River Training Works

By Dr. R. G. Patil, Scientist D

Central Water And Power Research Station,
Pune - 411 024
What is Training of River?

'River training' refers to the structural measures which are taken to improve a river and its banks. **River training** is an important component in the prevention and mitigation of flash floods and general flood control, as well as in other activities such as ensuring safe passage of a flood under a bridge.

Why is it necessary to Train a river?
Natural Problems

- Frequent changes in river course.
- Avulsion of one river into another.
- Heavy shoal formation - diversion of main current towards banks.
- Development of natural cut-off.
- Landslides in catchment - rise in silt load.
- Aggradation of river bed - high flood levels - Flooding
- Heavy erosion of banks by hill streams due to flash floods.
- River instability - change in bed slopes (seismic activity).
- Changes in river channels due to changes in rainfall pattern.
- Erratic behaviour of rivers in deltaic areas.
- Erratic behaviour of braided rivers.
- Navigational problems due to shoal formations.
- Formation of sand bars at river out-falls into sea.
- Changes in a river due to changes in its base level.
Anthropogenic Problems

• Degradation of river bed downstream of a dam or a barrage.
• Effects of constriction of river width.
• Effects of flood embankment on the regime of rivers.
• Effects of extraction of sand and boulders.
• Effects of spurs and bed bars of different types on river behaviour.
• Effects of inter-basin transfers of water on the regime of rivers.
• Effects of river bed cultivation and construction by farmers.
• Effects of dredging/channelization of river bed.
• Effects of pucca bathing ghats in big cities and places of pilgrimage.
• Effects of heavy urbanization along the river banks.
DIFFICULTIES OF RIVER BEHAVIOUR

• Bank erosion, Channel Course Change.
• Flood Protection.
• Aggradation/ degradation of channel bed.
• River Flow extraction/diversion.
• Bridging the river channel.
• Maintaining Navigable Channel.
Objectives of River Training

- Safe and quick passage of high flood
- Efficient transport of sediment load
- Make river course stable and prevent bank erosion
- Provide sufficient draft for navigation
- Prevent outflanking of a structure by directing the flow in a defined stretch of the river
Rivers are dynamic and continuously change their position, shape, and other characteristics with variations in discharge and time.

Stable River has different definitions for differing people.

<table>
<thead>
<tr>
<th>Role</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Navigation engineer</td>
<td>one that maintains adequate depths and alignment for safe navigation</td>
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<tr>
<td>flood control engineer</td>
<td>channel maintaining the ability to pass the design flood</td>
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<tr>
<td>local landowner</td>
<td>that does not erode the bankline</td>
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<tr>
<td>Geomorphologists and biologists</td>
<td>Erosion is simply part of the natural meandering process of stable rivers and would be perfectly acceptable in their definition of a stable river.</td>
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Stable River: Final definition

- River behaviour may be influenced by a number of factors.
- Schumm (1977) identified these as independent and dependent variables.
- Independent variables may be thought of as the basin inputs or constraints that cause a change in the channel morphology.
- Independent variables include: basin geology, hydrology (discharge of water and sediment), valley dimensions (slope, width, depth), vegetation (type and density), and climate.
- Dependent variables include: channel slope, depth, width, and planform.
- A channel that has adjusted its dependent variables to accommodate the basin inputs (independent variables) is said to be stable.
- An Unstable River causes erosion of bed and bank.
River training structures can be classified into two main categories:

- **Transversal protection structures** and
  
  *installed perpendicular to the water course*: Check dams, Spurs, Sills, Screen, bandals, Porcupines, Bank protection as a bar.

- **Longitudinal protection structures**.

  *installed on river banks parallel to the river course*: Levees or earth fill embankments, Concrete embankments, Revetments and rock riprap, sheet piles, etc

- **Other Protection Structures**.
  Sandbagging, Channel lining, Bamboo piles
Classification based on action:

Direct protection works and indirect protection works.

Direct protection works are the one which are placed directly over the portion that needs to be protected such as, Riprap over the erosion prone bank.

Indirect protection works are the one which modify the flow conditions to protect the erosion prone bank such as, spurs, vanes etc.
Sloping Bank Protection Work

NOTE:

1. SKETCH NOT TO SCALE
2. GEOFABRIC FILTER SHOULD BE CONTINUED FROM KEY, TOP OF BANK SLOPE, TOE WALL AND FURTHER UNDER LAUNCHING APRON

RAILWAY EMBANKMENT

Level = HFL+ Free board

CRATES OF SIZE
1.0 M (L) X 1.0 M (B) X 0.5 M (D)

EXISTING BANK LINE
BED BARS @ 30 M C/C SPACING AT AN ANGLE 75° TOWARDS UPSREAM CRATES OF SIZE 1.0 M (L) X 1.0 M (B) X 1.0 M (D)

LOW WATER LEVEL

TOE WALL SIZE
5.0 M (L) X 1.2 M (B) X 1.8 M (D)

EARTH FILLING

SAND FILLED HDPE BAGS

TWO ROWS OF STEEL/SALBALLA PILES

LAUNCHING APRON
CRATE SIZE 1.0 M (L) X 1.0 M (B) X 1.0 M (D)

STONE CRATES

15 CM THICK SAND LAYER
GEOFABRIC FILTER
30 CM THICK SAND LAYER

5 M RIVER CROSS SECTION

5 M
Bank protection works along with sleeper porcupines.
Direct Bank Protection Work: Details

- **RIVER SIDE**
  - H. F. L.
  - Launching apron (as per sample calculation given in text)
  - 15 cm Thick sand layer
  - Geo-fabric filter
  - 30 cm wide stone boulder filling
  - Slope protection (as per sample calculation given in text)
  - Free board

- **COUNTRY SIDE**
  - Turfing
  - 2.5 H
  - 1 V
  - 1.5 m berm if required
  - 1.5 m

Note: Sketch Not to Scale
Failure Process of Direct Bank protection Work/ improvement

Eastern Guide bund of Kosi Mahasetu.
Mining of Sand Near Direct Bank Protection Work

Note: Sketch not to scale
Bridge vent blocked by sediments brought by tributary of river swan – Sediments obstruction by check dams in tributories
Tributary Confluence streamlining

- Embankment top
- Turfing on country side slope - 2.5 H : 1 V
- SWAN RIVER
- Toe wall
- Slope on river side 2 H : 1 V
- Launching apron
- TRIBUTARY

Sketch not to scale
Discussion about Free board ???

(IS 10635: Freeboard requirements in embankment ...)

2014 Jhelum flooding Kashmir
Chennai flooding of 2015
Typical layout of River Training Measures used in barrage/bridge
Kosi Mahasetu at Nirmali, Bihar

Road cum Rail Bridge – U/S and D/s Guide bunds, extended guide bunds or afflux bunds
Alignment, layout are best decided based on model studies.

Original Proposal – Stage I

Modified Proposal with Afflux bund – Stage II

Modified Proposal with Afflux bund and reduced waterway- Stage III
Embankment or levees or stop bunds or encasing
SPURS or DYKES or Thoker
(STRUCTURES CONSTRUCTED TRANSVERSE TO FLOW)

GUIDELINES FOR SPURS

• 2 to 5 spurs are constructed in a battery.
• shouldn’t be used in narrow channels.
• could be permeable (may be submerged) or impermeable (non submerged).
• Height of spurs < the bank height (Kosi).
• Submerged spur height ~ 1/3 to ½ times the water depth.
• Flow constriction 20 % max or length of spur ~ 1/5 of river width and not less than 2-2.5 times scour depth on concave bank and 2.5 to 3 times on convex bank.
• Spacing – 4 to 5 times length
• Nose, u/s & d/s portion of shank needs protection
• Filter below launching apron essential.
• Model study to establish favorable flow conditions necessary.
Types of Spurs

An **Attracting** spur points downstream and attracts the flow towards its head and thus to the bank.

A **Deflecting** Spur is normal to the flow and diverts the flow at its head.

A **Repelling** spur inclines in upstream direction and diverts the flow away from itself.
Generalized flow pattern downstream of Kosi barrage for a discharge of 5,663 m$^3$/s after placing porcupine screens along active channels.
FLOOD PROTECTIVE MEASURES

Porcupines
Bamboo screen and permeable spur
Flow diversion using studs immediately d/s of barrage
STUDS

Short submersible boulder spurs.

Used primarily to slow down the rate of erosion when river is close to embankment and where spurs cannot be provided.

Kosi Barrage, Nepal

Guide Bund

Series of studs

Sluice

Spurs

Image © 2014 CNES / Astrium
Impermeable spur
Model of River Ganga u/s of Farakka
Flume model for study of spur protection works
Typical photograph of dry model after running the model for a discharge of 5,663 m³/s with porcupine units placed near the spur nose.
Spur on river Brahmaputra
Spur with Stone core
Spur with aprons

Geo-textile filter
Spurs in River Alaknanda

How not to disturb River/
not to construct
series of spurs constructed in river beas, H.P.
Bamboo Porcupines
Porcupines in action during floods
RCC Porcupine
Working principles of bamboo bandals
Stabilization of river bank with the bamboo bandalling
VANES

Structures designed to guide the flow away from an eroding bank line.

Can be constructed of rock or other erosion-resistant material.

Top of vanes are below the design water surface elevation and would not connect to the high bank.
Bottom Vanes for navigability improvement
River Alaknanda (Steep slope) HNBG University campus (2013 Flood)

Photograph showing vertical profile of the affected site from river bed

Damaged approach road, falling retaining wall and water supply line as on 27-06-2013

Photo 2: Rock outcrop at upstream left bank of erosion site.
River Beas near Manali – River Behaviour

Bridge near Palchan U/S of Manali

Chute Channel behaviour
River Yamuna at Paonta Sahib, near Gurudwara.

Plan of River

Upstream right bank erosion

Upstream right bank erosion
River Batta, Paonta Sahib, Himachal Pradesh

Batta River U/S and D/S of a bridge Aggrading/degrading, Grade control structures shall have d/s protection.  

Outflanking of Studs and failure  

Erosion of foundation due absence of launching apron  

If sufficient space is available, 1:2.5 or 3 sloping protection could be adopted. Else vertical wall protection is necessary.
How shoal formation Stops after the railway Bridge? Vanes could be used To disrupt the anticlockwise rotating vortex! VANES
How to select:
1. Direct
2. Indirect
3. Mix
4. -------

Thank you