Construction Materials For Coastal Structures And River Bank Protection

Purpose of Coastal Structures and River Bank Protection

- Coastal structures and river bank protections are engineered solutions designed to withstand natural processes such as erosion, water flow, and saltwater corrosion. Their primary goal is to preserve shoreline stability, protect human settlements, manage water resources, and maintain ecological balance in coastal and riparian zones.

Challenges Faced

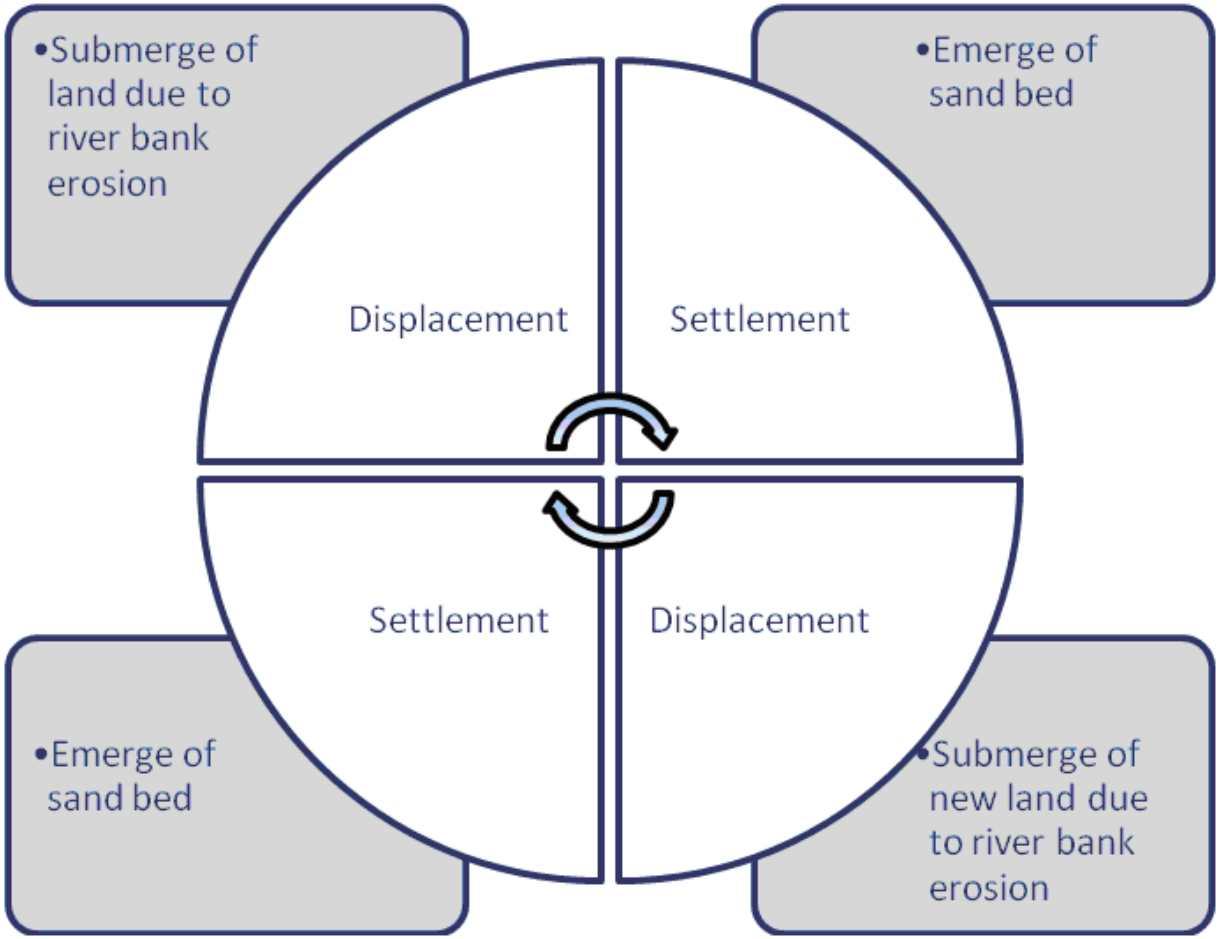
These structures must endure various environmental challenges:

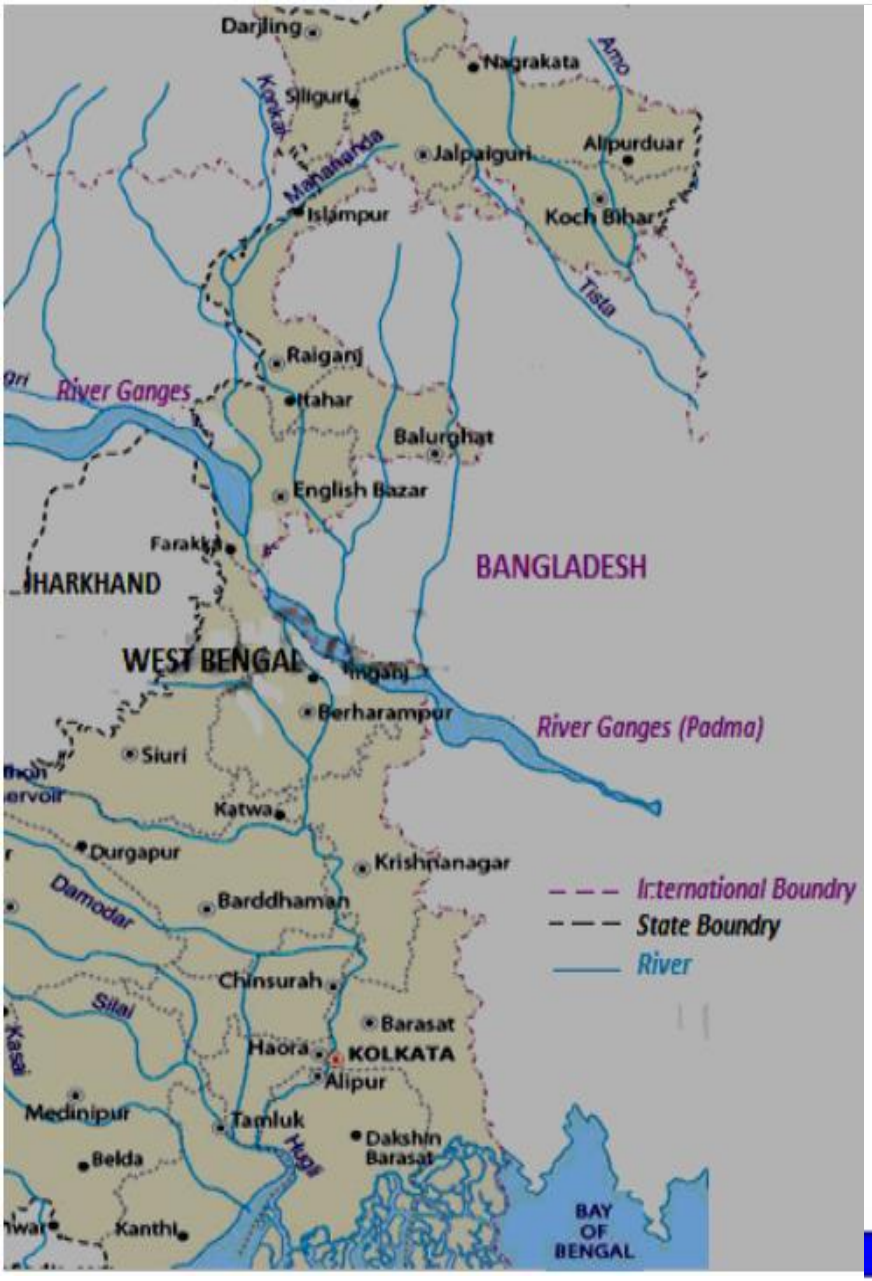
- **Hydraulic Forces:** From waves, currents, and river flows which can cause severe erosion and structural damage.
- **Chemical Corrosion:** Especially in coastal environments where saltwater accelerates the corrosion of many building materials.
- **Biological Factors:** Such as deterioration from organisms in marine environments (e.g., shipworms in timber).

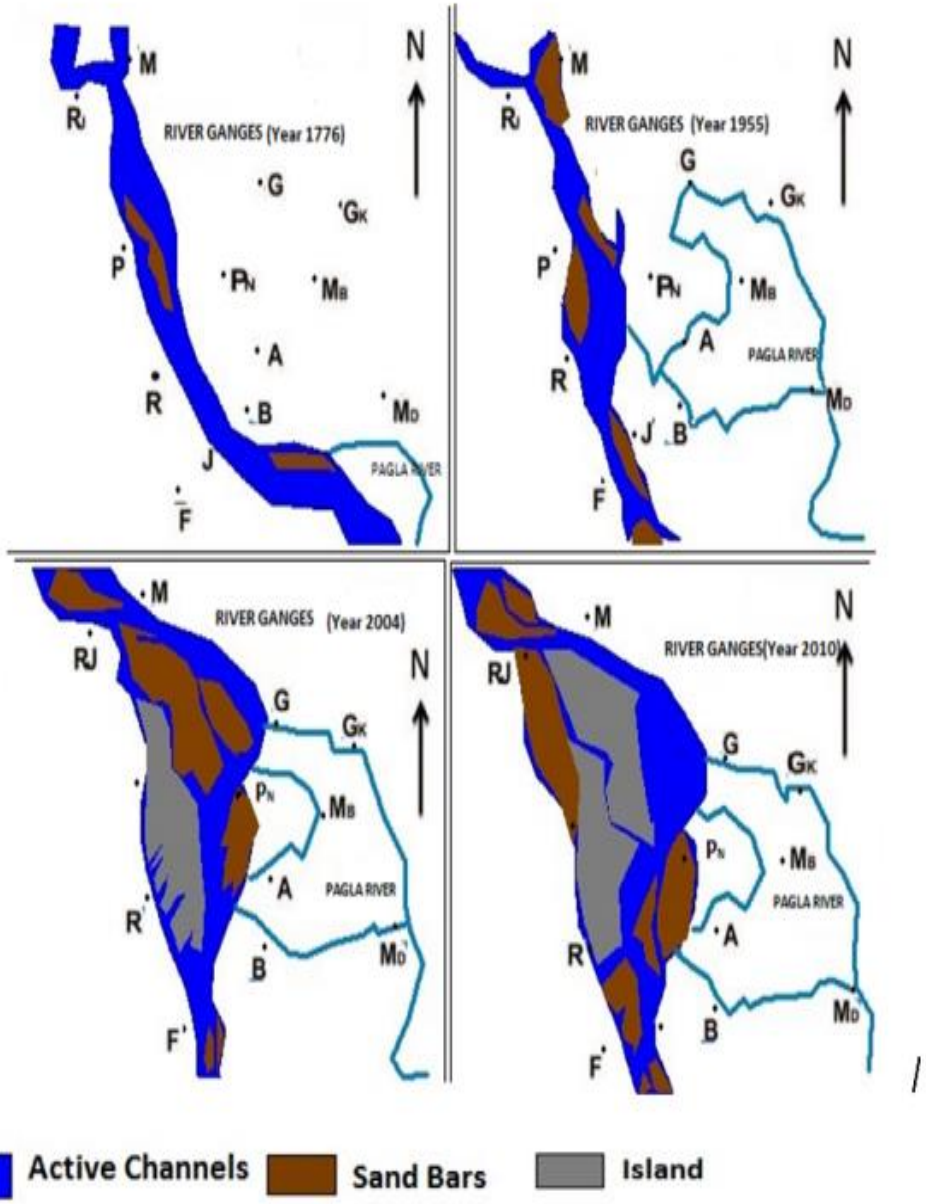


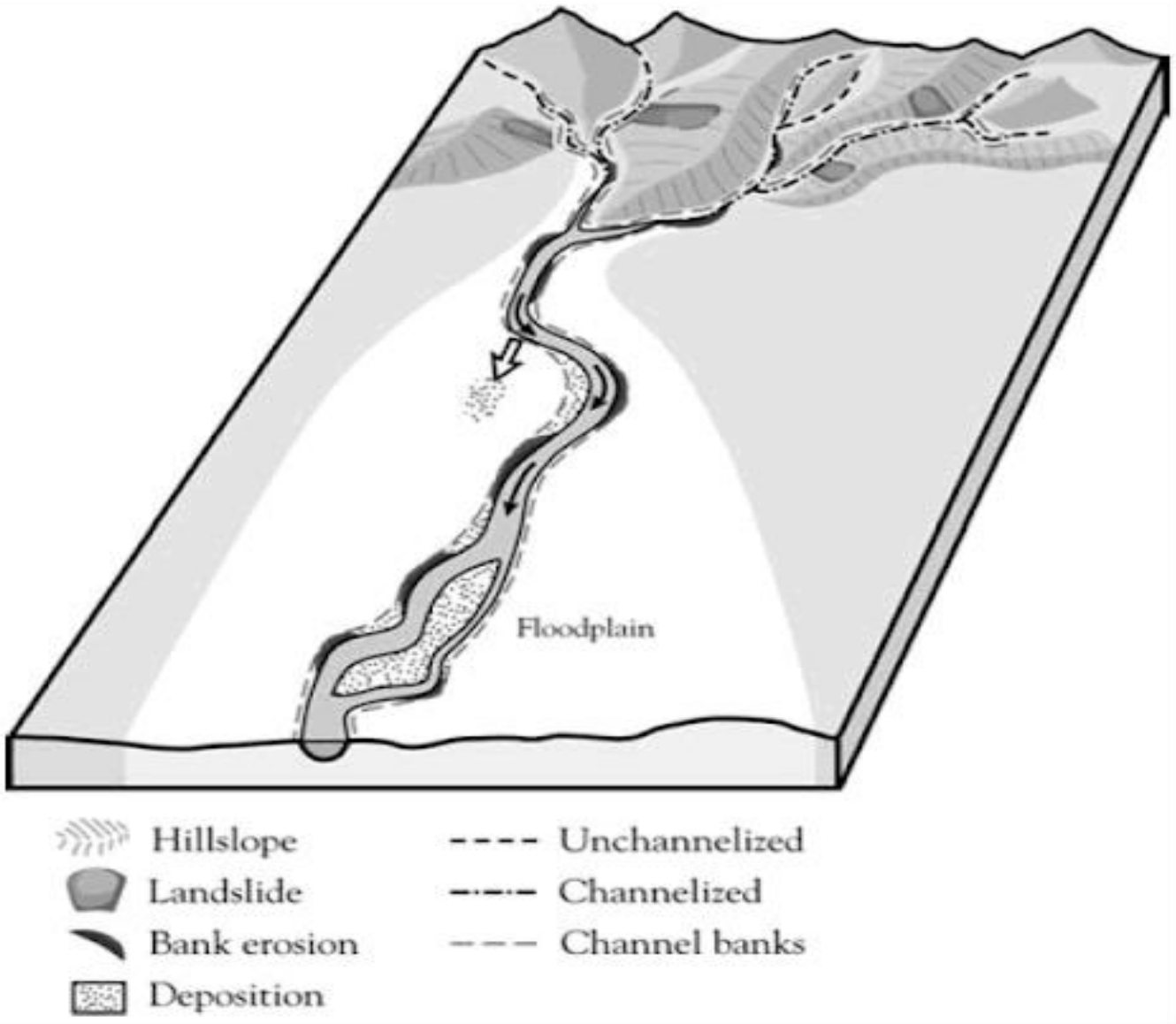
Hydraulics _ Forces & Motion _ Physics _ FuseSchool.mp4

Continuous process of forced migration




Darjling
Nagrakata
Sliguri
Jalpaiguri
Alipurduar
Islampur
Koch Bihar
Raiganj
River Ganges
Itahar
Balurghat
English Bazar
Farakka
BANGLADESH
JHARKHAND
WEST BENGAL
Berharampur
River Ganges (Padma)
Siuri
Katwa
Durgapur
Krishnanagar
Barddhaman
Chinsurah
Barasat
Haora
KOLKATA
Alipur
Medinipur
Tamluk
Dakshin Barasat
Belda
Kanthi
BAY OF BENGAL
International Boundry
State Boundry
River

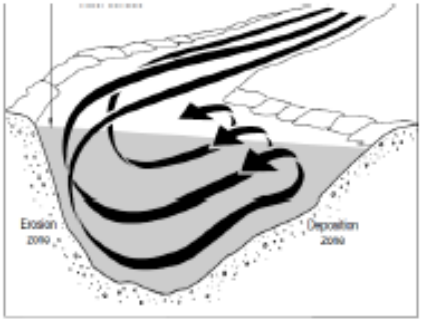

RIVER GANGES (Year 1776)
RIVER GANGES (Year 1955)
RIVER GANGES (Year 2004)
RIVER GANGES(Year 2010)
PAGLA RIVER
Active Channels
Sand Bars
Island


Floodplain
Hillslope
Landslide
Bank erosion
Deposition
Unchannelized
Channelized
Channel banks

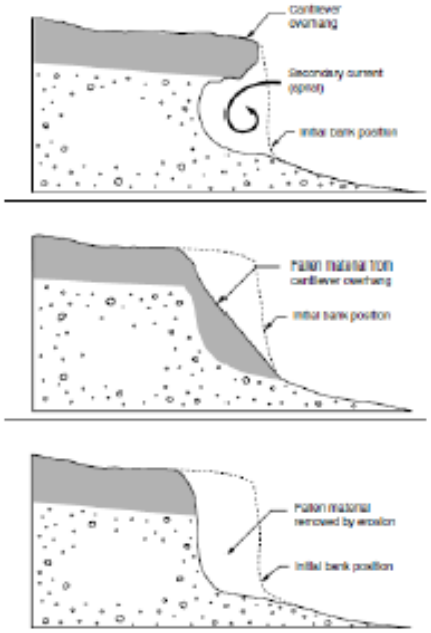
Bank Degradation: Cause and Effect

Bank erosion is a natural process in stable rivers; however, it can become accelerated and exacerbated by direct and indirect human impacts.

- **Bank destabilization causes:**
  - *Direct*: Livestock trampling, removal of riparian vegetation
  - *Indirect*: Channel incision, then widening from hydrologic alteration in watershed
- **Bank destabilization processes:**
  - *Hydraulic*: Toe scour -> cantilever failure or rotational slide
  - *Geotechnical*: Channel incision -> supercritical bank height and bank failure from mass wasting, or due to positive pore pressure in stream bank (Fischenich, 1989)



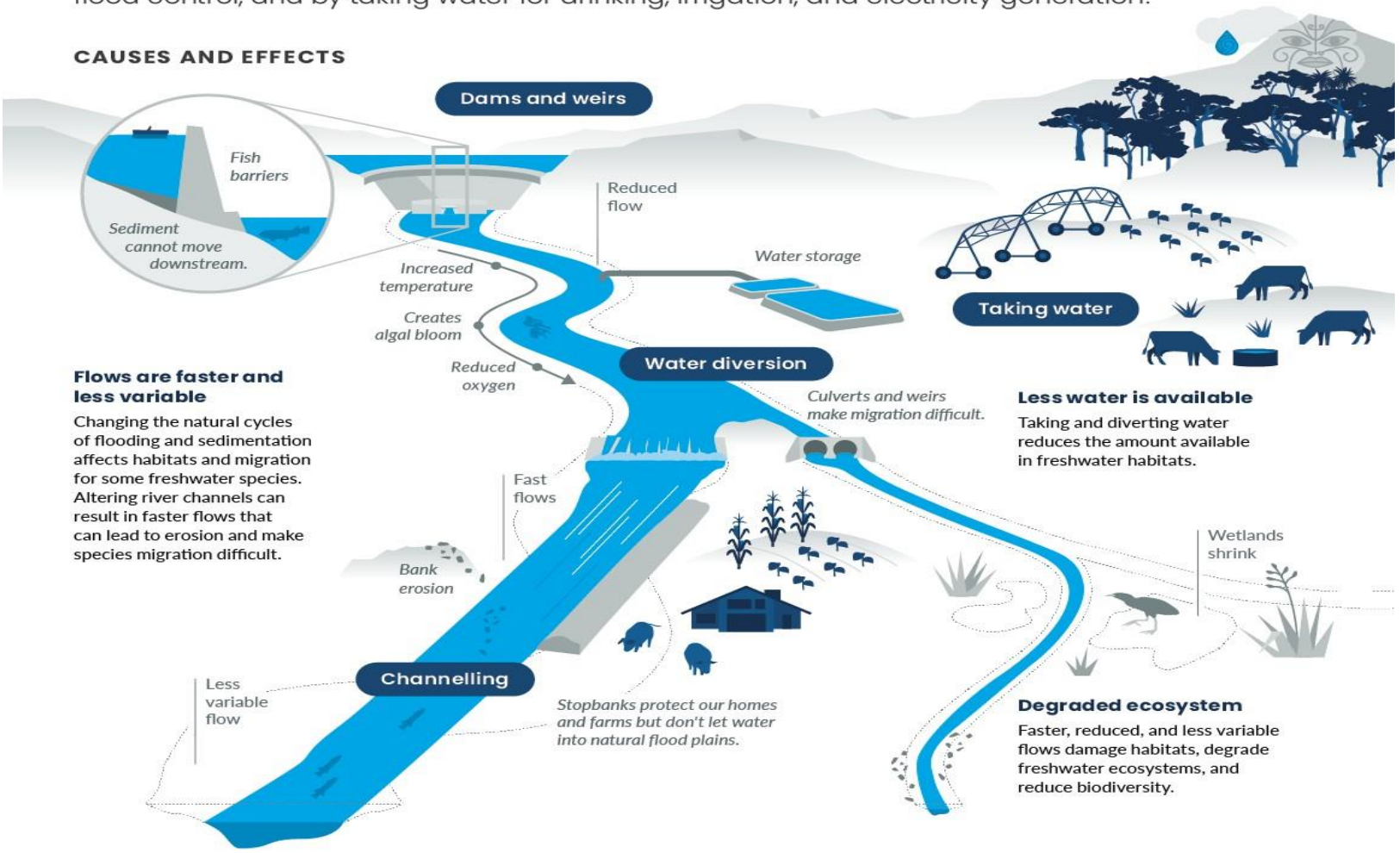
Secondary flow hydraulics enhance bank erosion on outer banks in meander bends. (Kunzig 1989)



Bank Failure by Toe Scour (Johnson & Stypula 1993)

The natural flow of water is changed by modifying waterways for urban and rural development, flood control, and by taking water for drinking, irrigation, and electricity generation.

CAUSES AND EFFECTS



Flows are faster and less variable

Changing the natural cycles of flooding and sedimentation affects habitats and migration for some freshwater species. Altering river channels can result in faster flows that can lead to erosion and make species migration difficult.

Less water is available

Taking and diverting water reduces the amount available in freshwater habitats.

Degraded ecosystem

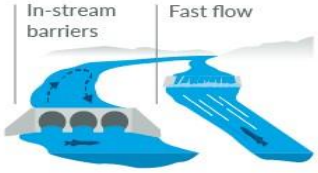
Faster, reduced, and less variable flows damage habitats, degrade freshwater ecosystems, and reduce biodiversity.

IMPACTS



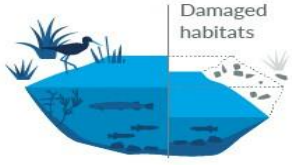
Habitat shrinks

Rivers become less dynamic and have fewer channels. Taking water from aquifers can reduce the water flow in rivers and vice versa.



Fewer fish migrate

In-stream structures and altered river channels and flows make it difficult or impossible for fish to move up and down stream.



Less biodiversity

Many of our native freshwater fish and birds are threatened with or at risk of extinction. Loss and degradation of habitat increases this risk.



Cultural impact

Altering natural flows can reduce the mauri of the environment. This reduces the ability of tangata whenua to exercise kaitiakitanga of wetlands, rivers, and lakes.

Impacts of Bank Degradation

Societal Impacts

- Property loss from undermining structures
- Sedimentation of in-stream structures



Environmental Impacts

- Fine Sediment Loading
  - Water quality impacts from fine sediment and attached nutrients (e.g., Sekely et al. 2002)
  - Aquatic habitat fouling and eutrophication
- Channel Widening:
  - As banks widen, sediment transport capacity decreases and aggradation may occur potentially smothering aquatic habitat
  - Riparian habitat can also be damaged-



Bank Stabilization Objectives and Approaches

- Protect river banks from degradation
- Prevent lateral migration of alluvial channel when property at risk

Two main approaches for river bank stabilization

- **Strengthening the bank**
  - Hard Approaches : Riverbank riprap & retaining walls
  - Softer Approaches: Bioengineering and vegetation
- **Reducing Hydrodynamic force**
  - Flow control structures

Comparing Hard and Soft Approaches

Hard, Engineering Approaches

- Advantages:
  - Durable, highly stable, can give rise to vegetation
  - Local damages can be repaired easily
- Disadvantages:
  - Need construction practice and restricted to some design parameter
  - Need manpower, materials, equipment
  - Comparatively costly

Soft, Bioengineering Approaches

- Advantages:
  - Long-term, re-generating protection
  - Often less costly
  - Potential for better environmental outcomes
- Disadvantages:
  - May require time to establish
  - Not always practical (requires, soil, water and mild slopes)
  - Can cause damage later on via wind-throw of mature vegetation

Riprap

A permanent, erosion-resistant ground cover of large, loose, angular stone





Properties

- Made of durable, angular stones.
- Size of stone 10-50 cm.
- Weight 10-500 kg.
- Density 2 Mg/m^3
- Compressive strength 40 MPa.



Purpose

- To protect slopes, streambanks, channels, or areas subject to erosion by wave action.

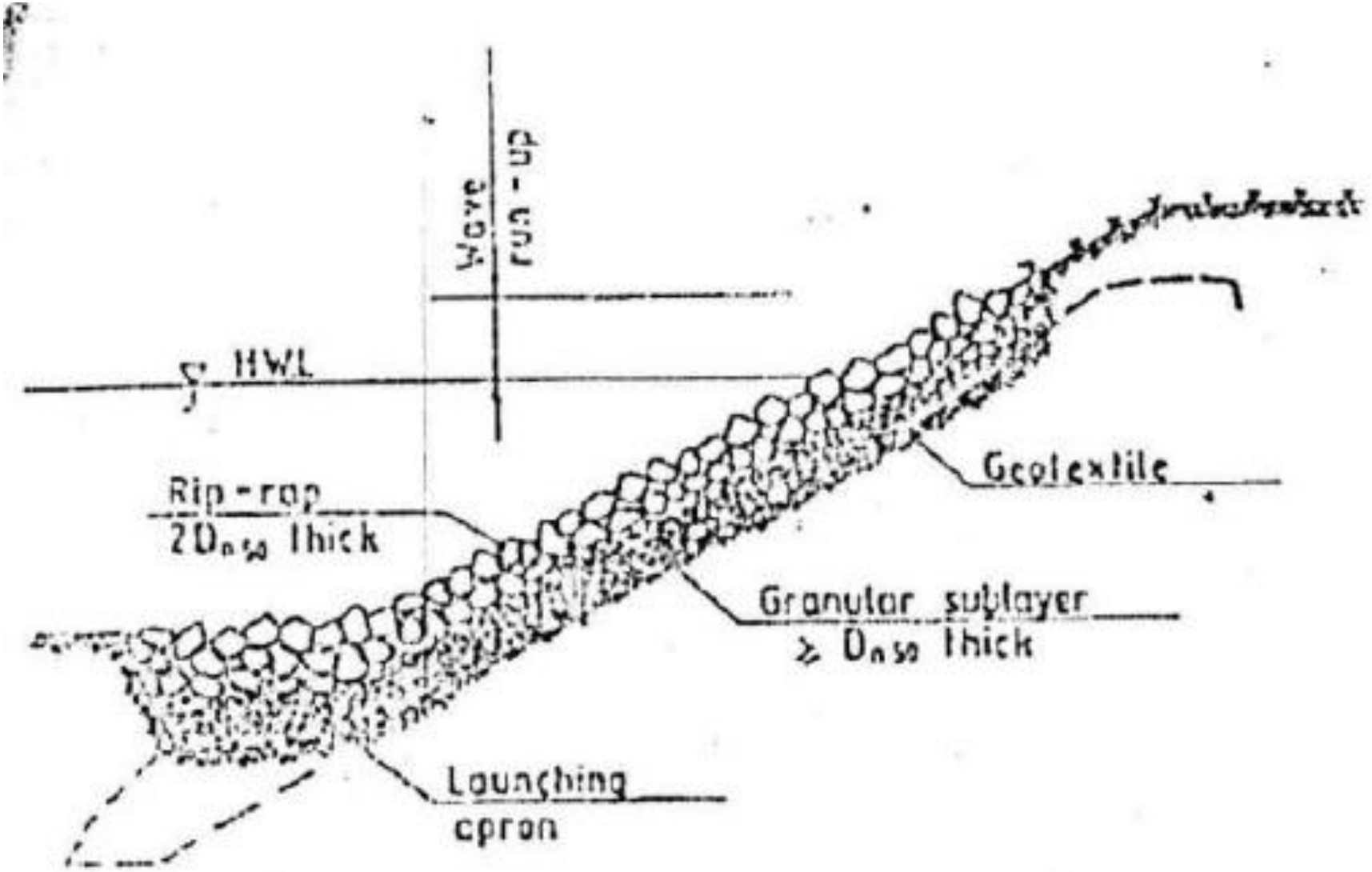
- Rock riprap protects soil from erosion.

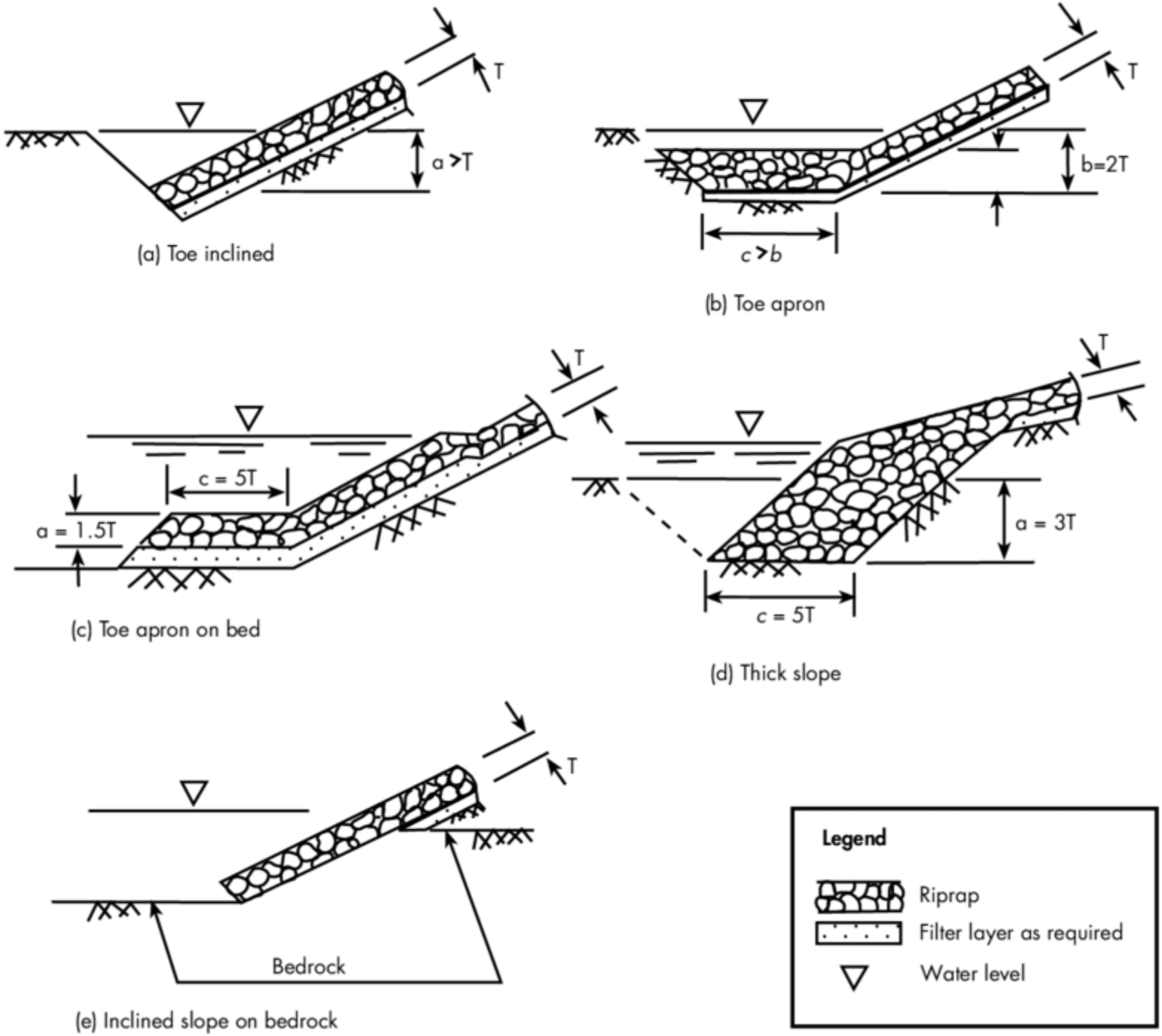
- It is used to stabilize slopes.

- It is also used to slow the velocity of concentrated runoff which in turn increases the potential for infiltration.

Uses/Application

- Cut or fill slopes subject to seepage or weathering.
- Channel side slopes and bottom.
- Inlets and outlets for culverts, bridges, slope drains, grade stabilization structures, and storm drains.
- Stream banks and stream grades.
- Shorelines subject to wave action.


Wave run-up
HWL
Rip-rap
$2D_{n50}$ thick
Geotextile
Granular sublayer
$\geq D_{n50}$ thick
Launching
apron


T
a >T
(a) Toe inclined
T
b=2T
c >b
(b) Toe apron
T
c = 5T
a = 1.5T
(c) Toe apron on bed
T
a = 3T
c = 5T
(d) Thick slope
T
Bedrock
(e) Inclined slope on bedrock
Legend
Riprap
Filter layer as required
Water level

Advantages

- Decreases water velocity and protects slopes from erosion.
- It is simple to install and maintain.
- Durability.
- High roughness to alternate waves & currents.
- Natural, environmentally acceptable appearance.

Disadvantages/Problems

- Riprap is more expensive than vegetated slopes.
- There can be increased scour at the toe and ends of the riprap.
- Riprap does not provide the habitat enhancement that vegetative practices do.

Design Considerations

- Normally placed in one, two or three layers

- Dumping in flowing water may be displaced by the distance L. Where,

$L = 0.25.h.u.D^{-0.5}$ (m)

D=Dia in m, u=m/s, h=m

- Slope not exceeding 1:2 or 1: 1.5

- Rock riprap is used where erosion potential is often high

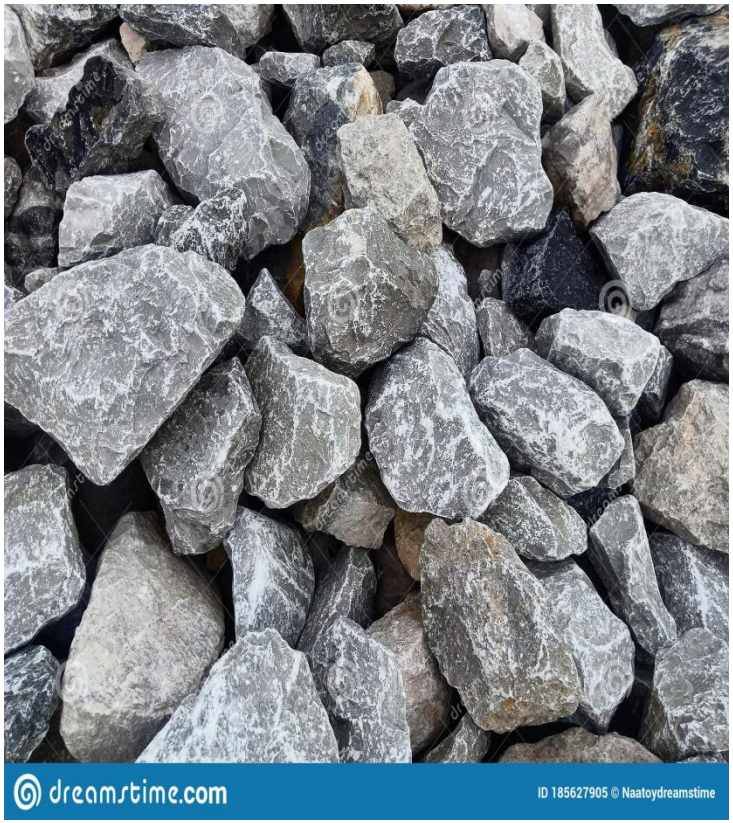
Pitched Stone

A rough-faced stone having each edge of the exposed face pitched at a slight bevel from the plane of the face.



Properties

- Hand placing is normally used for pitched stone
- Usually single layer & relatively smooth upper surface
- Size of stones 20-50 cm.



Purpose

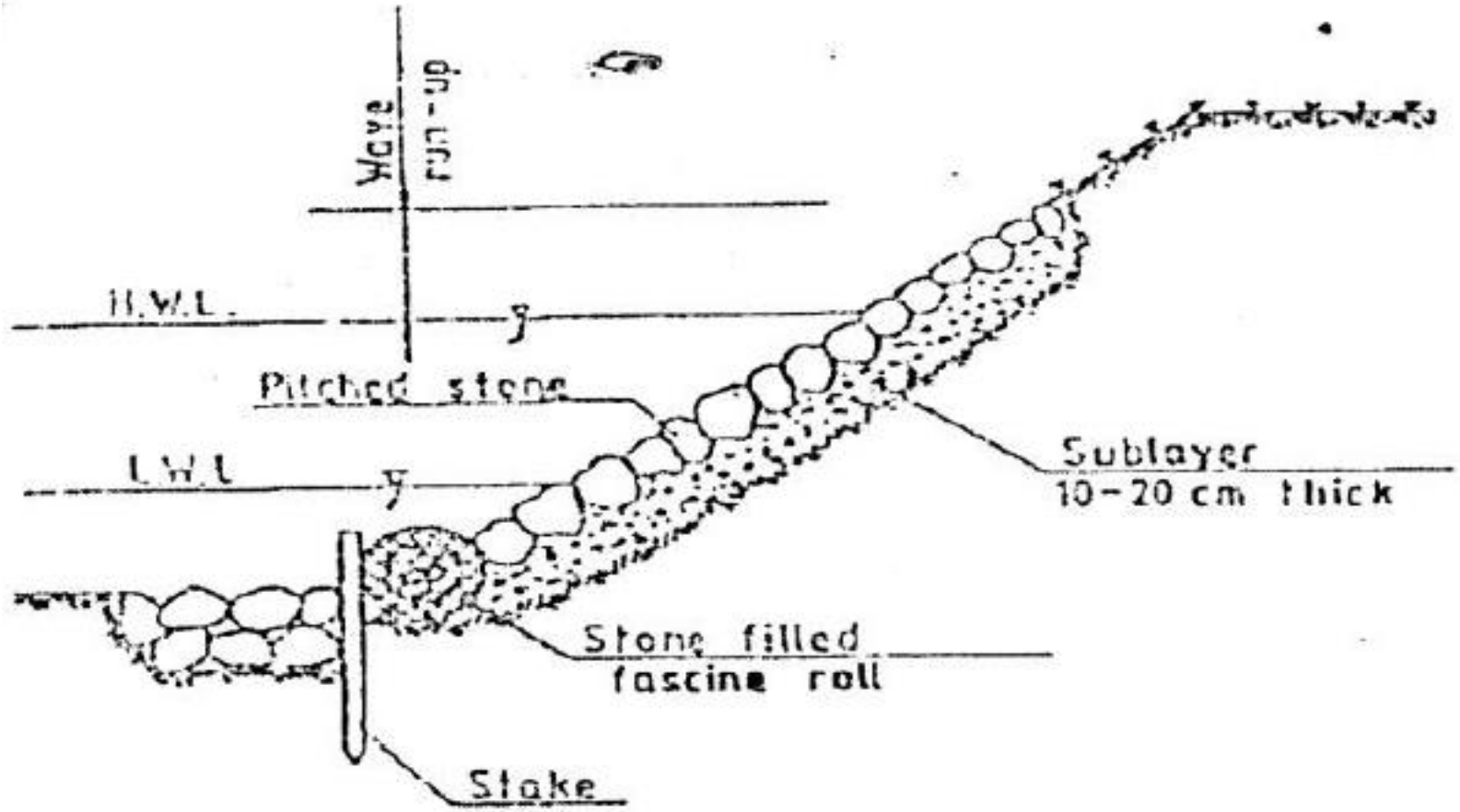
- To withstand medium to heavy flow attack.

- To provide aesthetically pleasant and neat revetment.

Uses/Application

- It is usually confined to small areas of revetment and to repair of existing bank protection.

- Only occurs on upper bank areas and rarely as bed protection.


Wave
run-up
H.W.L.
Pitched stone
L.W.L
Sublayer
10-20 cm thick
Stone filled
fascine roll
Stake

Advantages

- Placed in a single layer, forming much smoother surface than riprap.
- Close jointed to minimize the erosion of underlying soil.

Disadvantages/Problems

- Relatively inflexible due to close joint.
- Limited ability to resist settlement and soil deformation.
- High labor cost in construction and maintenance.

Design Considerations

- Stone are placed in rows, at first lowest row then the upper rows bounding with lower ones.

- After pitching the gaps are filled with gravel.

- The height above still water level h can be estimated by:

$h=3H$,

Where, H= Design wave height

Geotextiles

A permeable geosynthetic comprised solely of textiles.





Properties

The four main polymer families most widely used as the raw material for geotextiles are:

1. Polyester
2. Polyamide
3. Polypropylene
4. Polyethylene

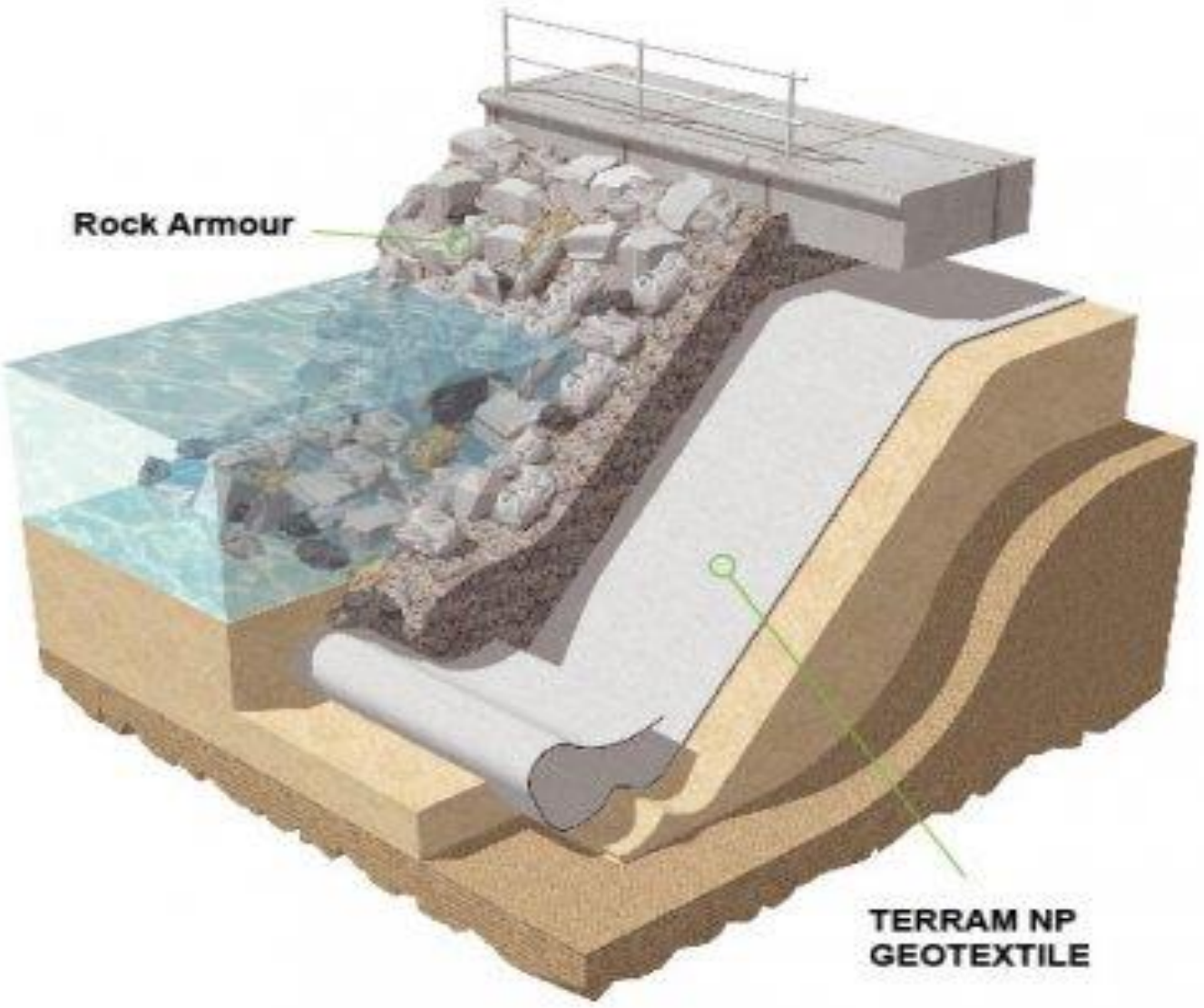


Purpose

- Geotextiles are permeable fabrics which are used in association with soil, have the ability to separate, filter, reinforce, protect, or drain.

- To protect river banks from erosion due to currents or lapping. When used in conjunction with natural or artificial enrockments, they act as a filter.

- To strengthen the soil, geotextiles are placed at the tension surface.


Rock Armour
TERRAM NP
GEOTEXTILE

Uses/Application

- Geotextiles are used for sand dune armoring to protect upland coastal property from storm surge, wave action and flooding.

- Geotextiles can improve soil strength at a lower cost than conventional soil nailing.

- For erosion prevention, geotextile used can be either woven or nonwoven.

Uses/Application

- The woven fabrics are recommended in soils of larger particle size as they usually have larger pore size.

- Nonwovens are used where soils such as clay silt are formed.

- Serves to separate two dissimilar materials, eg, two different soils, landfill materials etc.

- Provides added strength to the whole system.

Advantages

- Woven Geotextiles: Perfect for stabilization and separation in areas needing high strength materials.

- Nonwoven Geotextiles: Ideal for drainage or filtering applications. Products typically have a high permittivity rate for these kinds of erosion control needs.

Block Systems

Cable connected blocks

- Greater the flexibility & stability
- Less risk of localized failure
- Less problems with vandals & thieves
- Easier laying under water
- Quicker laying, including a anchoring to subsoil

Block Systems

Geotextile - bounded blocks

- The blocks are connected directly to a geo-textile mat either by casting the blocks on to connectors fixed to the mat or after casting by adhesive or special connecting pins.

CONTAINER SYSTEMS

Bags : GEOBAG

Uses/Application

- On both sides of the river or natural shore zone environment.
- Used at sea and lake shore, the surface of the landslide ,culvert mouth ,drainage ditch, soil erosion, irrigation system, steep slope stability.
- Geobag is used in express way`s erosion.
- The geobag is used in express way slope protection
- It can be used in drainage project
- Used in the river watershed

Advantages

- **Anti-wet:** The original material of geobag cannot absorb water, it will not destroy the geobag when there is water appearing and would not change its shape ,which also does not melt in polluted liquid.

- **Anti-chemical corrosion:** According extensive research test shows that the geobag has a strong resistance for a certain concentration of acid and alkali chemicals, which can used in many polluted areas.

Advantages

- **Resistance to biodegradation and animal damage:** The geobag takes special material, nonsupport, nonabsorb, nonhelp the fungus produce, not rot, not moldy, not bad. It will not be digested by animals.

- **Anti-high temperature and low temperature:** The geobag could bear 150 celsius until melt, and it could bear -40 celsius.

Anti-UV: The material of geobag contains carbon ink and other anti-uv material

CONTAINER SYSTEMS

Tubes : GEOTUBE

Uses/Application

- Geotube geocontainment technology is used as an integral component in the design and construction of a variety of marine and hydraulic engineering structures such as breakwaters, levies, and marine spoil-containment structures.

- Geotube technology has been used to produce sand dune cores; wetlands and other habitats; jetties, dikes, and groynes; and underwater structures — and to even raise brand new islands from under water.

Gabions

Properties

- Thickness 0.5 m to 1.0 m
- Mesh size varies from 440 x60 mm to 100 to 120 mm.
- Are filled with any-hard, durable stone.
- Width 1.2 or 2.5 m
- Spacing 1.5m to 6.0 m

Mattress

- Are thinner (O.15m-0.3m)
- More flexible
- Most popular is Reno mattress
- Slopes not steeper than 1:1.5
- Stability & durability can be increased by partial or full grouting with asphalt mastic