with 90° turn angle, there are 22 impermeable cribs at the turn with a distance of 20 cm crib and non-sedimentary water. Observation is carried out with a constant discharge of 6.35 litters/second, 3 variations in the angle of the crib installation of impermeable crib 60°, 45°, and 30° to the flow direction for 3 hours for each angle variation. The step conducted in this test is explained in Figure 1:

![Figure 1. Flowchart of research stage](image-url)
This test is conducted in the Hydraulics Laboratory of the Department of Civil Engineering, Faculty of Engineering, Yogyakarta State University.

2.2 Testing Procedure
The activity is carried out in the laboratory include testing sand gradation, making river turn modelling, placing basic material, compiling crib variation, discharge setting for running the current, and scour depth reading after running using a densitometer. Every data taken uses the same or stable debit and flow depth. Retrieval of data carried out by observing the scour that occurred around the cliff and river base until the scour is stable, the experiment is carried out for three times. The distance between 20 cm crib is constant. the test data’s taken are:
1. Crib with 60º angle (Figure 3)
2. Crib with 45º angle (Figure 4)
3. Crib with 30º angle (Figure 5)
3. Results and Discussion

3.1 Pattern and Shape of Scour

Figure 6. Scour pattern of crib contour with 60° angle

River base material is shown in green. The largest scour is indicated by red colour occurring on the outer cliff while on the opposite cliff the deposition is shown in dark blue. Decreasing the river base is shown in yellow starting at the beginning of the turn until the end of the river.

Figure 7. Scour pattern of crib contour with 45° angle

River base material is shown in cyan colour. The largest scour is indicated by red occurring on the outer cliff at the end of the river turn (downstream of the river) while the relatively small precipitation occurs on the opposite cliff in the middle of the turn shown with moss green. The decline in the river base is shown in brown starting at the beginning of the turn until the end of the river base.

Figure 8. Scour pattern of crib contour with 30° angle
River bottom material is shown in yellow. The largest scour is indicated by red occurring at the foot of the outer cliff at the end of the river turn (downstream of the river). The decrease in the river base is indicated by the orange colour and precipitation is indicated by light green on the opposite cliff.

3.2 Graphical Scour Depth

![Graphical Scour Depth](image)

**Figure 9.** Graph comparison of crib angle variation in the beginning of turn

From the graph above it can be seen that the graph of the cross-sectional profile of the scour depth of three variations in the angle of installation of the crib at the beginning of the turn P15 30° angle is most effective in reducing the scour depth at the beginning of the river turn while the largest scour and precipitation occurs at 60° angle.

At the beginning of the turn the flow changes when the flow approaches the crib, because the obstruction of the water flow by the crib makes the flow pattern rotate. Flow velocities that occur when approaching the slow crib begin to decrease and continue to occur in the next crib until the end of the turn, so that the minimum flow velocity on the river is at the end of the crib. At the beginning of the turn the flow changes do not cause severe scouring.

![Comparison Chart](image)

**Figure 10.** Comparison chart of crib angle variation in the middle of turn

From the graph above it can be seen that the graph of the cross-section profile of the scour depth of three variations in the angle of installation of the crib in the middle of the curve P35 30° and 45° is effective in reducing the scour depth in the middle of the river bend while the largest scour and precipitation occurs at 60° angle.

In the middle of the turn the flow velocity decreases and after the turn shifts towards the outside of the turn area, this is due to the influence of the centrifugal force resulting in a transverse direction current which forces the flow towards the outside of the turn

Therefore, in the middle of the turn there is a severe scour on the outer cliff of the turn and on the opposite cliff the deposition occurs.
Figure 11. Comparison chart of crib angle variation in the end of turn

From the graph above it can be seen that the cross-sectional profile graph of the scour depth ratio of three angles of installation of the crib at the end of the curve P48 30º angle effectively reduces the scour depth in the middle of the river bend while the largest scour and precipitation occurs at 60º angle crib.

At the end of the turn of the flow changes that occur is concentrated flow velocity and tracing the outer cliff before the flow passes through the middle of turn (the line dividing the bend angle is equal), and after going through the middle the turn the effect of the transverse direction current decreases. This causes the occurrence of cross waves (spiral flow) which will affect the flow velocity in inner turn area and it can hit the cliff inside the turn final area so that it occurs deposition on the inner cliff.

3.3 Discussion

Based on the graph of the cross section of the scour depth at the installation of 60º angle crib, it is found that at the beginning of the turn the maximum is -1.4 cm at the foot of the outer cliff of the river turn while the maximum deposition on the cliff at +2.0 cm and the decline of the river base occur evenly the scouring range is -0.9 cm, the middle of the scour turn is maximum of -2.0 cm at the foot of the outer Bends while the maximum deposition on the cliffs of +2.0 cm and the decrease in the river base occur with an average scour of -0.8 cm, and at the end of the turn the maximum of -2.0 cm at the foot of the outside Bends of the river while the maximum deposition on the cliff equal to +1.0 cm and the decrease in the river base occurs with an average scour of -1.2 cm.

In the installation of 45º angle crib, it is found that at the beginning of the turn there is no scour on the outer turn of the river but a precipitation of +12 cm occurred on the opposite cliff while the decrease in the river base occurred with an average scour of -0.7 cm. scour occurs on the outer cliff and settling on the opposite cliff but a decrease in the river base occurs with an average scour of -0.5 cm, and at the end of the turn there is a maximum scour at the cliff outside of the river turn is -1.5 cm while on the opposite cliff there is a maximum deposition of +0.5 cm and a decrease in the river bed occurs with an average scour of -1.2.

In the installation of 30º angle crib, it is found that at the beginning of the turn there is no scour on the cliff outside the river turn but on the opposite cliff there is a maximum deposition of +0.4 cm and a decrease in the river base with an average scour of -0.3 cm, at the middle of the turn there is no scour on the outer cliff but on the opposite cliff there is a maximum deposition of +0.4 cm and a decrease in the river base occurs with an average scour of -0.4 cm, and at the end of the turn there is no scour on the outer cliff but at the opposite cliff has a maximum deposition of +0.5 cm and a decrease in the river base occurs with an average scour of -1.3 cm.

Based on the pattern and shape of the scour illustrated using the surfer program, it is found that the scour pattern formed due to the influence of 30º angle crib installation is the largest scour occurring at the end of the river turn while the opposite cliff is deposited and a relatively small decrease in the river base occurred at the middle to the end of the river. In the installation of permeable
crib with bamboo, it is found that from the beginning to the end of the turn there is no scour on the 
cliff outside the river turn.

Deposition occurs at the back of the crib with an increase of +0.5 and the opposite cliff occurs 
with a maximum deposition of +0.4 cm and a decrease in the river base occurs with an average scour 
of -1 cm.

Based on the pattern and shape of the scour illustrated using the surfer program, it is found that 
the scour pattern formed due to the influence of 60º angle crib installation is the largest scour 
occurring in the middle of the turn while deposition happens at the middle until the end of the turn, 
and the decrease in the river base occurs at the beginning turn until the end of the river turn. The 
scouring pattern is formed because the effect of 45º angle crib installation is the largest scour occurs at 
the end of the river bend and the decrease in the river base occurs at the beginning of the turn until the 
end of the river turn. The scour pattern that is formed because of the influence of the installation of 30º 
gle crib is the largest scour occurs at the end of the river turn, on the opposite cliff, there is a 
deposition and a relatively small decrease in the river base occurs at the end of the river turn.

Based on the cross-sectional profile graph of the comparison of three variations in the angle of 
crib installation it is found that the 30º angle crib effectively reduces the scour depth at the beginning 
with a scour depth of -0.3 cm and the middle of the river turn with a scour depth of -0.4 cm. The 45º 
gle crib effectively reduces the scour depth at the beginning with a scour depth of -0.7 cm and the 
middle of the river turn with a scour depth of -0.5 cm. Whereas, 60º angle crib is not effective in 
reducing the scour depth at the beginning, middle, or end of the turn.

4. Conclusion
Based on the test result and discussion, the maximum scour occurs at the middle of the river turn with 
60º angle crib on the outer cliff of the turn with erosion of -2.0 cm while at the opposite cliff there is a 
maximum precipitation of +2.0 cm.

The effect of the crib installation with angular variation on the river turn is seen in a gradient 
that is at the beginning of the effective turn of the crib with an angleof 30º, then in the middle of the 
effective turn is used at 45º angle, and at the end of the effective turn is at 30º. Crib with an angle of 
60º is not effective to be used on river turn.

Based on the result of the evaluation and discussion, the maximum amount at the river base 
occurrs at the end of the river is -2.0 cm while at the opposite cliff there is a maximum deposition of 
+1.8 cm.

The effect of the installation of permeable crib with bamboo on the river turn is seen in the 
effective gradient of its usefulness from the end to the end of the turn because there is no scour on the 
outer edge of the turn, sedimentation also occurs behind the permeable crib.

5. References
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