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# River training works of Gomti River 3k.m. downstream from Indira Canal Aqueduct: A case study

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## ABSTRACT

***River training work between on Gomti River 3 K.M. downstream from Indira Aqueduct Lucknow. There are various techniques for River Training Works and the suitable one is selected according to the characteristics of soil and river flow.***

***Keywords***— *River training works, meandering, spurs, guide banks, Groynes*

## 1. INTRODUCTION

For construction of hydraulic structures across the river a water resource engineer must consider the effect of the structure on the hydraulics of the river and the best way to train the river such that the structure performs satisfactorily and to minimize the damage. The fundamental objective is to restrict the horizontal movement of the river channel along certain alignment. It has utmost importance in the North Indian alluvial soil to minimize the effect of soil erosion and to control flash flooding.

## 2. MEANDERING PHENOMENA AND PARAMETERS

### 2.1 Meandering

Meandering is considered a wave phenomenon which is formed when moving water stream erodes to outer bank and widens its valley and the inner part of the river has less energy and deposits what it is carrying. A meander channel become deeper towards the concave bank and progressively gets shallower towards the convex bank.

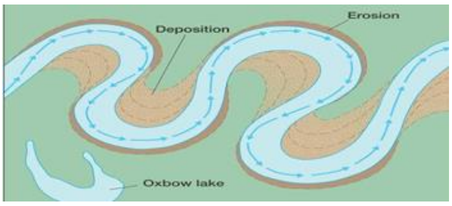


**Fig. 1: Meandering phenomena in rivers**

### 2.2 Causes of Meandering

(a) Size and grade of sediments which make up the river bed
(b) Extra turbulence created by transported sediments during flood
(c) Valley slope
(d) Bed slope and side slope of the river channel.


**Fig. 2: Satellite image of Gomti River in Meandering stage**

 

When the quantity of silt is in excess of quantity required for stability of the river, the river starts building up its slope by depositing silt on its bed. Concave banks goes on eroding while the convex bank goes on silting and forming meanders

### 2.3 Meander Parameters

(a) Meander Length: It is the axial length of one meander. Axial length refers to the tangential distance between the crest or trough of the meander in plan view.
(b) Meander belt width**:** Distance between top and bottom portions of the consecutive crest or trough in the plan view of river.
(c) Meander ratio**:** Ratio of Meander Belt Width and Meander Length.
(d) Tortuosity or sinuosity*:* Ratio of arcual length to the direct axial length.

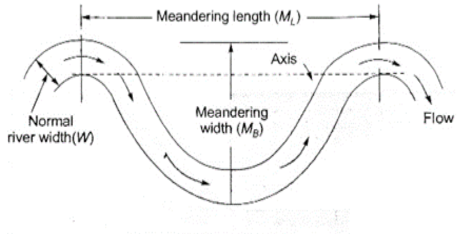


**Fig. 3: Meander parameters**

### 2.4 Classification of river training works

Based on the purpose there are following types:

- High water training: For flood control and training for discharge by Dykes or Levees
- Low water training: to control the depth during low water period for proper navigation
- Mean water training: For efficient disposal of suspended load and sediments. It is mostly used.

## 3. METHODS OF RIVER TRAINING

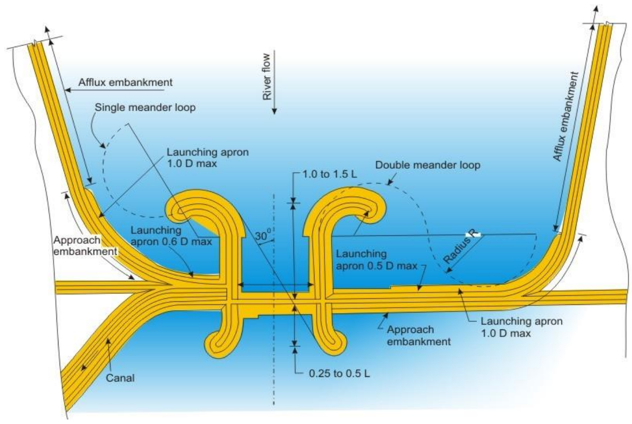


**Fig. 4: Components of a river training work**

There are following methods for river training works:

1. Levees or marginal embankment
2. Guide banks or guide bunds
3. Groynes or spurs
4. Cut-offs (oxbow lake)
5. River Bank protection works
6. Pitched island

### 3.1 Levees or marginal embankments

These are earthen embankment constructed in the flood plain and run parallel to the river bank along its length. Main aim of levees is to confine the river flood water within the cross section available between the embankments. This is provided for most of the rivers in India that are flood prone with low banks.

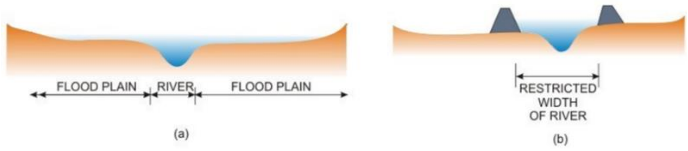


**Fig. 5: (a) River in original state during flood (b) river embanked during flood**

### 3.2 Guide banks or guide bunds

These are earthen embankment for guiding flood water near a structure constructed across a river (bridge, weir). These are the heavily built embankment in shape of a bell mouth on the both ends of the channel. By providing guide banks an artificial gorge section is created in which river can flow without causing abnormal velocities or scour and hence length of work to be constructed is reduced considerably.

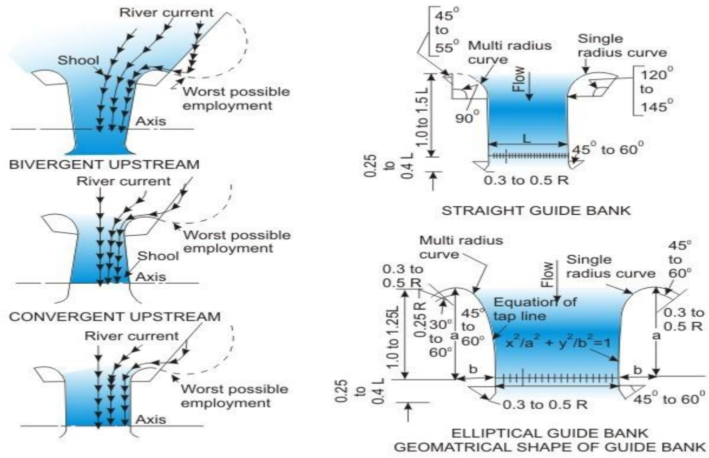


**Fig. 6: Types of guide banks and typical dimensions**

### 3.3 Groynes or spurs

These are the structure constructed transverse to the river flow and extend from bank into the river up to certain limit. They are also called as spurs. They guide the river, promote scour and deposition of sediment load to built up new river banks. They have the function of Training a river by attracting, deflecting or repelling and contracting the width of the river to promote navigation.

These have following classification criteria.

- Based on method and material:
  - (a) Impermeable
  - (b) Permeable
- Bases on height:
  - (a) Submerged
  - (b) Non submerged
- Based on function:
  - (a) Attracting
  - (b) Deflecting
  - (c) Repelling
  - (d) Sedimenting
- Special types:
  - (a) Denehey's T- Headed
  - (b) Hockey type

Impermeable spurs generally do not allow easy flow through them but the permeable allow restricted flow through them. Impermeable spurs are made of core of sand or mixture of sand and gravel and they are protected by stone or concrete block pitching.

 

Permeable spurs are generally made up of the wooden timber and seated some depth even below the maximum depth of scour and they are joined together in a framework. Erosive action is reduced due to velocity damping and this causes sediment near the groynes. These are temporary in nature and may get damaged due to shock and pressure generated by the floating debris.

Repelling Groynes has the angle 10° to 30° from the line normal to the bank. A local pocket of still water is formed on the upstream of the groyne and the suspended load that is brought by the river gets deposited in this pocket regime. The current coming into contact with still water area adjacent to the Groynes causes vertical eddies and deep scour. This deflect the water in a direction nearly perpendicular to itself.

Attracting Groynes points downstream in the direction of flow. They have 30° to 45° of inclination from the normal of flow line. They require heavy construction on the upstream face as they are exposed to frontal attack on the upstream face.

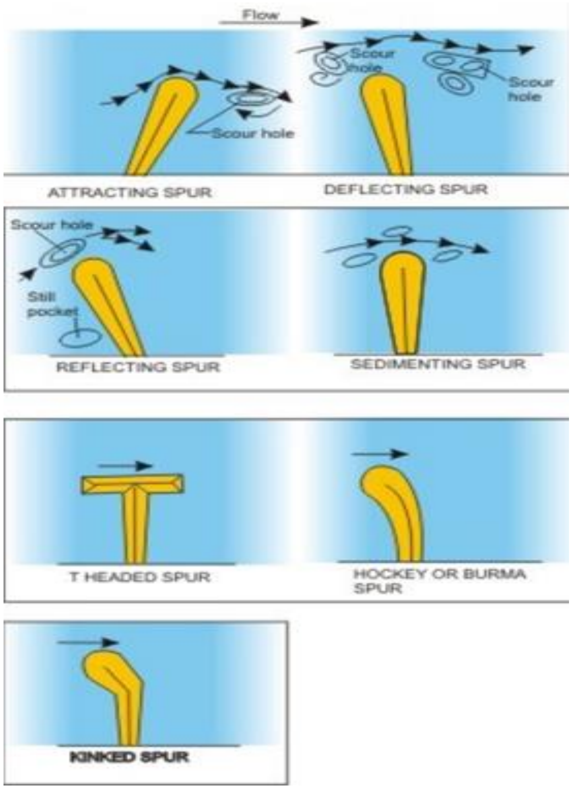


**Fig. 7: Different types of Groynes or Spurs**

(a) Layout of Groynes or spurs**:** Groynes are considered to be more effective when they are constructed in series as they create a pool of standing water between them which resist the flow of water and gradually accumulate silt.

(b) Length of Groynes**:** It depends on the position of the original bank line and the design normal line of the trained river channel. In easily erodible rivers the lengthy spurs may get damaged. So it is preferred to make shorter one and then gradually keep on increasing its length.

(c) Spacing of Groynes*:* Prime factor to decide the spacing is their length. 2-5 times of the length is used as the spacing distance at the convex bank and equal to length at concave bank is used. T- Heads are generally placed at 800 metre spacing with the T-Heads on the regular curve or a straight line.

(d) Design of Groynes or spurs:

- Top width**:** 3-6 metre at formation level.
- Free board*:* The top level of spur is worked out by giving generally a free board 1-1.5 metre above the highest flood level of return period of 500 years *or* the anticipated highest flood level, whichever is maximum.
- Side slopes: Maximum upstream slope 2:1, maximum downstream slope varies from 1.5:1 to 2:1
- Thickness of pitching: Calculated as per the formula T=0.06 Q1/3. Where Q is the design discharge in cumec. The thickness of the stone pitching need not be provided same throughout .it can be progressively reduced from the nose.
- Provision of filter: Filter satisfying the filter criteria are designed below the pitching at nose and on the upstream face for a length of 30-40 metre for the next 30 to 45m from the nose with thickness 20-30 cm. The thickness of the filter can be reduced to about 15 cm and beyond that it can be excluded.

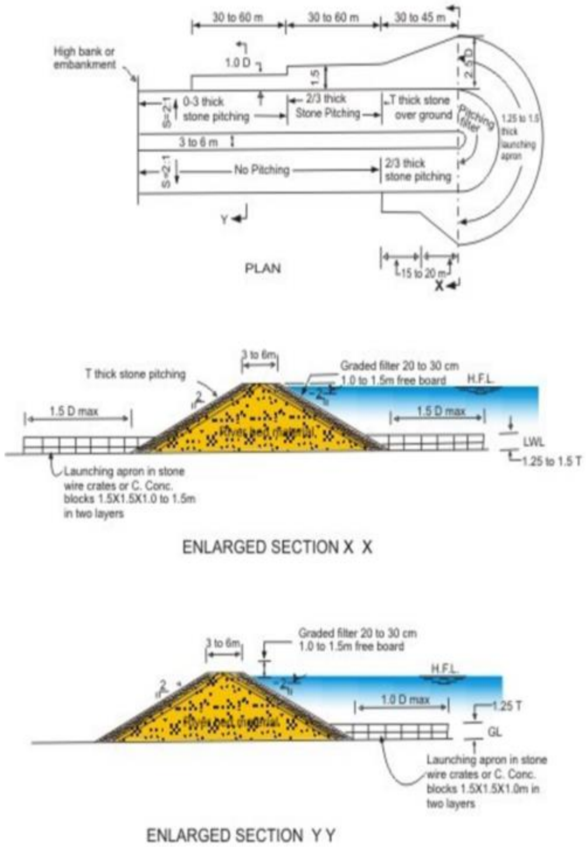


**Fig. 8: Typical layout and section of spur**

### 3.4 Cut-off Loops (Oxbow Lake)

Oxbow lake is formed when growing meanders intersect one another other and cut-off a meander loop leaving it without an active system. Oxbow shaped stream is formed due to extreme sinuosity phenomena of river.

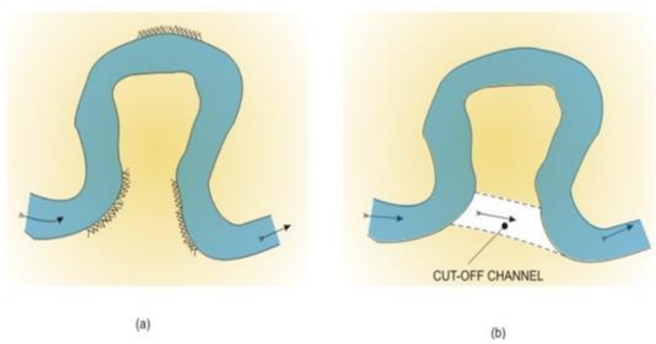


**Fig. 9: (a) Meandering river with possible threat to bank erosion (hatched portion) (b)An emerging cut-off channel**

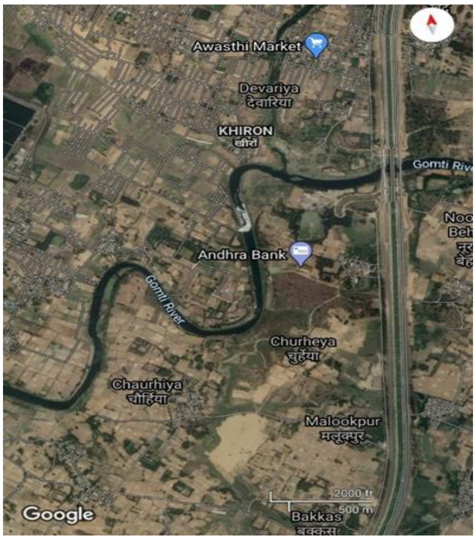


**Fig. 10: Satellite image of Gomti river near Indira Aqueduct**

### 3.5 Bank Protection Works

Bank Protection works include protection work that aims at maintaining stability of land against action of water. They can be direct type or indirect type. Direct type works are the work done on bank itself such as Pitching, Revetment. Indirect type works are not constructed on bank; they are the structures such ag Groynes or spurs which restrict the flow.

A launching apron of loose stone is provided at the toe of the bank to secure the toe of the wall against damage**.**

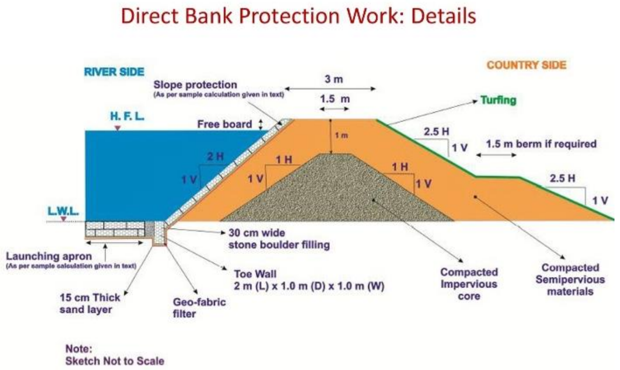


**Fig. 11: River bank protection work**

### 3.6 Pitched Island

Pitched island is artificially created in river. It is protected by stone pitching from all sides. It's a newly developed method. It is constructed with sand core and boulder lining. A launching apron is additionally provided to safeguard it from scouring.

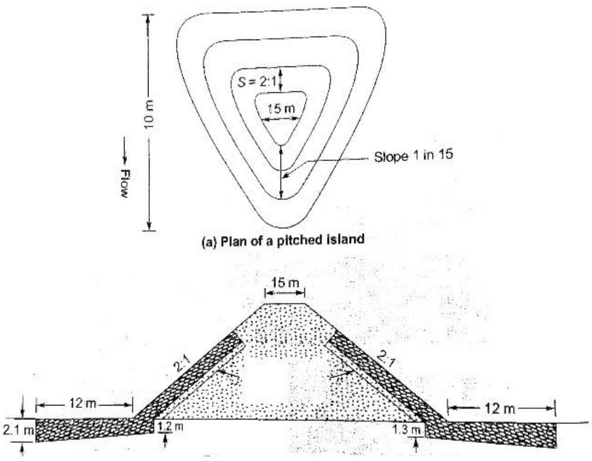


**Fig. 12: Pitched island**

## 4. DESIGN WORK

### 4.1 General Data

HFL =112m
Bed level =104m
Silt factor(f) =1.1
Discharge Q= 4200 cumec

### 4.2 Lacey's Perimeter

$$P = 4.75\sqrt{Q}$$
$$P = 4.75\sqrt{4200}$$
$$P = 307.83 \text{ m}$$

### 4.3 Design of stone pitching

Thickness of stone pitching is given by

$$T= 0.06 [Q]^{1/3}$$
$$T=0.06(4200)^{1/3}$$
$$T=0.968\text{m}$$

Providing thickness of T =1.0m
This can be kept 1m above of HFL i.e. 113m

### 4.4 Design of scour:

$$R= 0.47 (Q/F)^{1/3}$$
$$R= 0.47 (4200/1.1)^{1/3}$$
$$R=7.34\text{m}$$

Max. Scour = 1.25 R
=1.25x7.34
=9.18m
RL. At maximum anticipated scour
=112-9.18
=102.82m
Depth of max. Scour D=104-102.82
=1.18m
Length of Apron =1.5D
=1.5x1.18
=1.77m = let 2.0m

In curvilinear transition portion of guide bund
Max. Scour = 1.5R
=1.5x7.34
=11.01m
R.L. of max. Scour = 112-11.01
=100.99m = 101m
Depth of max scour D=104-101
=3m

### 4.5 Design of Launching Apron:

Length of apron=1.5D
=1.5x1.18
=1.17m =2.0m
Thickness of Launching apron
=1.9T
=1.9x1
=1.9 m =2.0m

## 5. CONCLUSION

River training work mainly rely on the kind of river, its characteristics of flow, its regime (area of flow). Different areas have different hydrogeological parameters hence one type of river training might not be effective on other regimes. Selection of river training work also depends on economy, social importance etc. A comprehensive planning and testing is required for the choice of methodology. Considering the hydrogeological, socio-economic conditions of site, the most effective method for river training at this site can be the provision of Bank Protection Works because in that area sinuosity of the river is nearly unity (relatively straight flow).

## 6. ACKNOWLEDGMENT

In the sense of great pleasure and satisfaction we present this project entitled River Training Works on Gomti River 3 K.M Downstream from Indira Canal Aqueduct. The completion of this project includes an invaluable support and contribution of numerous people.

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