The Effect of Check Dam Installation and Gabion with Distance Variation at River Turn using a Laboratory Test Model

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Abstract. Scour or avalanche is a problem that often occurs in river turn. One of the cliff guard buildings are check dam and gabion. This research aims to determine the effect of the distance variation of check dam and gabion installation at the river turn. This test is hydraulic model test using river flume with turn length of 5 m, width of 0.8 m, and height of 0.5 m with trapezoidal channel. Observation’s held with a constant discharge of 7.07 liters/second for 3 hours, the angle for check dam was 90º with 3 distance variations were 68 cm, 85 cm and 102 cm, while the gabion angle was 30º with distance variation of 17 cm, 34 cm, and 51 cm. The scour occurred in the river model without protection was 4.70 cm, while the scour occurred in the river model with check dam was -4.32 cm (3.08%), -3 cm (1.21%), and -3.72 cm (1.25%). The results of gabion tests were 3.01 cm (7.9%), -1.07 cm (0.22%), and -2.07 cm (0.27%). The results of the test showed the check dam reinforcement effectively used at the beginning and the center of the turn, while at the end of the gabion.

Keywords: river turn, gabion, check dam, scour

1. Introduction
Landslide often occur at the cliff of river turn. This is caused by the scour that occurs continuously on the outer side of the river cliff. Scouring occurs because of the water flow that moves quickly at the river turn so that the length of the cliff at the turn experiences landslide. 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 [1]. Flow variables are very irregular in space and time. These variables are channel latitude, roughness, base slope, turn, flow rate and so on.

Defines scour as an enlargement of a flow accompanied by the transfer of material through the action of fluid movements [2]. Local scouring occurs at a flow rate where sediment transported is greater than supplied sediment. One of the rivers that experiences cliffs landslide is Bogowonto River. Bogowonto River is one of the rivers which is located in Purworejo Regency, Central Java Province. The river has a length of about 67 km which flows from Wonosobo area to the south and empties into the Indian Ocean. The morphology of the Bogowonto River which consist of several rather steep river cliffs has clay type and there is no strong barrier such as vegetation in Purworejo area, so that landslide potential occurs may happen in a heavy rain. In addition, the river bank in Bogowonto River experiences landslide due to continuous scour caused by the high speed of water flow in this river.
Construction of handling cliff damage was chosen based on the cause of the damage. If the results of the analysis state that the cliff damage that occurs is caused by eroded river paths, then the alternative construction that can be used as a protector of river cliffs is revetment of stone gabions, Gabion stone gabions or shoot Crete [3]. If the results of the analysis state that the damage caused by small cliff stability, then alternative constructions that can be used are construction grouting and nailing, construction of retaining walls, sheet pile construction, or construction of stone gabions.

Conducted research using the method used in this study was an experimental method by making a river model [4]. The river model tested is a river model that has not undergone protection and repair of land, a model of a river with cliffs that is improved by compaction and a model of a river with cliffs protected by tetrapod’s. Model testing is done by flowing the river with a flow of 7 liters / second for 3 hours.

Reports on the study of the effect of river bend angles on scour volume. The results of this study indicate that the scour volume is directly proportional to the river bend angle [5]. Reduction of scour volume exceeds 20% if the river turn angle decreases from 60º to 30º. Increased flow rate also increases the scour volume to reach more than 100% at the river turn with a small angle.

The method used to reduce the scour that occurs on the river bank is by installing check dam or barrier embankment and by using gabion. Check dam is a small dam with a simple construction (landfill or rock), made in a groove or a small river serve to inhibit the rate of particle. While the gabion has a function as a breakwater or stream flow.

The purpose of this test is to determine the amount of scour that occurs and to determine the effect of the installation of check dam and gabion with distance variation at the river turn in the laboratory model.

The advantages that can be obtained from testing the model on the effect of installation of gabion and check dam with distance variation at the river bend are 2, namely theoretically and practically. Theoretically, this modeling test is expected to provide general knowledge input regarding the world of civil engineering, especially those related to normalization at river turn. In addition, this modeling test can be used as a reference for further testing, especially regarding the installation of gabion and check dam with distance variation at the river turn and as a way of handling the effectiveness of existing water building in the field to reduce the scour depth at the river turn. And practically the result of this modeling test is expected to be able to contribute ideas towards the problem solving related to the normalization development at river turn.

2. Research Method

In accordance with the objective of this modeling test, then a river turn model is used in this test with a ductile base material. After conducting this test, it is expected to be able to plan a river turn security in the form of a gabion and check dam with a certain distance that is effective to protect the cliff at the river turn. This test is a hydraulic model test using a river flume with a 5m turn length, a width of 0.8m, and a height of 0.5m. Trapezoidal channel with a 90 turn angle. Observation are made with a constant discharge of 7.07 liters / second, 3 variations of the check dam mounting distance of 68 cm, 85 cm, and 102 cm and 3 variations in the installation of gabion which are 17 cm, 34cm and 51 cm towards the flow direction for 3 hours for each distance variation.

This study uses a quantitative approach in the form of calculating the amount of scour on the cliff at the river turn.

This test is conducted at the Hydraulics Laboratory of the Department of Civil Engineering, Faculty of Engineering, Yogyakarta State University. This research is conducted on April 4, 2018 and ends on May 17, 2018.
The tools used in this test are:

2.1 River flume
The river flume is the main equipment used in this test. This flume has a length of 5 m, width of 0.80, and has a height of 0.50 m. For the purpose of running it is used water flows to the flume with a closed circulation system in order not to have the water lost.

2.2 Water pump
For the purpose of a closed water circulation system, it is used a pump with a capacity of 6.0 liters / second. The water pump that is used in this study is a centrifugal water pump that has a 1.5 inch to 3 inch pipe specification, 9m suction power and a thrust power of 13.7 m to 16m.

2.3 Distometer
The leica distometer that is used is the A6 type which is equipped with a digital point finder, high resolution of 2.4 digital screen, 360° sensor and bluetooth technology. It is easy to use the tool, just by aiming for a position where you can read it by pressing the button on the device and then transferring data via bluetooth to your laptop or handphone. This tool is equipped with reading aids according to the desired distance.

2.4 Stopwatch
The stopwatch is used in this study to determine the timing of scour depth measurement during the research run.

2.5 Measuring instrument
Measuring instrument is applied to the wall channel to monitor the flow depth during research running.

2.6 Camera
The camera is used in this test to document the detail test result from the beginning to the end of the test visually.

2.7 Stone gabion
River bank safety building use stone gabion which is included in impermeable groin / gabion which do not pass through the flow. This Gabion modeling has a length of 10 cm with a width of 2.5 cm (a) and a length of 7 cm with a width of 2.5 cm (b).
2.8 Stone check dam

The type of water building used is a check dam that is installed across the river turn for safeguarding the river turn. The dimension of the check dam that is used in this study is modeled with a size of 44 cm in length and 5 cm in width in the lower layer while the upper layer has a dimension of 44 cm and width of 2.5 cm.

![Stone check dam](image)

**Figure 3.** Stone check dam

3. Data collection technique

Every data taken uses the same or stable debit and flow depth. The data taken is carried out by observing the scour that occurs around the cliff and river base until the scouring is stable, the experiment is carried out for three times.

At the check dam, the angle that is used is 90-degree constant. The test data retrieval are:
- Check dam with a distance of 68 cm
- Check dam with a distance of 85 cm
- Check dam with a distance of 102 cm

For the gabion the angle that is used is 30° and the test data retrieval are:
- Gabion with a distance of 17 cm
- Gabion with a distance of 34 cm
- Gabion with a distance of 51 cm

Scour data is taken by recording the result of depth measurement that occurs on the cliff and river base using a densitometer.

4. Test Stages

The stages that are carried out in this test are explained as follow:

4.1 Preparation Stages

The preparation stages for this study include:
- Preparation of Tools
- Preparation of Reading Aid
- Preparation of Basic Materials / Materials
- Preparation of Running / Data Collection

4.2 Implementation Stage

The stages of conducting the research are as follows:
- Preparation of Sediment Material
- Flume Tool Check
- Placement of Sand Material
- Preliminary Testing
- Testing Execution
5. Data analysis technique
It is attempted to make the flow that occurs is a sub-critical flow with the value of Fr <1. The depth of flow (γo) is measured at a certain point that has not been disturbed due to the presence of Gabion. Recording the flow depth is done several times at the same time in order to get the maximum data average flow depth. Scour depth (γs) is measured at the beginning of entering the turn until the end of the turn. In some results of Gabion angle variation installation, the maximum scour data, scour contour and scour length are obtained. Furthermore, data analysis is carried out with the aim of finding the relationship between the parameter obtained and to obtain the result of the analysis of the most effective effect of the installation of inter-Gabion distance variation to reduce scour at river the turn. Data analysis is performed using the Microsoft Excel Program.

6. Results and discussion
The result of observing the scour depth that occurred in early minutes it is found that there is big scour due to the unstable flow condition. At the last minute it can be said to be stable because the scour has reached equilibrium.

Considering to several things such as discharge, flow depth, and installation distance of check dam and gabion, laboratory result is obtained by doing river physical modeling and setting the most effective installation of check dam and gabion variation to reduce scour in the river are as follows:

![Figure 4. Comparison graph of scouring at the beginning of turn](image)

Based on the cross-sectional scour depth graph on the installation of check dam with a distance of 68 cm, it is known that at the beginning of the turn, the maximum sedimentation occurs on the outer cliffs is +2.2 cm and the decrease in the river base occurs with an average of -0.98 cm. For the check dam installation with distance of 85 cm it is found that at the beginning of the turn there are scour of -0.98 cm on the outer cliff and sedimentation occurs on the crossing of the cliff which is +1.38 cm and the decrease in the river base occurs with an average of -0.20 cm. On the installation of check dam with distance of 102 cm, it is found that at the beginning of the turn there is a scour of -2.16 cm on the outer cliff and sedimentation occurs on the crossing cliff, that is +1.20 cm and decrease in the river base occurs with average of -0.38 cm. Whereas the installation of gabion with distance of 17 cm has average scour of -3.01 cm, the installation of gabion with distance of 34 cm has average scour of -1.26 cm and the installation of gabion with distance of 51 cm has average scour of -1.62 cm.
In the middle of the turn on the installation of check dam with a distance of 68 cm, the maximum scour obtained is -0.40 cm at the outer cliff of river turn while the maximum sedimentation occurs at the opposite side of cliff, which is +0.86 cm and the river base decrease occurs with average of -0.32 cm. At the center of the turn on the installation of check dam with a distance of 85 cm, the maximum scouring obtained is -0.96 cm at the outer cliff of river turn, while the maximum sedimentation occurs at the opposite side of cliff is +1.32 cm and the decrease in river base occurs with average -0.66 cm. In the middle of the turn on the installation of check dam with distance of 102 cm, there is a maximum scour of -0.50 cm at the outer cliff of the river turn and no sedimentation occurs. The decrease in the river base occurs with average of -0.66 cm. While the installation of gabion with distance of 17 cm has average scour of -0.39 cm, the installation of gabion with distance of 34 cm has average scour of -0.01 cm and the installation of gabion with distance of 51 cm has average scour of -1.07 cm.

At the end of turn on the installation of check dam with distance of 68 cm, the maximum scour obtained is -4.50 cm at the outer cliff of river turn and there is no sedimentation and the decrease in river base occurs with average of -4.32 cm. On the installation of check dam with distance of 85 cm, there is scour of -1.46 cm at the outer cliff the river turn and there is sedimentation on the crossing cliff, that is +0.85 cm and decrease in the river base occurs with average of -3.69 cm. On the installation of check dam with distance of 85 cm, there is a scour of -4 cm at the outer cliff of the river turn and there is no sedimentation on the opposite side of the cliff, and the decline in the river base occurs with average...
of -4.09 cm. While the installation of gabion with a distance of 17 cm has average scour of -1.14 cm, gabion installation with a distance of 34 cm has an average scour of -1.26 cm and installation of gabion with a distance of 51 cm has average scour of -2.27 cm.

7. Conclusion
From the test result, it can be concluded that the reinforcement of the check dam at the river, it will be effective to use distance of 85 cm for the beginning and the end of the turn, while in the middle uses distance of 102 cm. Using gabion reinforcement with distance of 34 cm will be effective to be used at the beginning of the turn and center of the turn, then at the end of the turn it will be effective to use gabion with a distance of 17 cm.

8. References
[1] Triatmodjo B 2008 Hidrologi Terapan (Yogyakarta: Beta Offset) 103
[2] Hanwar S 1990 Gerusan Lokal di Sekitar Abutmen Jembatan, Tesis (Yogyakarta: PPS UGM) 4
[3] Teuku F and Wibowo S 2007 Perbaikan Tebing Sungai Luk Ulo Di Dukuh Jetis Desa Kutosari Kecamatan Kebumen Kabupaten Kebumen Skripsi (Semarang: Universitas Diponegoro)
[4] Melody 2018 Pengaruh Pemasangan Tetrapod dengan Variasi Jarak, Tugas Akhir (Yogyakarta: Universitas Negeri Yogyakarta)
[5] Djufrri H 2017 Studi Pengaruh Sudut Belokan Sungai Terhadap Volume Gerusan, INTEK. 4(1) 60-65.