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Phenomenon of Sediment Distribution Patterns in Bends Due to Changes in Check Dam Layout

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ABSTRACT

Indonesia has high rainfall, which often causes flooding. Large volumes of rainwater cause sediment in river channels to move from upstream to downstream. The shape of rivers in Indonesia tends to bend, so the researcher conducted a study of the turning channel using a check dam structure with three placement conditions, namely before the bend, in the middle of the bend, and after the bend. This research was conducted at the Fluid Mechanics and Hydraulics Laboratory, Department of Civil Engineering, Faculty of Engineering, Universitas Andalas, Padang. This study aims to determine the impact of sediment on erosion caused by the placement of check dams on river bends and to determine the distribution of sediment due to changes in the position of Check Dam buildings on river bends. A 12.8 m long channel, made of 5 mm acrylic, with a cross section of 0.4 m x 0.4 m and a bend angle of 120o, was used in the experiment. Researchers measured flood discharge and sediment distribution for each of the three check dam positions. The study showed that the sediment distribution varied significantly depending on the location of the check dam. The researchers observed that the most balanced sediment distribution, with relatively equal deposition on the inner and outer sides of the bend, occurred when the check dam was placed after the bend. Based on these findings, they recommend placing check dams after bends in meandering rivers to minimize erosion and promote a more balanced sediment distribution.

Keywords: *The Bend; Sediment Distribution; Check Dam.*

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INTRODUCTION

Many rivers in Indonesia have a meandering topography. Meandering rivers are a common feature of the Indonesian landscape, but they are often problematic, causing widespread erosion and sediment deposition that threaten communities and infrastructure. This can cause flooding, damage agricultural land and disrupt transportation. Recognizing the significant impact of these problems, various interventions have been explored, including the use of groins, retaining dams and other flow control structures, so researchers are also investigating the role of river morphology and sediment characteristics in influencing erosion and deposition patterns, aiming to develop sustainable solutions for river management.

Ramli's suggestion that sabo dams should not be located on river bends is very relevant and needs to be considered in the planning and construction of sabo dams. By understanding the reasons behind the suggestion and considering other related factors, it is hoped that the sabo dam can be built appropriately and function optimally in controlling water and sediment flow. [1]

Sunaryo, et al conducted a study on a 120° bend channel in the form of a physical simulation (Test) at the laboratory with a groyne. This study was conducted to obtain a pattern of cliff collapse on a channel bend and its effect on the installation of a groyne that does not allow water to pass through, also its variations in the angle and distance of the groyne installation. From the results of the study, it was found that the best installation of groynes to reduce wall collapse and sediment deposition in the bend channel was to use an angle of 135o, within distance of 10 cm, and small discharge. This is because the water turbulence is getting smaller (narrow turning space), so that the cliff conditions are quite stable. [2]

Darwizal did research on a bend channel that was varied using channel made of 5 mm acrylic with angles of 60°, 90°, 120°, and 150° along with materials taken from the Kuranji River. In each test, it was done by placing 10 cm thick sediment and the length was adjusted to the shape of the bend. The results of the study were obtained that the greatest erosion occurred outside the bend, especially at the beginning of the bend, and sedimentation tended to occur inside the bend, particularly at the end of the bend. By varying the bend angle, the results showed that the more blunt the bend angle, the greater it sediment discharge that occurred. [3]

Tryantini Sundi Putri et al conducted a study at the Laboratory of Materials and Construction Technology, Faculty of Engineering, Halu Oleo University on porous groyne concrete as a protective construction at river bends. The results of the infiltration rate test can be concluded that the greater the variation in the size of the coarse aggregate used, the greater the infiltration rate that occurs in non-sand concrete. It caused by many cavities in it and the use of coarse aggregate is less than other aggregates, allowing water movement through large pores to be faster and have a large infiltration capacity. [4]

Hasdaryatmin conducted research using an experimental model at the Hasanuddin University River Engineering Laboratory. This model allows researchers to control variables and directly observe the scour phenomenon that occurs. Hasdaryatmin's research shows that the angle of river bends has a significant influence on scour volume. This effect interacts with flow velocity and discharge. A good understanding of the interaction of these factors is essential in sustainable river management. [5]

Research conducted by Zulfan, et al (2018) on the effectiveness of kribs in reducing scour in the outer bend of the Bengawan Solo River provides very valuable information in efforts to control and overcome the problem of river scour. This research shows that the installation of kribs is an effective solution to reduce scour in the outer bends of rivers, such as those that occur in the Bengawan Solo River. The optimal krib configuration, i.e. with a more spaced krib (d = 2L) and the number of kribs adjusted to the river alignment, can result in a significant reduction in flow velocity and change the flow pattern to be more dispersed, thereby reducing the risk of scour and river bank damage. [6]

Maizir conducted a study to analyze the scour depth on the outer river bend using the Ripley formula and compared it with the results of direct scour cross section measurements in the field. This study aims to determine whether the Ripley formula can be used to predict the depth of scour that occurs in rivers. Maizir concluded that the scour depth calculated by the Ripley formula has a relationship between the scour depth calculated by the Ripley formula straight with the scour depth measured in the field. That is, the greater the scour depth calculated by the Ripley formula, the greater the scour depth measured in the field. [7]

Santoso run a study on the influence of the configuration of the groyne building on a river bend with a bend angle of 90°. The research and creation of the channel model were conducted at the Flow Laboratory of the Civil Engineering, Diponegoro University. This research model uses an open channel with a river morphology cross-section of fine sand that allows the bottom and banks of channel to be eroded due to water currents. From this study, it was concluded that the placement of groynes with an angle of a=90° is more effective than the placement of groynes with an angle of a=60°, and the closer the groynes are, the level effectiveness also increases. [8]

Artia and Atima did an analysis of the characteristics of sediment and the sedimentation rate of the Walanae River, Wajo Regency. From the results if research at the Laboratory and calculations of sediment transport data, they concluded that the total sediment transport rate in the Walanae River flow for 15 years was 1318.9 tons. [9]

Jeni Paresa conducted research on the effect of impermeable type upstream kribs on scour in river bends. The research was conducted by conducting an experimental model in the laboratory using 3 models of discharge variation (Q), 3 variations of crotch length, and 3 variations of flux time. This research results in the effect of installing kribs upstream can reduce scour that occurs in river bends. [10]

Research conducted by Apria and his team on the Numerical Model of Nays2DH for the Placement of Krib Buildings at River Bends provides valuable insights into scour control at river bends. The test results show that the perpendicular krib formation is the most effective formation in reducing scour at the bend of the Ciasem River. This study concludes that krib placement with perpendicular formation is the most effective in reducing scour at river bends. This formation can direct flow and sediment away from areas prone to scour, thereby protecting the riverbanks and reducing the risk of erosion damage. [11]

Research conducted by Agung Wiyono and his team aims to understand and compare the local scour that occurs around vertical wall abutments with and without wings in various channel geometry conditions, namely straight, 90° bend, and 180°. The study showed that the type of abutment (with or without wings) and channel geometry (straight or bend) affect the pattern and magnitude of local scour that occurs. The use of appropriate formulas is essential for predicting and controlling scour around abutments. [12]

Sumardi conducted research on sediment transport analysis in Kolongan Water River, North Minahasa Regency with the aim of calculating and analyzing sediment transport in Kolongan Water River at the control point of Suwaan area. This study shows that there are significant differences in the results of sediment transport calculations using the Van Rijn and Einstein methods. The Van Rijn method produces a larger value, so it is considered more appropriate for the conditions of the Kolongan Water River. The rise of the riverbed that occurs due to high discharge in January also needs to be a concern in river management. [13]

Aidil Saputra and Darwizal Daoed conducted a study on 120° bend using a stepped spillway. This study was conducted by simulating a stepped spillway model by varying the position of the stepped spillway as many as 3 positions placed before the bend. Each position will be flowed with 3 variations of discharge (Q). This study shows that the flow profile follows steps for small discharges and there is a jump for large discharges. The greater the flow rate, the tendency for the erosion happened on the downstream of the spillway getting bigger, and vice versa. The smallest erosion volume occurs at the spillway which is as far as the width of the spillway before the bend. While the volume of erosion is quite large if the spillway is placed near a bend and extends very far from the bend. [14]

Research conducted by Lutfi Hair Djunur on the study of riverbed configuration with gravel base material on bends with physical models provides important information about flow behavior and riverbed changes on bends. This study aims to examine changes in the riverbed at river bends due to changes in flow parameters, such as discharge, velocity, time, flow height, bend angle, and bend radius. This research provides a better understanding of how flow parameters affect riverbed changes at bends. This information can be used in river design and management, particularly in river bend stability planning. [15]

From several studies on bends in river channels, researchers see a gap in previous research, namely the lack of research on the effect of check dam placement on river bends. Previous research, such as that conducted by Darwizal Daoed, focused more on the variation of the bend angle, but has not touched on the aspect of check dam placement.

This research is very important because check dams are one of the commonly used flood and sediment control structures. A good understanding of the effective placement of check dams on river bends will help in optimizing the design and implementation of these structures in the field.

The main objective of your research is to determine how the placement of check dams on river bends affects water flow and sedimentation. The three placement positions to be investigated (before the bend, in the middle of the bend, and after the bend) will provide valuable comparative data. The results of this study are expected to provide useful information for water resource planners and managers in designing more effective and efficient check dams, especially on rivers with bends.

METHOD

Research Approach

The research method used is descriptive with a quantitative approach. This type of research is conducted to investigate a predetermined population or sample, where data collected through research instruments, and the results are analyzed statistically and quantitatively. The purpose of this study is to test the previously formulated hypothesis.

Research sites

The experimental investigations were performed at the Fluid Mechanics and Hydraulics Laboratory, Department of Civil Engineering, Faculty of Engineering, Andalas University, Padang

Data Collection Technique

Data collection is in the form of primary data sourced from direct data processing by the author, which inclu des laboratory test results with several condition comparisons.

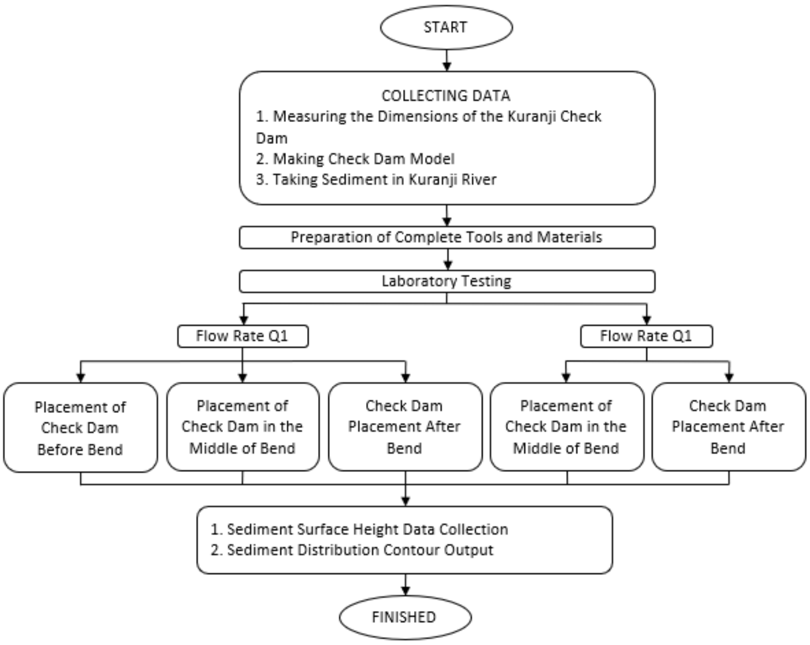

Figure 1. Research Flowchart

Based on SNI ASTM C 136-06 on test methods for sieve analysis of fine aggregates and coarse aggregates, this method is used to determine the gradation of materials in the form of aggregates, the size of grain gradation can be determined using sieves. [16]

Test Procedure

1. First, calibrate the equipment which will be used, such as:
2. Ensure that the required equipment can be used properly
3. Ensure the channels are clean, except for the materials and equipment used
4. Arrange the water discharge that will be flowed into the channel
5. Prepare clean water available in the reservoir
6. After that, testing at the laboratory can be done by starting with Check Dam placement before the bend.
7. The channel is filled with sediment as high as 0.1 m along the bend.
8. Turned on the water pump, so the observations are conducted with the sediment distribution phenomenon in the channel.
9. Calculate the flow rate using a water reservoir and stopwatch.
10. After ensuring that sediment is calm and does not move, the water pump is turned off.
11. After the water in the channel recedes, the sediment height is calculated using a measuring scale at every multiple of 2 cm on the x-axis (channel length) and y-axis (channel width).
12. Repeat procedures from points 2 to 7 for the placement of Check Dam in the middle and after the bend.
13. After all laboratory test processes are complete, the sediment surface height data will be input into excel and imported into the AutoCad 3D application to get a picture of the contour that has been carried out at the Laboratory.

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RESULTS AND DISCUSSION

Research result

The test result data is the inputted into excel format and then imported into the AutoCad 3D Application to create a sediment distribution appearance form on the bend channel. The following are the results of sediment distribution simulations carried out on bends with different Check Dam positions.

Figure 2. Sediment Distribution when the Check Dam Position is Before the Bend

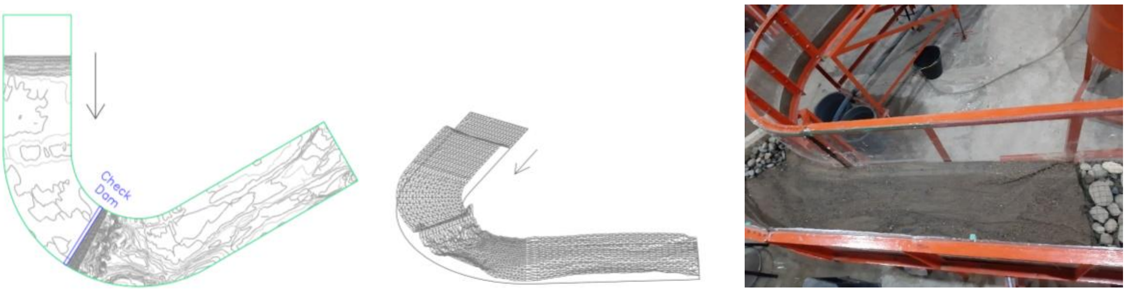

Figure *3*. Sediment Distribution when the Check Dam position is in the middle of a Bend

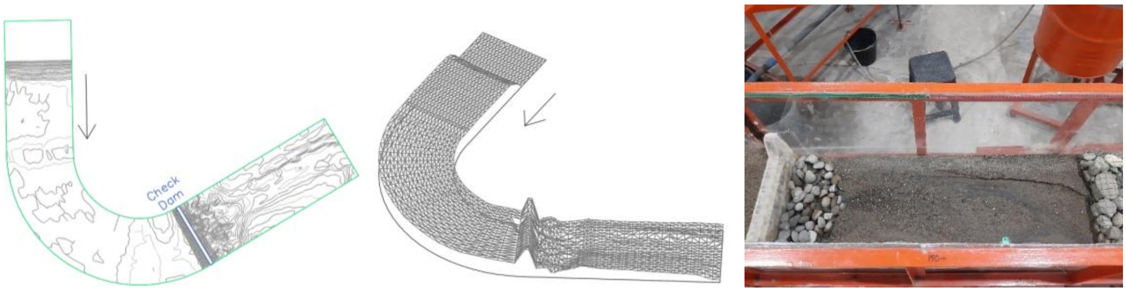

Figure 4. Sediment Distribution when the Check Dam position is After the Bend

Research Discussion

As a comparison of changes in sediment distribution with differences in Check Dam positions, cuts were made on the channel. As seen in the image below, there are 5 Cuts in the bend channel that are used as comparison of sediment distribution.

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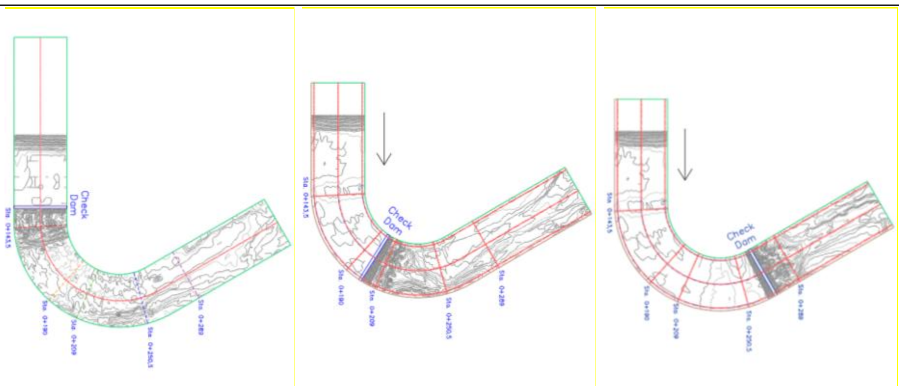

Figure 5. Cut On Bend Channel

1. Stationing Cut. 0+143,5

   In this section, it can be concluded that the placement of the check dam before the river bend shows greater erosion potential compared to the placement in the middle or after the bend. This explicitly informs that the greatest scour occurs when the check dam is placed before the bend. Scour is the erosion of soil or sediment due to water flow. In this case, it means that placing the check dam before the bend causes more sediment to be eroded and carried away by the water flow.

   The variation in sediment surface height indicates that there is instability in the flow and sedimentation pattern. When the check dam is located in the middle or after the bend, the sediment surface height tends not to change. This suggests that this placement creates more stable flow conditions and reduces erosion.

   Check dams placed before the bend can disrupt the flow of water entering the bend. This can lead to increased turbulence and flow velocity around the bend, which in turn increases erosion. Placement of check dams in the middle or after the bend may help regulate water flow and reduce turbulence. This can help reduce erosion and create more balanced sedimentation conditions.

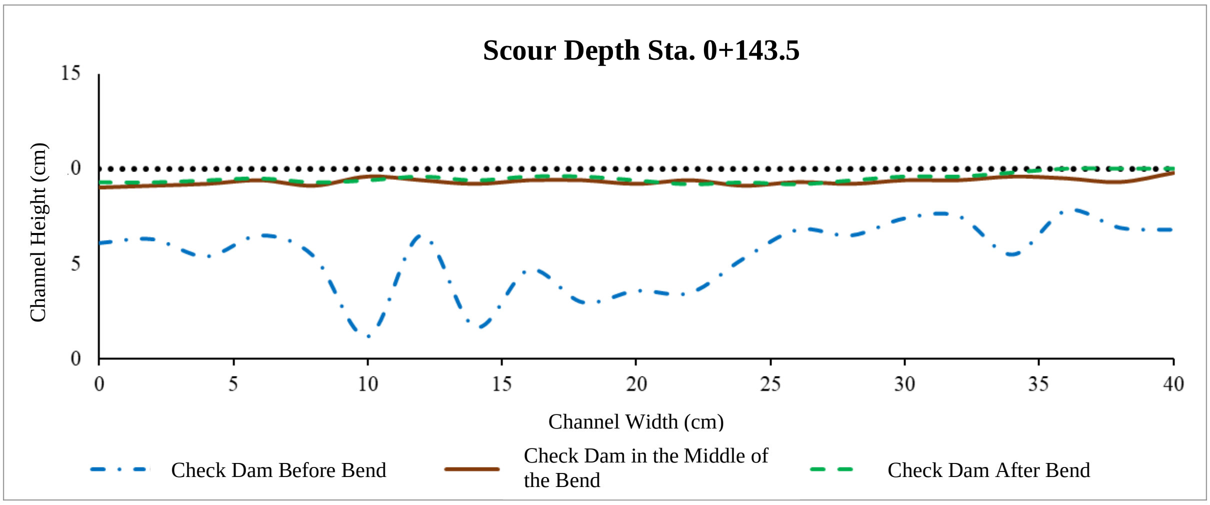

Figure 6. Channel Cut at Station 0+143,5

2. Stationing Cut. 0+190,0

   This section indicates that the placement of the check dam before the bend creates the most unstable flow conditions and is most susceptible to erosion. Water flow obstructed by the check dam before the bend is likely to experience increased velocity and turbulence as it enters the bend. This leads to increased shear forces on the river bed and bank of the bend, which in turn triggers greater erosion or scouring.

The absence of significant changes in sediment surface height when check dams are placed in the middle or after the bend suggests that this placement tends to create more stable flow conditions. Check dams placed in these positions may help to dampen flow energy and reduce turbulence, thereby reducing erosion potential and allowing sediment to settle more evenly. The placement of check dams essentially changes the flow pattern of the river. Check dams can slow the flow, increase turbulence or change the direction of flow, depending on their position relative to the bend. These changes in flow patterns directly affect sediment dynamics. Erosion occurs when the shear force of the flow exceeds the ability of the sediment to resist erosion. Conversely, sedimentation occurs when the flow velocity slows down and allows the sediment to settle out

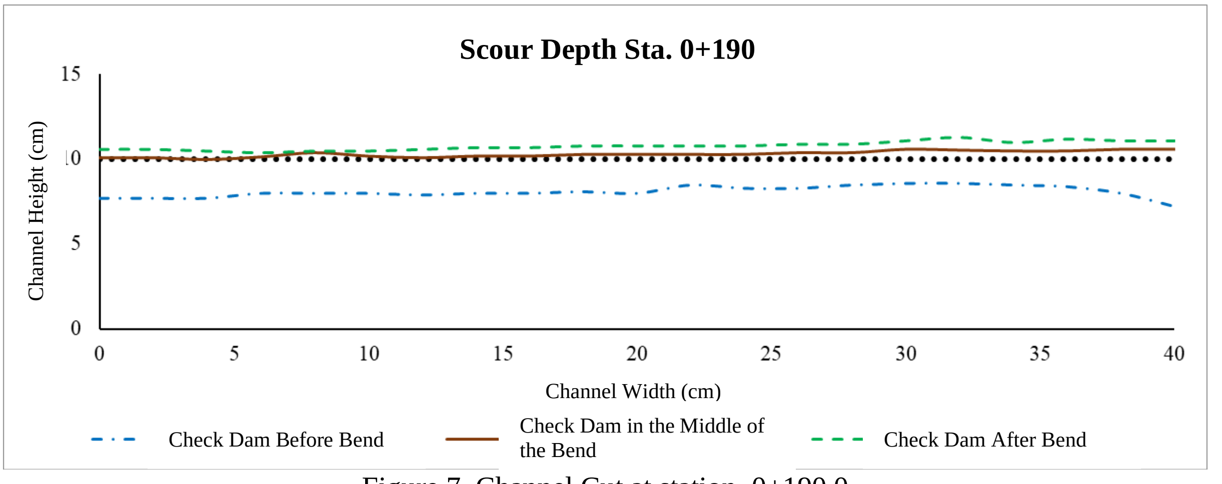

Figure 7. Channel Cut at station. 0+190,0

3. Stationing Cut. 0+209,0

   This section indicates that the placement of check dams before and in the center of the bend creates unstable flow conditions and is prone to erosion.

   Check dams placed before the bend can disrupt the flow of water entering the bend. This can lead to increased turbulence and flow velocity around the bend, which in turn increases erosion. The scour that occurs tends to be towards the inside of the bend as the water flow pushed by the check dam will flow towards the inside of the bend.

   Placement of the check dam in the center of the bend also causes scour and variation in sediment height as the check dam disrupts the normal flow pattern within the bend. This leads to complex changes in flow velocity and direction, which can trigger erosion and changes in sediment height.

   The absence of significant sediment surface height changes when check dams are placed after the bend suggests that this placement tends to create more stable flow conditions. Check dams placed in this position may help to dampen flow energy and reduce turbulence, thereby reducing erosion potential and allowing sediment to settle more evenly.

   The placement of check dams essentially changes the flow pattern of the river. Check dams can slow the flow, increase turbulence or change the direction of flow, depending on their position relative to the bend. These changes in flow patterns directly affect sediment dynamics. Erosion occurs when the shear force of the flow exceeds the ability of the

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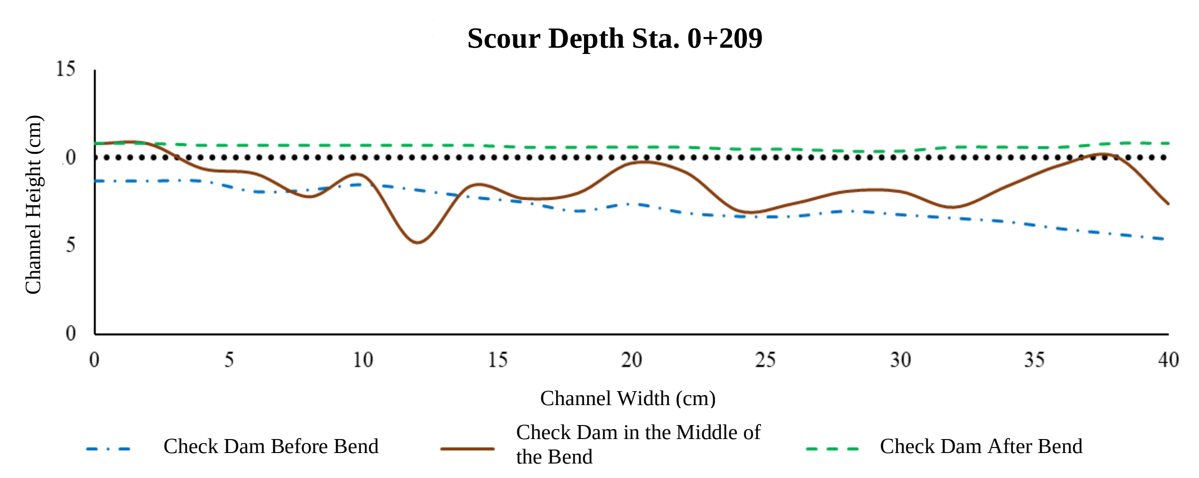

Figure 8 : Channel Cut at Sta. 0+209,0

4. Stationing Cut. 0+250,5
   In this section, the placement of check dams before and in the center of the bend creates unstable flow conditions and triggers erosion (scour).

   The check dam placed before the bend results in scour dominant on the inside of the bend. The water flow pushed by the check dam flows to the inside of the bend with great energy, causing sediment erosion.

   Placement of the check dam in the center of the bend resulted in scour causing variations in sediment height. The check dam disrupts the normal flow pattern of the bend, generating turbulence and variations in flow velocity. As a result, localized erosion and sediment height variations occur around the check dam.

   Placement of the check dam after the bend results in sediment deposition on the outer side of the bend. Flow conditions are more stable as the check dam dampens flow energy and reduces turbulence. This allows the sediment to settle more evenly.

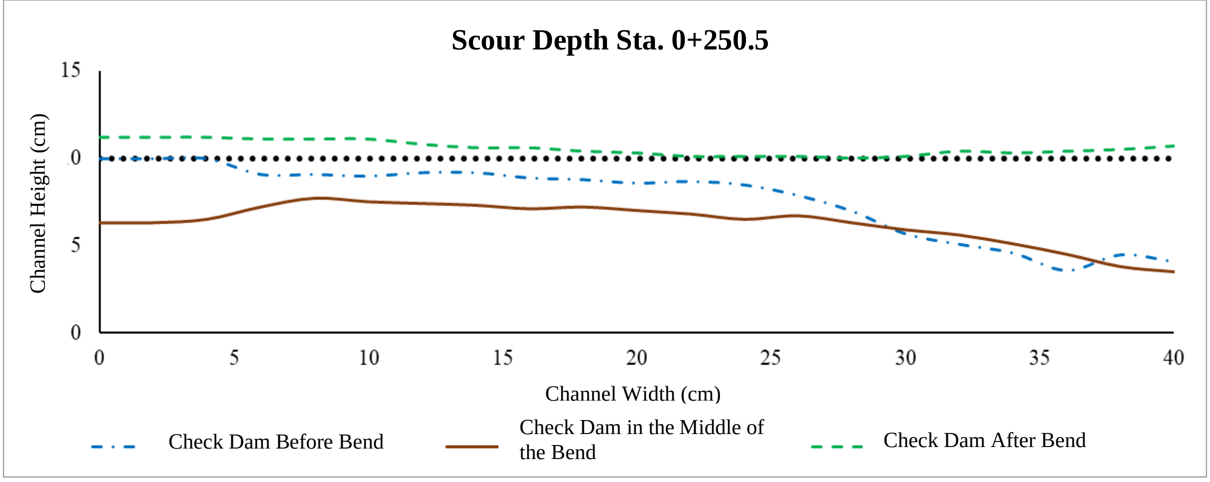

Figure 9 : Channel Cut at Sta. 0+250,5

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5. Stationing Cut. 0+289,0

In this section, the results are a bit counter-intuitive. Typically, check dams are placed before or in the middle of a bend in order to reduce erosion and stabilize flow. However, from the resulting study, it was the placement of the check dam after the bend that caused the greatest scour. This is because check dams placed after the bend can change the downstream flow pattern. Flow exiting the bend and passing through the check dam may experience a significant increase in velocity or turbulence, causing erosion downstream of the check dam.

Check dams can cause backwater effects or inundation upstream of them. If the check dam is placed too close to the bend, this backwater effect may affect the flow conditions inside the bend and trigger erosion. Although check dams generally aim to control sedimentation, their improper placement can cause sedimentation in one area and erosion in another. Placement after a bend may cause sedimentation upstream of the check dam, but also increase flow velocity and erosion downstream.

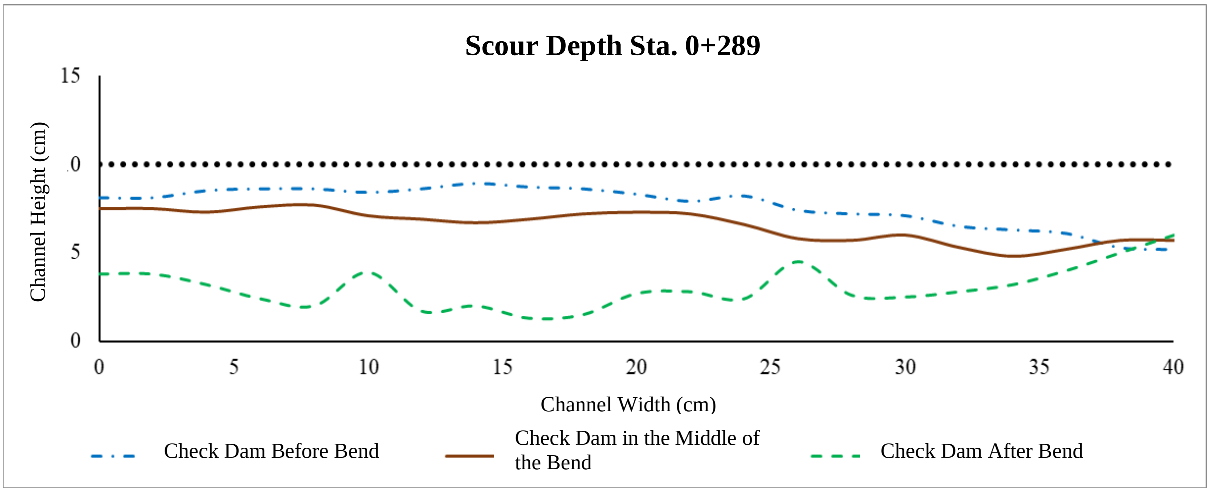

Figure 10 : Channel Cut at Sta. 0+289,0

From the five pieces of information obtained, it can be concluded that the layout of the check dam building greatly affects the sediment distribution pattern along the river bend. The main conclusion of this study is that the use of check dams after the bend is the best option to address sediment dispersal issues. This study shows that the position of the check dam relative to the river bend has a significant impact on how sediment is distributed. The three positions studied were before the bend, in the middle of the bend, and after the bend.

The results concluded that placing the check dam after the bend gave the best results in controlling sediment distribution. This is because the sediment before the check dam or along the bend is not damaged by the placement of the check dam in this position. This means that the check dam does not disturb or aggravate sedimentation conditions upstream or inside the bend itself.

However, the sediment after the check dam experienced considerable scouring. This suggests that the check dam is effective in controlling sediment moving downstream, although there may be some localized erosion downstream of the check dam.

Placing the check dam before or in the center of the bend creates scour problems inside the bend. This scour can result in undesirable deformation of the river channel and potentially damage the surrounding infrastructure.

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CONCLUSION

From the results of the experiments and discussions conducted on the Check Dam in the bend channel, the following conclusions can be drawn:

1. Placement of Check Dam in a bend channel tends to cause erosion on the outside of the bend and sedimentation on the inside of the bend. This can result in widening of the bend channel.
2. Placement of check dams after bends offers significant advantages in terms of even distribution of sediment. This contributes to channel stability, optimal check dam function, and minimization of erosion.

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