STRUCTURAL MEASURES FOR FLOOD MANAGEMENT & OPTIONS

Dr. R N Sankhua
Director, NWA, Pune

1.0 INTRODUCTION

Legislative and administrative policies frequently cite two approaches – structural and nonstructural – for adjusting to the flood hazard. In this context, "structural" is usually intended to mean adjustments that modify the behavior of floodwaters through the use of measures such as dams, levees, and channel modifications. Structural alternatives for flood management include physical changes to the river environment and adjacent surroundings. For ease of discussion, the flood control of structures is divided between those in the floodplain, the floodway, and river channel. The floodplain encompasses roughly all the land at or below the 100-year flood elevation, but exclusive of the floodway and river channel. Structural alternatives for the floodplain may appear to be remote from the river, but are subject to floodwaters on occasion.
The structural measures for flood management/erosion control (may further be classified into long term measures and short term measures) which bring relief to the flood prone areas by managing the flood flows and thereby the flood levels are:

a) Creation of reservoir;
b) Diversion of a part of the peak flow to another river or basin where such diversion would not cause sizeable damages;
c) Construction of flood embankments;
d) Channel improvement; & Watershed management;
e) Construction of spurs, groynes, studs etc.;
f) Construction of bank revetment along with launching apron;
g) RCC porcupines in the form of screens, spurs, dampeners etc.; and
h) Vetivers, geo-cells, geo-bags etc.

The structural measures for flood management mentioned above are designed as per BIS codes. However, many works like RCC porcupines, Geo-textile materials, vetivers etc are not covered in the existing BIS codes. Here in this lecture we will have discussions on some options of structural measures of flood management.

1.1 Bank Protection

The following are seven main classifications of bank protection:
1) Pipe-and-wire fence
2) Riprap (dumped rock)
3) Rock paving (hand-placed)
4) Wire and rock mattress
5) Gunite slope paving
6) Reinforced concrete open channel
7) Reinforced concrete closed conduit

1.2 Causes of Levee Failures

The following six as possible causes of levee failures, and their application to the subject project:
1) Overtopping

2) Internal erosion (piping)
3) Slides within the levee embankment and/or foundation
4) Surface erosion
5) Undermining of bank protection (scour)
6) Channel configuration

2.0 FLOOD-PROOFING ALTERNATIVES

Flood-proofing may involve changes to the structures themselves or changes to the surroundings while leaving the structures alone. Structural changes include relocation, elevation, and encapsulation/waterproofing. Changes to the surroundings may include flow diversion and the construction of dikes or levees.

Relocate / Move to higher ground

Structural Measure

Relocation involves either physically moving the structure in the floodplain to ground with an elevation above the 100-year flood level, or demolishing the structure and rebuilding a similar structure above the 100-year flood level. Moving a structure requires that the structure be in sound condition to be jacked up and transported to higher ground. This is a very expensive alternative and one not used very often.

Impact on Flood Control

Since the alternative removes an obstruction to flood flow in the floodplain during the flooding event, the impact has either negligible impact or a positive impact, depending on the footprint of the structure removed. It also means there is no longer a structure in the flood plain needing protection, so other flood or erosion control measures such as levees or riprap may also be removed. This in turn may allow the river greater latitude during floods and may reduce flood hazard up and down the river.

Impact on River Process

Relocation of structures out of the floodplain would benefit river processes. River channel dynamics require the ability of systems to remain connected with the floodplain, an area that receives the floodwaters of the river at high flows. In the River, the majority of sediment is transported during flood flows. Levees that have been constructed to protect structures constrict the flow of the river, and do not allow connection to the floodplain or to side channels that convey floodwaters. By removing human made structures from the floodplain, including the levees and other structures that are intended to protect human property from flooding, uninhibited use of these areas would be re-established and the natural migration of the river would be more likely to occur in the channel migration zone. River bends can and do migrate across the floodplain over time. The removal of structures from the floodplain would allow natural river processes to occur without causing damage, or risk of damage to human made structures.

Elevate

The structure can be elevated onto either a new pad foundation or onto piles.

Structural Measures

- Pad foundation

- Elevating a structure onto a pad foundation can be done by building the pad adjacent to the structure and relocating the structure (jack-up and transport) to the pad, or jacking up structure and filling in under the elevated structure.
- Pile foundation

Elevating a structure onto piles can be done by installing the piles adjacent to the structure and relocating the structure (jack-up and transport) to the piles, or jacking up structure and drilling piles under the elevated structure, then lowering the structure onto the piles.

Impact on Flood Control

The impact of the flood control depends on the size of the pad relative to the original foundation of the structure. If the pad is similar in size to the original foundation of the structure, the pad will not change the impacts on flood control. If the pad is larger than the original structure foundation, the pad may restrict flood flow some small percentage and negatively impact flood control by elevating the flood elevation upstream. Elevating a structure onto piles can be done by installing the piles adjacent to the structure and relocating the structure (jack-up and transport) to the piles, or jacking up structure and drilling piles under the elevated structure, then lowering the structure onto the piles.

Impact on River Process

Elevating structures above the floodplain would have mixed effects on river processes depending on the structural approach used. An elevated pad foundation would not offer direct improvement to river processes because the structure would still disrupt the natural use of the floodplain. The removal of levees that may occur with the elevation of structures would offer some improvement to river process function. An elevated pile foundation would allow for some improvement to river process function in that the floodwaters would be able to flow through and around the piles, which would cause less overall disturbance to natural floodplain processes. The indirect effects of this alternative measure would be the same as those for the pile foundation. If protection measures such as levees could be removed as a result of the elevation of the structure, than natural river process function would likely improve.

Encapsulate/Waterproof Below Flood Level

Structural Measure

This alternative involves either installing watertight doors and windows in the structure below the 100-year flood elevation or strengthening and wrapping that portion of the structure in water proof film.

Impact on Flood Control

Waterproofing structures within the floodplain will have no direct effects on the frequency or duration of flooding. This measure will decrease the risk of potential damage to property. The impact depends on the size of the encapsulation material relative to the original foundation of the structure. If the structure is just wrapped in a waterproof film material and results in a section similar in size to the original foundation of the structure, this alternative will not change the impacts on flood control. If the encapsulation results in a section larger that the original structure foundation, it may restrict flood flow some small percentage and negatively impact flood control by elevating the flood waters upstream.

Impact on River Process

Waterproofing structures below the flood level would have no direct improvements on river processes. The structures would remain in the floodplain, and there would be no increase in the ability of the floodplain to dissipate floodwaters. The protection provided to structures from waterproofing measures is unlikely to allow complete removal of protection measures such as levees. If the levees and other flood protection measures remain in place, the indirect benefits to river process function from waterproofing structures are likely to be less than the potential indirect benefits from structure elevation, and much less than those from the removal of structures from the floodplain.

2.1 Levee/Floodwall/Dike Around Foundation

Structural Measure

This alternative involves constructing a levee or floodwall around the foundation of the structure. The protection can be either temporary or permanent and typically extend up to the 100-year flood elevation. A levee typically consists of a trapezoidal-shaped section of earth-material with a plant, concrete-block, or riprap scour protection facing. A floodwall is typically a vertical wall constructed of man-made material. A levee or floodwall is usually with a few feet of the structure foundation.

Impact on Flood Control/ River Process

Levees, floodwalls, berms, and dikes all provide flood control to structures inside the barriers by raising the height to which the water has to rise before spilling into the structure area. These measures provide protection to one structure or set of structures, but may be increasing the risk to other structures by occupying space on the floodplain. The barriers also may increase the potential damage to the very structures they are protecting if the barrier should fail. In the event that one of the barriers fails, the resultant flood waters inundate the surrounding area to a much greater extent than would have occurred without the water height provided by the barrier holding back the water. Levees, floodwalls, berms, and dikes all have similar impacts on river processes. These structures would be used to surround a structure on the floodplain and prevent floodwaters from damaging the structure. However, additional floodplain space would be occupied by the levees or other protection structures, so the ability of the floodplain to process floodwater would be reduced. The disconnection of the river from a larger part of the floodplain would have a negative effect on the development of natural river processes.

2.2 Divert Flow

Off-stream Detention Pond

Structural Measure

This alternative involves constructing a detention pond on the floodplain or beyond, but away from the floodway, and cutting a channel to it. Flood flow is channeled to the detention pond when the flood level reaches a specified elevation, but less than the 100-year flood.

Impact on Flood Control/ River Process

During a flood, floodwaters are diverted to the detention pond and impacts downstream are improved. The detention pond stores some of the flood water lessens the amount water the river system has to carry.

Creation of an artificial off-stream detention pond could alter river processes by reducing the level of flow downstream from the pond. Reduction of flows would reduce the sediment transport capacity in downstream reaches. Reduction of sediment transport could lead to channel aggradations in downstream reaches, and deposition of fine sediment. Additionally, diversion of flow into an off-stream detention pond includes the risk of more river flow than anticipated entering the pond, and the potential for river channel avulsion.

Abandoned Channel Restoration / Split Channel

Structural Measure

This alternative involves constructing a channel from the existing river channel to an abandoned or less-used river channel. This alternative is available only in meandering and braided sections of the river. It may require some further excavation/dredging of the previously abandoned channel to accommodate flood volumes.

Impact on Flood Control/ River Process

During a flood, floodwaters are diverted to the abandoned channel and impacts downstream are improved. The abandoned channel stores some of the flood water and lessens the amount of water the river system has to carry. In effect, this diversion would increase the flood conveyance of the main stem, and allow flood waters to recede gradually as they returned from side channels or abandoned channels to the main channel, or percolated into the groundwater.

Reconnecting an abandoned channel to the mainstem channel could have various effects on river process, depending on the current status of the mainstem channel. If the mainstem channel has been extensively affected by human efforts to channelize the river through diking and bank hardening techniques such as riprap, reconnection with an abandoned channel may allow the river system to regain more of its natural sinuosity and allow the dissipation of excess energy that had been created by channelization. Identifying areas with existing human-made barriers would be beneficial in selecting sites for reconnection with abandoned channels and other off-channel habitats.

Diversion of flow into a side channel, abandoned channel, or newly created channel can have a variety of effects on river processes. Naturally, new river channels are often created by avulsions or meander bend cut-offs. The incorporation of deflectors or wood structures to divert flows at high water may increase the rate of creation of new channels that would have occurred naturally, only at a slower pace. woody debris often plays a role in channel avulsions and diversion of flows to side channels during peak events. If there is a lack of woody debris in the river system, artificial placement of log jams or other structures may be necessary to maintain channel diversity. However, the artificial diversion of high flows could alter the channel forming processes that occur during high flow events be reducing the amount of flow in the main channel. The main work of sediment transport occurs during high flow events, and if those flows are diverted into other channels, sediment may begin to aggrade in the main channel.

3.0 FLOOD WAY

The floodway includes the active channel and the river banks up to the level of bankfull flow. The floodway is the portion of the land adjacent to the river that enables flood waters to pass without increasing flood depths upstream, but is exclusive of the river channel. A floodway usually has a small bank either cut by previous floods or a natural levee deposited by overflow of previous floodwaters.

3.1 Reduce bank slope

Structural Measure

Bank reduction involves excavating or cutting the bank back at a gentler slope than currently exists. The process usually includes replanting or surfacing the bare bank slope with some form of scour protection.

Impact on Flood Control/ River Process

Reducing bank slopes may increase the flood conveyance of the channel by increasing the bankfull width of the channel. The reduced bank slope will increase the surface area of the bankfull channel and therefore, the volume of the channel at bankfull flow. If banks with reduced slopes have time to revegetate, bank stability will likely increase and natural channel containment will occur. Water velocity will decrease in areas that have vegetation, which increases channel roughness. Reduced water velocities will further reduce the erosive force of the water, but may also reduce the capacity of the channel to convey high flows without over topping its banks. However, bank vegetation is likely to trap sediment from high flows, and banks may build up further as a result of floods. The long-term effectiveness of reducing bank slopes is a site-specific issue that is difficult to generally predict.

Reduction of bank slopes will reduce the potential for erosion of river banks. This reduction in erosion potential will have several effects including: reducing delivery of sediment to the channel, reducing recruitment of large woody debris, and reducing channel migration. If the channel is experiencing excessive erosion and bank failure, reducing bank slopes may help to stabilize the banks to allow them to revegetate. However, the natural process of erosion is vital to the dynamic balance of river systems, and reducing bank slopes affects this process. Bank erosion is the primary driver behind the delivery of woody debris to river channels, and without natural erosion, in-channel levels of woody debris will decrease, reducing channel complexity.

3.3 Reinforce Bank

Bank reinforcement involves adding material to the bank face to increase the bank stability, protect the bank from river scour, or both.

Bioengineering

Bioengineering refers to the use of plants or planting to stabilize the bank and increase its ability to resist scour by river and flood flows.

Structural Measures

Hydroseeding includes various methods of applying a liquid mixture of water, fertilizer, and plant seeds to the bank. Over time, the plants grow and establish a mature root system. The plants provide a surface roughness to slow flood flow. The plant roots entangle with the soil and increase the soil mass resistance to scour.

Hand plant

Hand planting involves the insertion (planting) of saplings or mature plants into the riverbank. An advantage of hand planting is that the plants are immediately available to provide flow reduction and scour protection. Also, a variety of plant sizes can be introduced at the same time.

Plant mats

Plant mats are blankets or meshes of natural or synthetic material containing fertilizer and plant seeds. The mats are rolled onto the riverbank and then anchored or stapled into the bank. Water can be sprayed onto the mats to start the growing process or fluctuation in the river level can be used to start the growth

Impact on Flood Control/ River Process

Bioengineering in not likely to reduce the frequency or duration of flooding, but may help prevent banks from failing and accelerated channel migration. These measures are designed to stabilize banks without drastically increasing water velocity, which could lead to channel downcutting or excessive erosion. Bank stabilization will not control floods, but may help reduce property damage and loss.

Bioengineering allows failing banks to be reinforced in a manner that is more reflective of natural processes than traditional “hard” engineering practices. The incorporation of organic materials into the design, as well as the use of vegetation to increasingly stabilize the banks through time, provides a longer lasting, more natural treatment that requires less long-term maintenance. The organic materials mimic the natural inputs of the riparian environment, such as woody debris . Vegetation used to stabilize banks will increase in root strength over time, and flood adapted species are likely to thrive in high flows. As vegetation increases, channel roughness may increase and water velocity may decrease. This effect is similar to the long-term effects from reduction in bank slope.

Gabions

Gabions are wire-mesh baskets filled with locally available stones, usually in the 2-inch to 6-inch range. The baskets come in block or mattress (flat) form. The former can be stacked to form a stepped wall. The latter can be laid on gentler slopes to form a surface covering of scour protection.

Impact on Flood Control/ River Process

Like bioengineering, gabions will not affect the frequency or duration of flooding, but may provide protection to streamside property and prevent bank erosion. However, unless combined with vegetation to re-enforce the strength of the structure, these rock filled baskets will deteriorate over time, and will need to be replaced to maintain their level of function.

Gabions are often used to protect banks in areas where erosion and channel migration are excessive, or to protect property on the river banks. These hard structures can prevent erosion and decrease the delivery of fine sediment to downstream habitat. Gabions are designed to deflect river flow and provide an erosion resistant armor for banks. The deflection of flow may redirect erosion to other areas in the river channel. Gabions, like berms and dikes, may also increase the velocity water flow and decrease backwater habitat available for fish.

Concrete-block mattresses

Structural Measure

Concrete-block mattresses consist of concrete blocks about 12 inches by 12 inches by 9 inches laced together with synthetic or steel rope. The blocks are interlaced to for a flexible pad or mat of blocks that resist erosive flood forces. The blocks come in closed and open (holes through them) form. The latter form allows soil to be placed in the openings and plants to be grown in the soil, thereby providing for a softer visual impact. The mattresses are placed on sloping banks and anchored into the underlying soil. The concrete-block mattresses armor the floodway bank and prevent erosion of the floodway bank or surface.

Impact on Flood Control/ River Process

Bank hardening structures, such as concrete-block mattresses would affect river processes by restricting the natural migration of the channel. This restriction would reduce the overall sinuosity of the channel over time and prevent the creation of meander bends and additional off-channel habitat. The mattresses would channelize the flow and could increase velocity by decreasing bank roughness. At the location of the structures, bank erosion would be decreased or eliminated, but further downstream, increases in flow velocity may increase downstream erosion. Localized decreases in bank erosion may decrease sediment and woody debris levels downstream. However, if there are downstream increases in flow velocity, sediment and would input could increase in those areas.

Riprap/Geotextiles

Riprap is an exposed layer of well graded stone or rock placed on a sloping bank face to resist erosive flood waters. A synthetic geotextile is usually placed between the riprap and underlying soil to act as a filter, thereby preventing the piping of soil through the rock and relieving hydrostatic pressure. Riprap has been commonly used to protect roads and other structures from erosion and channel migration. These measures do not alter the frequency or duration of flooding, but provide longerterm protection to structures or property on river banks. Riprap may also increase channel conveyance if water velocity or bank heights are increased.

Impact on River Process

Riprap has similar effects on river processes as gabions, however, riprap is likely to affect river processes for a longer time period, and will not provide spawning size gravel to downstream fish habitat. Riprap may also increase the channel velocity more than gabions depending on the design and channel roughness. Increased channel velocities, as discussed earlier are likely to cause increased erosion downstream and may cause channel downcutting. Riprap re-enforced banks are highly unlikely to deliver woody debris to channels or allow for natural channel migration. The artificial constriction of the river is likely to cause changes in the dynamic equilibrium downstream.

Cable trees

Structural Measure

Trees, shorn of leaves, are placed parallel to and along the base of the bank. The trees are held in place by wrapping a cable around the tree and attaching it to an anchor buried in the bank or to large vegetation along the bank.

Impact on Flood Control and River Process

Cabled trees may increase the frequency and duration of flooding if used extensively. Increasing the roughness of the channel is likely to reduce flow velocity, thereby reducing the level of conveyance of the channel. If flood conveyance is reduced, the river may flood more frequently, and flood waters may remain out of banks for longer periods of time.

Trees are anchored or cabled in place to reduce erosion and to slow water velocity. These trees increase the channel roughness as the water interacts with the branches of the trees. Sediment is deposited as the water velocity slows, and erosion of the banks is prevented where the trees are cabled or otherwise anchored. This measure will slow overall water velocity and tend to reduce sediment transport. Additional wood may also be racked on the cabled trees which may increase the size of the channel obstruction and direct flow against the opposite bank. In this manner, cabled trees may increase the migration of the channel and deflect erosion problems to other banks.

Anchor Logs/Root Wads

Structural Measure

Logs, with all limbs removed except the root wad, are placed parallel to and along the base of the bank. Each log is held in place by a cable or chain wrapped around or through the log, and the cable or chain is attached to an anchor buried under the log.

Impact on Flood Control andRiver Process

Anchor logs and root wads, like cabled trees, increase the roughness of the channel and are likely to decrease the flood conveyance of the channel, but may provide protection to riverside structures or property by re-enforcing bank stability. As the flood flow recedes, the logs can trap sediment, which eventually supports natural vegetation growth; and this can slow subsequent floodwaters near the boundary layer.

Anchor logs and root wads have many of the same effects as cabled trees on river processes, however, they are likely to increase in size over time as new wood is recruited to the structure. Root wads may be more likely to retain additional wood that floats down the channel due to the complexity of their structure and the strength of roots versus branches.

Geogrids

Structural Measure

Geogrids are synthetic (plastic) mesh strips that form open hexagons when laid out on the surface of the ground. The hexagons are filled with gravel. Grasses or sod can be grow over the gravel. The geogrids provide a more stable surface cover and reduce the potential for erosion of the bank

Impact on Flood Control andRiver Process

Geogrids, like other bank reinforcement measures, do not alter the frequency or severity of flooding, but do provide localized bank protection to prevent bank failure or structure damage. The growth of vegetation may increase channel roughness, but is unlikely to slow the water velocity to the point of increasing flooding.

The effects of geogrids are likely to be very similar to the effects of bioengineering discussed earlier due to the use of vegetation to reinforce the mesh. The grass and other plants that grow in the mesh are likely to increase in root strength over time, and provide bank stability, however, are not likely to significantly increase channel roughness, or to slow the water velocity. As with other bank protection measures, this approach will locally decrease bank erosion and sediment input, but may transfer those problems to downstream reaches. woody debris recruitment would locally be decreased due to the prevention of bank erosion, but may increase in downstream reaches if the erosive force of the water is transferred to other areas of the channel.

3.4 Bridge Replacement

Structural Measure

Narrow bridge abutments can be replaced by wider spaced abutments by replacing the existing bridge with a longer bridge, thereby increasing the width between abutments. The deck of the bridge can also be raised to a higher elevation.

Impact on Flood Control and River Process

The wider spaced abutments allow a greater amount of flood water to pass at lower velocity and pressure and they reduce the elevation of floodwaters between the abutments.

Bridge replacement may allow for the functionality of natural river processes to increase in areas where the channel has been constrained by bridge piers. Channel constrictions at bridge and road crossings often cause increases in water velocity downstream of the bridge or road crossing. These constrictions may also cause backwaters to form upstream of the constriction. Undermining of the bridge piers may occur if water flow is forced inside of an undersized bridge structure, or channel migration advances under the constructed piers. Downstream or localized effects from bridge construction may not be realized until decades after the bridge is constructed.

3.5 Levee and Dike Setback

Structural Measure

Some levees have been placed at the edge of the river's bankfull zone, cutting off side channels and reducing the river's floodway to a narrow zone. Levees and dikes can be set back to some higher point, perhaps as far back as the prehistoric floodplain line, or can at least be set back to allow a wider river meander and channel zone within the flood plain.

Impact on Flood Control and River Process

Moving these levees back into the floodplain allows the river more room to meander and more volume capacity during high flows. Setting back levees leaves the lands between the new levee location and the old one fully susceptible to flooding, but does a better job of protecting structures behind the levee because the river is less likely to overtop the levee, even in very large flood events.

Levee setback is one of the most effective ways to restore river process. It allows the river more of its historic channel and floodway, often allows access to side channels during both high and lower flows, and allows the river its natural meander zone. All these measures improve the river's ability to carry large volumes of water during flood events and to re-establish a more natural riparian community.

4.0 RIVER CHANNEL

4.1 Detention Pond/Reservoirs

Structural Measure

A detention pond is created by constructing a weir or low dam across the river thereby impounding a portion of the floodwaters, and possibly excavating the river bank to widen the river immediately upstream of the weir or dam. Flood flow is regulated by the height of the weir or dam, and the width and elevation of the outlet.

Impact on Flood Control and River Process

Detention structures in river channels have been used in flood control nationwide. These structures can effectively ameliorate high flows and release water slowly downstream after flood events. Impacts may include reduction in river flow downstream, slowing of the river flow velocities in the detention pond, and inundation of more of the river valley upstream.

Detention ponds or reservoirs disrupt the natural flow of rivers through the channel. The dam structure used to create the pond prevents the downstream movement of water, sediment, and wood, as would occur in a natural river system. The effects of dams on river process are extensive and well documented. The disruption of river flow creates imbalance in the dynamic equilibrium of the system and significantly alters the hydraulic processes of erosion and deposition, which changes the sediment transport regime. Water flow below the detention pond or reservoir is likely to be much lower than above the dam, as water is held back behind the dam. Dams used for flood control eliminate the natural high flows that help to create the features of a natural channel. Changes in water temperature can also be significant if water is released from the bottom of the dam. The reservoir upstream of the dam will generally have little to no current, and will collect all of the sediment and woody debris that the river carries from higher in the watershed. The channel below the dam will consequently be sediment and wood starved, which could lead to higher rates of bank erosion downstream.

4.2 Sediment Trap/Mining

Structural Measure

A sediment trap is constructed by excavating or dredging a depression in the bottom of the river. The dimensions of the sediment trap are optimized by a careful assessment of the sediment load in the river during a flood. The trap will need to be mined (sediment removed) after each major flood event to be efficient. The latter usually requires the construction of haul roads and an excavator pad adjacent to the trap for cleaning out the trap.

Impact on Flood Control and River Process

In-channel sediment traps or gravel mining can be used to reduce the amount of sediment in the channel and increase the channel volume and flood conveyance. The removal of sediment may improve flood conveyance in the short-term, but sediment transport processes will continue to bring sediment downstream, and repeating the sediment removal is likely to be required.

Gravel mining within the river channel would significantly alter natural river processes. The active removal of sediment from the channel will change channel morphology, which will affect the interaction of water flow with the bed of the channel. Removal of sediment from the river may cause a change in channel gradient, which would cause further changes in gradient upstream and downstream. If gradient is increased in one location, a "nick point" could form at which the sudden increase in gradient causes the channel to re-adjust by headward erosion in the bottom of the channel. At the nick point, the water flow erodes at the channel bed to a point upstream where the gradient stabilizes, or where the substrate is resistant to erosion, such as a bedrock channel bottom.

4.3 Anchor Logs

Structural Measure

Logs, with all limbs removed except the root wad, are placed at various angles across the bottom of the river. Logs can even overlap. Each log is held in place by a cable or chain wrapped around or through the log, and the cable or chain is attached to an anchor buried under the log

Impact on Flood Control and River Process

Anchor logs will not prevent flooding, but may provide protection to eroding banks or other sensitive areas that need protection from erosion. If the logs do slow the water velocity significantly the total flood conveyance at the location of the logs may be reduced. Anchored logs can create quiet pools in the river channels. They can trap sediment which modifies the configuration of the river channel(s).

Anchor logs place in the channel would likely have many of the same effects on river processes as those placed along the banks. These measures would generally increase the roughness of the channel, slow water velocity in local areas, and may cause a scour pool to be formed where the flow interacts with the log.

Impact on Flood Control

Anchor logs will not prevent flooding, but may provide protection to eroding banks or other sensitive areas that need protection from erosion. If the logs do slow the water velocity significantly the total flood conveyance at the location of the logs may be reduced. – Anchored logs can create quiet pools in the river channels. They can trap sediment which modifies the configuration of the river channel(s).

4.4 Deflector Structures

Deflector structures are constructed to reroute water flow in the river.

Structural Measures

Vanes are vertical panels placed in the river channel to divert flow in a prescribed direction. The panels are typically made of steel or concrete. They are held in place by piles or by having the lower half of the panel buried in the river bottom.

Spur dikes

Spur dikes are built to extend from the river bank into the river channel, usually at an angle to the river flow. Spur dikes are usually constructed of rock; but steel sheet-piles, concrete panels, and lines of closely spaced timber piles have been used.

Impact on Flood Control and River Process

Spur dikes and vanes serve to redirect river flow, but do not change the frequency, severity, or duration of floods. These structures can provide protection to river side structures and property that could be at risk of flood damage, or failure due to bank erosion.

Deflector structures such as vanes and spur dikes provide erosion protection to banks and divert flow away from sensitive areas. The structures extend out into the current and force the water flow away from the bank. There may be additional downstream affects from this flow redirection that could affect river processes. Whenever water is redirected, the force of that water affects other areas within the channel. The redirection of flow by spur dikes is unlikely to dissipate the flow energy of the current. The re-directed flow may come into contact with banks downstream, and the remaining energy may increase downstream erosion rates. Vanes may allow more of the water to pass through the structure and are likely to allow more energy to dissipate. The potential for downstream erosion problems with vanes is less than that for spur dikes.

4.5 Flow Realignment

Structural Measure

Flow realignment involves digging new, and possibly deeper, channels in the river bottom with a different alignment than the existing channel(s).

Impact on Flood Control and River Process

Flow realignment may alter the frequency and severity of flooding if the channel is changed to increase the flood conveyance. Flow realignment can also be used to re-direct flows to provide additional protection to structures or property along the river

Flow realignment involves a major restructuring of the local channel morphology at the treatment site. Using this measure removes the influence of natural river processes from the reach and creates an alternative structure for the river channel and hydraulics. The local impact on river processes is significant, and the larger upstream and downstream effects may or may not be significant depending on site conditions. Flow realignment is an intrusive measure that requires significant use of equipment and generally involves movement of large amounts of sediment. Downstream effects to sediment levels are likely to be considerable during and immediately after construction.

4.6 Channel/Bed Dredging

Structural Measure

Channel bed dredging involves dredging existing river channels to a deeper elevation.

Impact on Flood Control and River Process

Channel dredging would increase the channel capacity and thereby, increase the flood conveyance of the channel. This increase in capacity would likely reduce the frequency, duration, and severity of flooding. Removal of sediment from the channel bed is likely to alter the sediment transport regime of the river.

4.7 Chevron Dams

Structural Measure

A chevron dam is a V-shaped, low height weir built across a river channel, with the V pointing downstream. The top of the V slopes downward from the arms to the center of the V, thereby diverting flow to the center of the channel

Impact on Flood Control and River Process

Chevron dams will not alter the frequency or severity of flooding. These structures may provide protection from bank erosion at low to moderate flows, but are unlikely to provide significant protection at high flows. At higher flows, the structures are at risk of being undermined or of having the river flow escape around the sides of the structure eroding the connection between the structure and the bank. Chevron dams can cause vortex shedding by the flood flow and increase the potential for erosion immediately downstream

Chevron dams are used to concentrate flow in the center of the channel to prevent the erosion of banks along the sides of the channel. These V-shaped structures guide river flow into the thalweg, or deepest part of the channel, and prevent localized channel migration. The prevention of channel migration has associated effects such as decreasing channel complexity and backwater habitat, prevention of woody debris recruitment, and increasing water velocity. The increase in velocity that may be caused by chevron dams could lead to additional erosion downstream or downcutting of the channel.

4.8 Gravel Bar Scalping

Structural Measure

Gravel scalping involves excavating or dredging the upper few inches or feet of coarse material on the gravel bars in between the braided river channels. Less material between the river channels can lower the flood level downstream.

Impact on Flood Control and River Process

Scalping of gravel bars, like other sediment removal techniques, is likely to increase the volume of the river channel, and thereby, increase the potential flood conveyance. The increased channel volume may decrease the frequency and duration of flooding.

Gravel bar scalping would have many of the same effects as gravel mining or dredging of the channel. Removal of sediment may affect the sediment transport process by decreasing the bedload available for transport. Gravel bars are often the sources of spawning gravel that is transported downstream to spawning beds at higher flows.

3.9 Bridge Approach Retaining Walls

Structural Measure

Gabions

Gabions are wire-mesh baskets filled with locally available stones, usually in the 2-inch to 6-inch range. The baskets come in block form and can be stacked to form a stepped wall.

Ecology blocks

Ecology blocks are approximately 3 feet by 3 feet by 6 feet concrete blocks with slots in the top and bottom to provide some interlocking of the stacked blocks. The blocks are placed one on top of the other in a staggered pattern to form a near vertical wall.

Steel sheetpiles

Sheetpiles are preformed panels of steel that interlock along the long edge and are driven into the river bank or channel. Because of the play in the interlock, the panels can form a curvilinear wall Concrete panels/H-soldier piles. Vertical concrete panels are attached to steel rods or cables on the backside of each panel. The rods or cables (tiebacks) are run horizontally back to anchors buried in the riverbank.

Concrete panels/tiebacks

Vertical concrete panels are attached to steel rods or cables on the backside of each panel. The rods or cables (tiebacks) are run horizontally back to anchors buried in the riverbank.

Impact on Flood Control and River Process

Increasing the stability of bridge abutments does not alter the flood frequency, duration, or severity, but may reduce potential damage to the bridge structure. The addition of abutments into the channel will decrease the water flow capacity of the channel, and may raise the level of flow at the bridge due to further constriction of the channel width. The sheetpiles will compress the flood flow and increase the flow velocity; however erosion by the floodwaters will be reduced.

Construction of retaining walls for bridge abutments is likely to constrict the river at the bridge crossing. This constriction will decrease velocity upstream of the bridge and potentially increase velocity downstream of the bridge. The increase in water velocity on the downstream side of the bridge may accelerate erosion, and cause channel instability farther downstream. The constriction would also prevent natural channel migration, and the associated effects of loss of habitat complexity, backwater habitat, and woody debris recruitment.

References

1. MoWR Guidelines of Flood Management Programme.
2. Sankhua R N, lecture notes on Flood management, NWA Pune