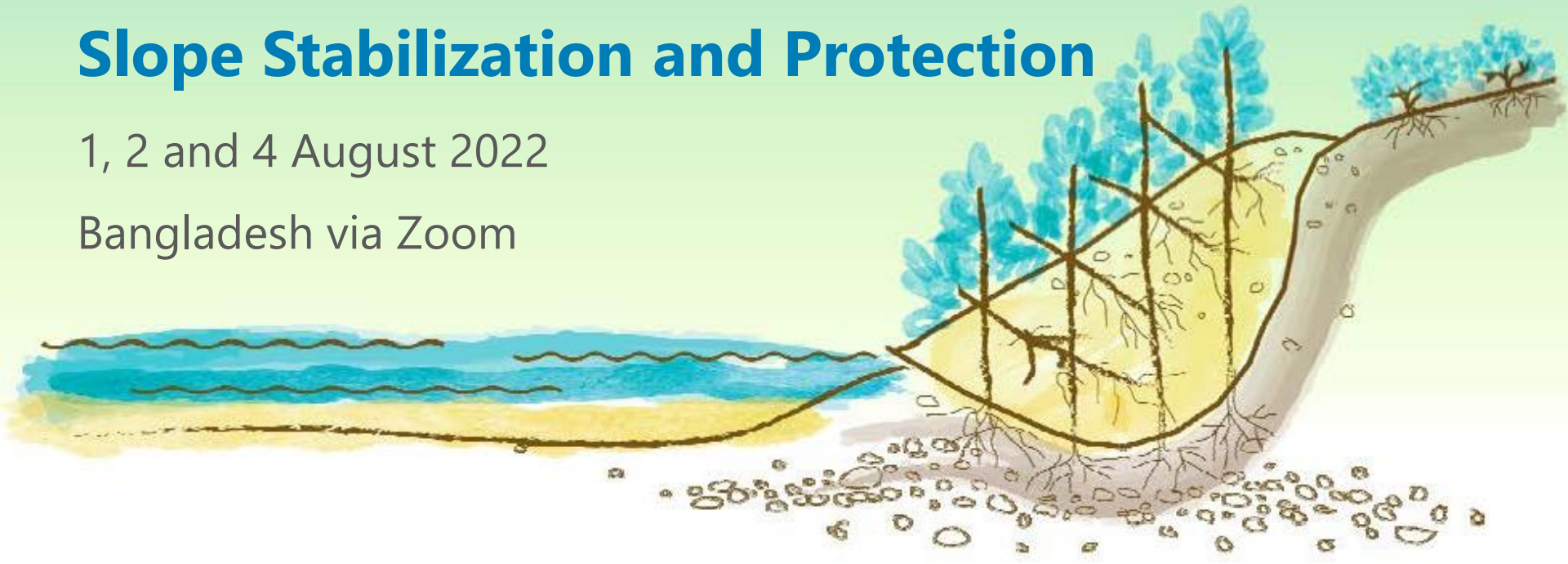
TRAINING ON

Bioengineering Nature-based Solutions for Linear Infrastructure Slope Stabilization and Protection

1, 2 and 4 August 2022

Bangladesh via Zoom



Day-3

Source of Material

This training programme was compiled and delivered by Shankar Rai, working with assistance from Shuva Sharma, Dr. Mohammed Shariful Islam and Syed Abdur Rahim. Quality assurance was provided by John Howell.

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Recap

- Siting of bio-engineering nursery;
- Nursery components and size;
- Nursery layout and nursery bed construction;
- Seed collection and storage;
- Collection of vegetative plant materials;

Session-17

Compost Production and Filling Polypots

Compost production

What is compost ?

- compost is organic material from plants or animals which has been broken down to form humus.

Compost production

Why compost is needed in nurseries?

- improves the soil structure;
- it improves drainage and aeration in a heavy soil;
- it retains water in a light soil;
- it adds nutrients to the soil;
- it improves rooting by making the soil more 'open';
- it helps keep the root ball in shape when a plant is transplanted.

Compost production

How to make compost ?

- prepare a compost bay or heap;

Compost production

How to make compost ?

- avoid using pits- they become water-logged in the monsoon;

Compost production

How to make compost ?

- use green material as much as possible;
- avoid using weeds carrying seeds;
- add alternate layers of different material;
- add animal manure in thin layers;
- add a soil layer every 20 - 30 cm;
- do not make the material more than 1 to 1.5 m deep;

Compost production

How to make compost ?

- keep the heap damp but not water-logged;
- turn the heap at least once a month and keep the material open;
- allow the material to compost well before use;
- sieve the compost before use and add sieving to a new heap.

Filling polypots

Polypots

- Polypot size: 4" x 7"
- Colour : Black
- Thickness: 200 gauge
- A pot needs 8 - 12 holes, about 5 - 6 mm in diameter in the lower third of the pot.
- Two bottom corners of the bag to be cut off for drainage.

Filling polypots

Soil mixture for polypots

- Forest top soil, compost and sand
- Fertile soil;
- well-drained;
- not too dry;
- medium/light texture (sandy loam or loamy sand);
- homogenous;
- contains well-made compost;

Filling polypots

Filling procedure

- use loose but very slightly moist soil;
- fill less than a quarter of a polypot at a time and gently compact the soil;
- make sure there are no air pockets;
- if possible allow to stand for at least one month after filling, before sowing seeds;
- keep the soil moist but not too wet once the pots are full.


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Seed Sowing and Planting Cuttings in Nurseries

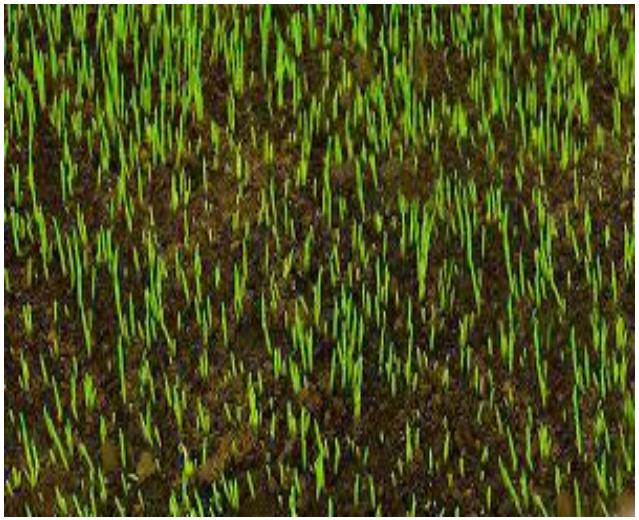
Seed sowing in nurseries

Grass seeds sowing

- Grass seed types include cereal crops such as rice, wheat and maize. The grass seeds we use are similar to other seeds except that they are generally quite small;
- Prepare good beds well in advance of sowing seeds.

Seed sowing in nurseries

Grass seeds sowing



- Grass seeds should be seeded at 20-25 grams per m^2
- Young grass seedlings can be scorched by the sun and killed, In order to avoid scorch, cover the seeds with hessian jute immediately after they are sown and keep this damp at all times. Remove hessian jute when the seedlings are about 1 cm tall.

Seed sowing in nurseries

Tree and shrub seeds sowing

Pre-treatment

- Soaking in warm water for a few hour to days before sowing depending on the species
- Soaking in hot water for a few hour to days before sowing depending on the species
- Chipping, many species have seeds with hard coats that will not let water in unless they are broken.

Seed sowing in nurseries

Tree and shrub seeds sowing:

- Prepare good seedbeds well in advance of sowing seeds;
- Prepare polypots well in advance of sowing seeds

Seed sowing in nurseries

Techniques for sowing different sizes of seeds

1. Sowing directly into polypots

- sowing seeds directly into polypots is recommended for seeds which are large enough to be handled individually, and which have high germination percentages (More than 60%).

Expected germination %	Seeds in each pot
More than 80	1 or 2 *
60 - 79	3

Seed sowing in nurseries

Techniques for sowing different sizes of seeds

2. Sowing in seed beds or seed trays is recommended when:

- seed is very small e.g. Eucalyptus;
- viability is expected to be low (less than 60 %);
- germination is prolonged e.g. Walnuts;

Seed sowing in nurseries

Techniques for sowing different sizes of seeds

2. Sowing in seed beds or seed trays is recommended when:

    - several plants germinate from one stone e.g. *Melia azedarach* (Bangla Ghoranim, Mohanim)
    - the seed is very scarce or expensive.

Planting cuttings in nurseries

General considerations in preparing and planting cuttings

- prepare good beds well in advance of planting the cuttings;
- treat cutting material carefully;
- look after cuttings carefully after they have been planted;

Planting cuttings in nurseries

General considerations in preparing and planting cuttings

- plant cuttings the same day that they are taken;
- keep cuttings damp at all times;
- ensure adequate but not excessive amounts of material are used.

Planting cuttings in nurseries

Types of cuttings

Grasses:

- Slip cuttings
- Rhizome cuttings
- Stem cuttings
- Stolon cuttings

Planting cuttings in nurseries

Preparing and planting cuttings

Grasses

- Slip cuttings

Preparing and planting slip cuttings

Planting cuttings in nurseries

Preparing and planting cuttings

Grasses

- Rhizome cuttings

Preparing and planting rhizome cuttings

Planting cuttings in nurseries

Preparing and planting cuttings

Grasses

- Stem cuttings

Preparing and planting stem cuttings

Planting cuttings in nurseries

Preparing and planting cuttings

Trees and shrubs

- Stem/Hardwood cuttings

Preparing and planting stem/hardwood cuttings

Planting cuttings in nurseries

Preparing and planting cuttings

Bamboo

- Single-node culm cuttings

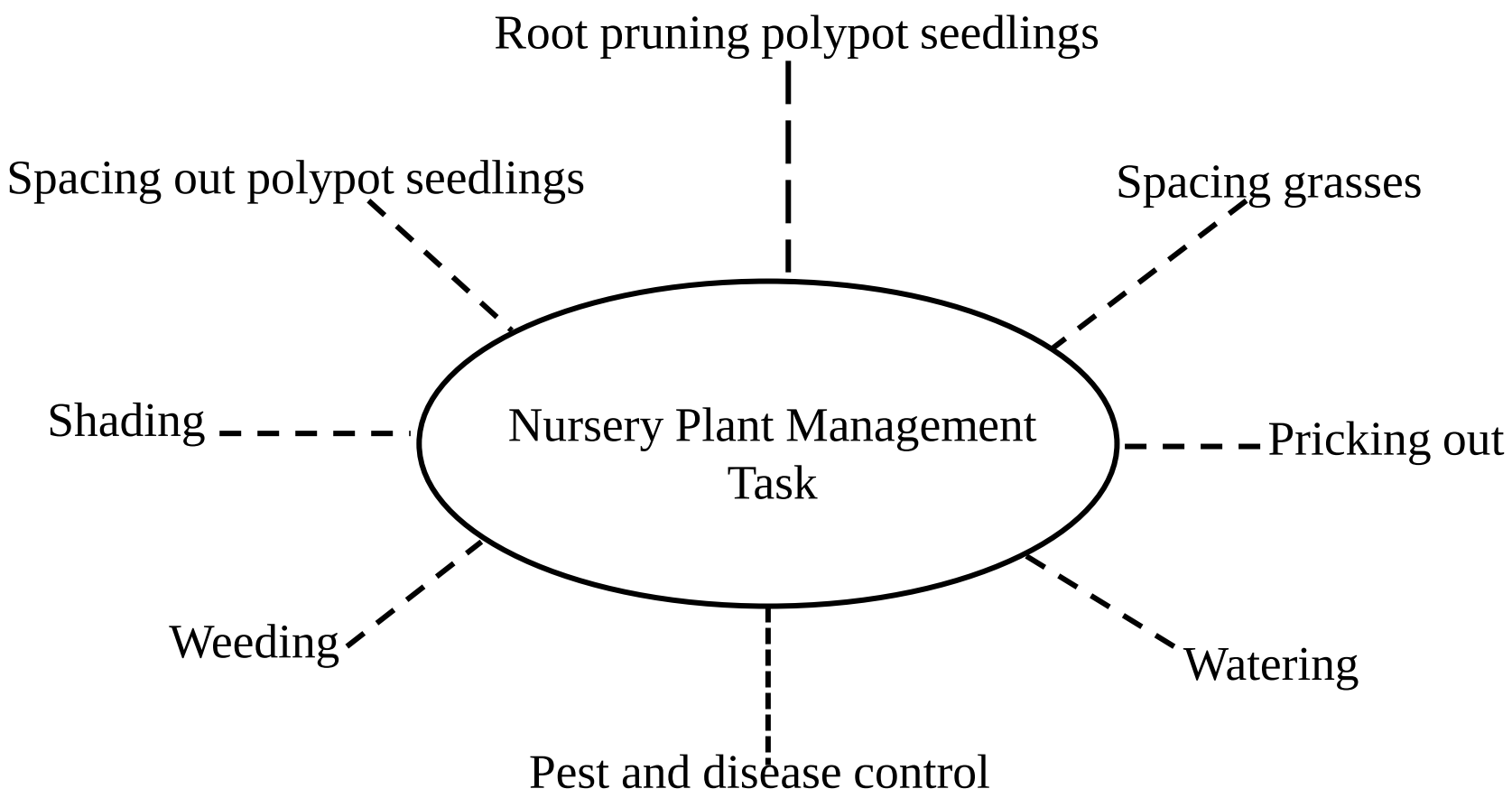
Preparing and planting single-node culm cuttings

Session-19

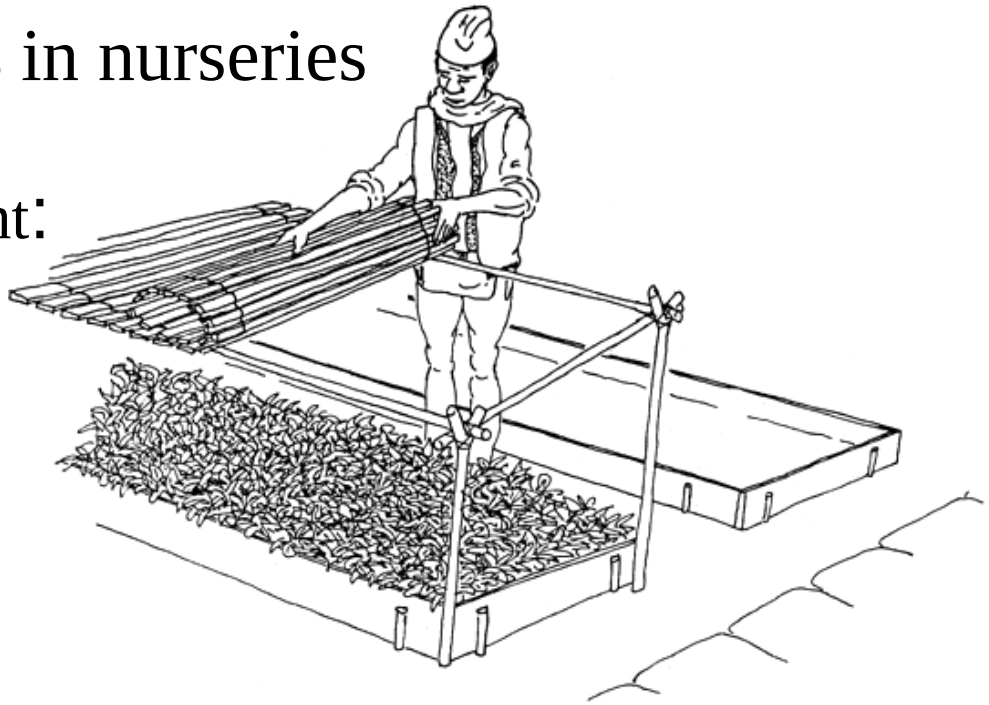
Care of Young Plants in Nurseries

Care of young plants in nurseries

Nursery plant management tasks



Care of young plants in nurseries



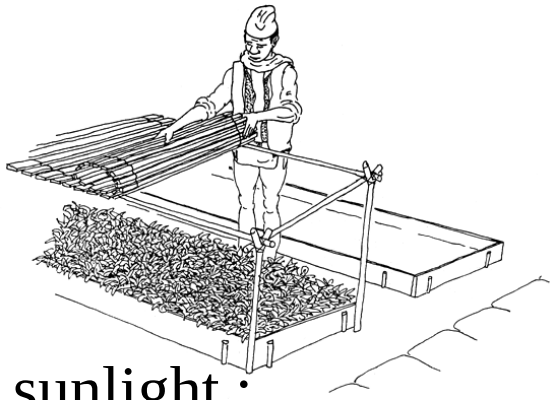
1. Environment management:

- Shading

- Purpose of Shade

  - to protect seedlings against hot sun, heavy rain and hail,

Care of young plants in nurseries

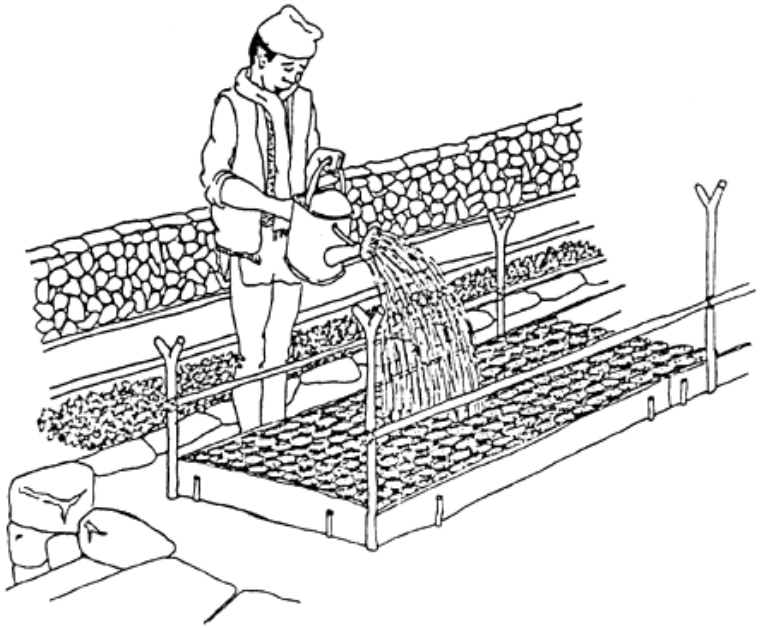


- Shade management
  - shade should pass about 40-60% of sunlight ;
  - shade should be removed during morning and evening sunlight whereas in the afternoon the shade should be placed again;
  - gradually, the shading time of the seedlings should be reduced;
  - shade should be placed during rain and night time.

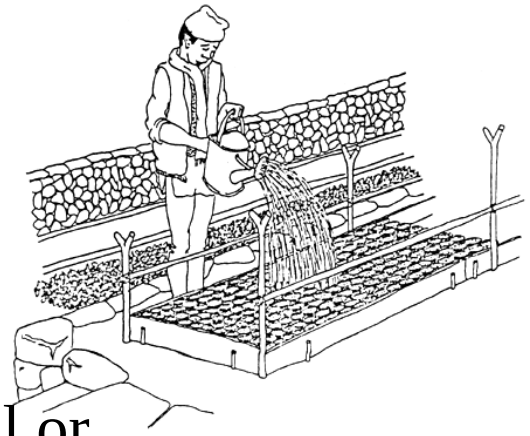
Care of young plants in nurseries

1. Environment management:

- Watering
  - the soil must be kept moist at all times;
  - too much water can be very damaging, so take care not to saturate the soil;



Care of young plants in nurseries



- Watering
  - the force of water falling on to the soil or hitting small plants can also be very damaging, therefore care must be taken to apply water slowly, using a fine spray;
  - during hot weather water should be applied in the cool of the morning or the evening;

Care of young plants in nurseries

2. Spacing out plants:

- Re-spacing grasses

  - grass slips and rhizome cuttings can grow into the large clumps they need to be re-spacing periodically to maximise the rate of root and shoot production;

  - re-spacing grasses is the lifting, splitting and replanting procedure is the same as for the initial planting operation.

Care of young plants in nurseries

2. Spacing out plants:

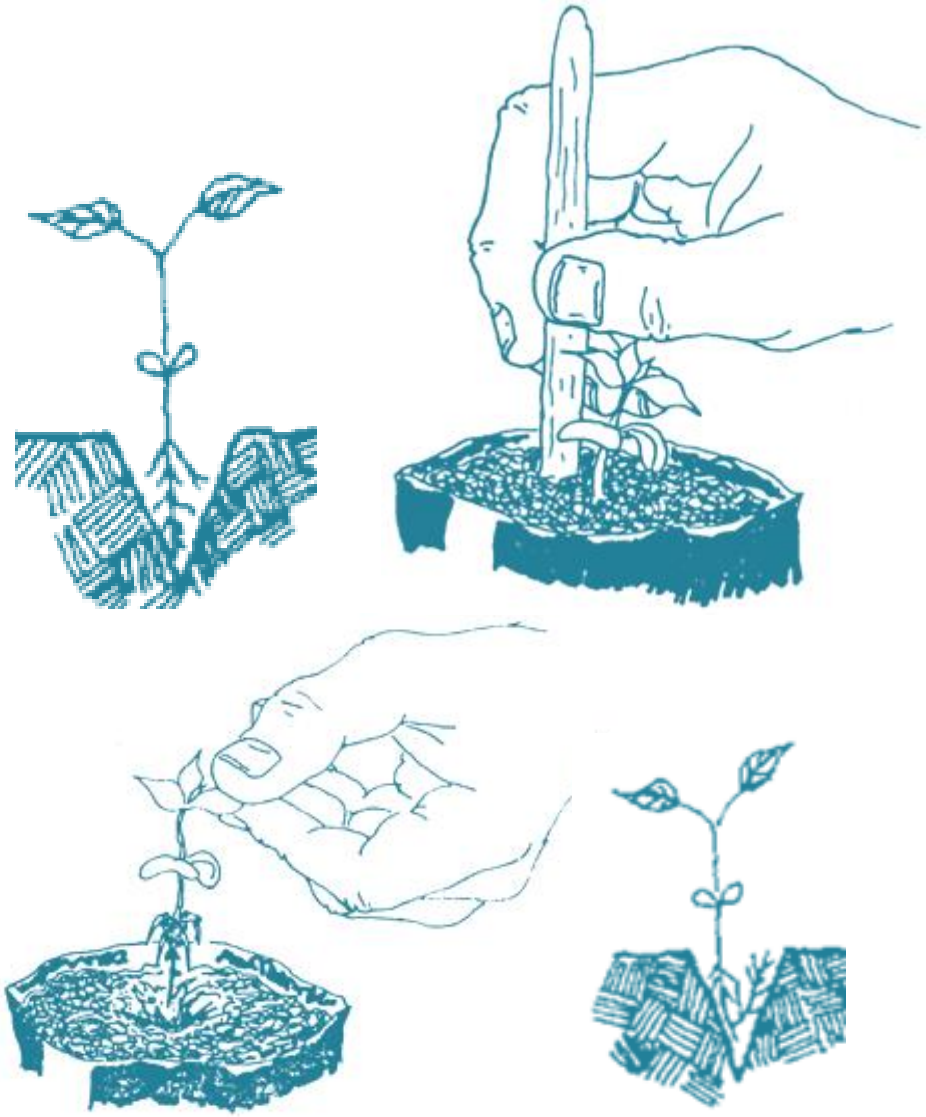
- Pricking out and transplanting

  Pricking out is the operation of moving a small seedling from the seed bed to the polypot.

  - never let the roots dry out during pricking out;
  - avoid physically damaging the seedling, especially the stem or roots, pick them up by their leaves;

Care of young plants in nurseries

Pricking out and transplanting



Care of young plants in nurseries

2. Spacing out plants:

- Pricking out and transplanting
  - make sure the roots are in contact with the soil and there are no air pockets;
  - watering carefully in the days immediately after pricking out;
  - keep the shades in place for the next few days.

Care of young plants in nurseries

3. Polypot management:

- Space out polypot seedlings;
- Root pruning
- Space out polypot seedlings
  - as the seedlings grow up, they start to compete for space and light. It then becomes necessary to space them out to provide space and light;
  - never leave more than one seedling in a polypot.

Care of young plants in nurseries

3. Polypot management:

- Root pruning polypot seedlings

Care of young plants in nurseries

4. Weed, pest and disease control:

- weeding
- insect and mammal pest control
- fungal disease control

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Hardening, Lifting and Transporting Plants to Site

Final care of plants in nurseries and transport to site.

Why is the final care of plants in the nursery and transport to site so important?

The reason is that site failures of bio-engineering planting works have been attributed to:

- the use of substandard plants brought from nurseries;
- damage to plants during removal from the nursery and transport;
- damage to plants while on site.

Final care of plants in nurseries and transport to site.

Preparation in nursery for site planting

- Hardening-off;
- Shoot-pruning;
- Culling;

Final care of plants in nurseries and transport to site.

What main work needs to be performed from before the plants leave the nursery until planting commences.

Packing, transporting to site and care on site

- Preparing and packing for transport;
- Caring for planting stock on site.

Final care of plants in nurseries and transport to site.

- Hardening-off
  - removing shade at an early stage;
  - spacing the plants in their rows;
  - reducing watering.

Final care of plants in nurseries and transport to site.

- Shoot- pruning

Plant preparation in nurseries for site planting

- Culling
  - only use good quality plants on site, using substandard plants will defeat the object of the bio-engineering programme;
  - it is quite normal for 20% of plants to be rejected at this stage. You should have allowed for this in the calculations of plant requirements from the nursery from the very beginning;
  - destroy all plants not used by the end of the season, be ruthless and never think of keeping them to the next year.

Plant preparation in nurseries for site planting

Preparing and packing for transport

- Grass
  - Grass clumps should lift complete with a root ball and wrap in wet hessian jute and keep them moist until they are actually ready to plant them.

Packing, transporting to site and care on site

- Preparing and packing for transport
- Polypot plants
  - water them thoroughly 2 - 3 days before transport to site;
  - lightly water previous evening so the soil in the polypot does not break up and damage the roots;

Packing, transporting to site and care on site

- Preparing and packing for transport
- Polypot plants
  - always handle the plants by the polypot not the stem to avoid damage and extra stress;
  - pack the polypots vertically and close together so they do not fall about;
  - never tie bundles of polypots together with string, you will break up the root ball.

Packing, transporting to site and care on site

- Caring for planting stock on site
  - keep bare-rooted plants in damp hessian;
  - never stack damp bundles in big heaps so that they will rot;
  - lift polypot seedlings by the pots, not by the plants;

Packing, transporting to site and care on site

- Caring for planting stock on site
  - move polypot seedlings in strong trays or a few at a time in the hands;
  - always keep plants moist and in the shade;
  - always handle plants carefully.

Session-21

Scheduling Nursery Work and Record Keeping

Scheduling nursery work

Which activities are undertaken throughout the year in a nursery?

Scheduling nursery work

Nursery activities

- Nursery construction
- Soil and sand collection
- Order new supplies
- Making compost
- Turning compost
- Bed preparation
- Prepare potting mixes
- Filling polypots
- Check material sources
- Planting material collection

Scheduling nursery work

Nursery activities

- Transplanting
- Re-spacing
- Check seed sources
- Seed collection
- Seed treatment
- Seed sowing
- Pricking out
- Root pruning
- Spacing out
- Weeding

Scheduling nursery work

Nursery activities

- Maintain water supply
- Watering
- Shading of young plants
- Protection of the nursery
- Record keeping
- General maintenance
- Pest and disease control
- Uplifting and preparing
- Transporting to site

Scheduling nursery work

Frequency of nursery activities

Activity	Continuous	Discontinuous (definite period)	Intermittent (indefinite period)
Nursery construction		✓	
Soil and sand collection		✓	
Order new supplies		✓	
Making compost		✓	
Turning compost			✓
Bed preparation		✓	
Prepare potting mixes		✓	
Filling polypots		✓	
Check material sources		✓	
Planting material collection		✓	
Transplanting			✓
Re-spacing			✓
Check seed sources		✓	
Seed collection		✓	
Seed treatment		✓	

Scheduling nursery work

Frequency of nursery activities

Activity	Continuous	Discontinuous (definite period)	Intermittent (indefinite period)
Seed sowing		✓	
Pricking out			✓
Root pruning			✓
Spacing out			✓
Weeding	✓		
Maintain water supply	✓		
Watering			✓
Shading of young plants			✓
Protection of the nursery	✓		
Record keeping	✓		
General maintenance	✓	✓	
Pest and disease control			✓
Uplifting and preparing			✓
Transporting to site			✓

Scheduling nursery work

Nursery activity calendar by fiscal year

Activity	Fiscal Year.....											
	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Nursery construction												
Soil and sand collection												
Order new supplies												
Making compost												
Turning compost				As required								
Bed preparation												
Prepare potting mixes												
Filling polypots												
Check material sources												
Plant material collection												
Transplanting												
Re-spacing								As required				
Check seed sources												
Seed collection				*	*	*	*					
Seed treatment				*	*	*	*					
Seed sowing												
Pricking out								As required				

Scheduling nursery work

Nursery activity calendar by fiscal year

Activity	Fiscal Year.....											
	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Root pruning									As required			
Spacing out									As required			
Weeding												
Maintain water supply												
Watering					As required							
Shading of young plants								As required				
Protection of the nursery												
Record keeping												
General maintenance	Regular checks and repairs made											
Pest and disease control	Daily checks and action taken when necessary											
Uplifting and preparing												As required
Transporting												As required
Site planting works												Depends on rain

* Main seed collection period only; other seeds are collected at other times of the year.

This an example only and a specific calendar must be made for every nursery.

Record keeping

Nursery record keeping

- good records help to improve planning, and the efficiency of the nursery;
- if plants of a particular species have not grown sufficiently by the beginning of the planting season, it may be quite easy to find out why, if the nursery register has a detailed record of how they were grown, showing the sowing date, potting mixture etc.;

Record keeping

Nursery record keeping

- recording the precise identity of seed is important so that the nursery can stop using poor seed lots;
- all beds in the nursery must be numbered so that they can be clearly identified in these registers;
- the records should be checked every time during visit the nursery.

Record keeping

Nursery register

- grass slip/hardwood cutting register;
- tree and shrub seedling register;
- seed identification register

Nursery registers

Grass Slips/Hardwood Cuttings Register

Name of nursery: ----------

Species: ----------**Identity no:** ---------- **Planting date:** ----------

Bed no: ---------- Number planted: ----------

Source of slips/cuttings:----------

Shoots starting Date started: ---------- Approx. percentage--------

Re-spacing (1) Date carried out:---------- Approx. number: ----------

Bed no: ----------

Re-spacing (2) Date carried out:---------- Approx. number: ----------

Bed no: ----------

Diseases/pests ----------

Other notes----------

Distribution record

Date	Number	Location	Notes

Nursery registers

Tree and Shrub Seedlings Register

Name of nursery: ----------

Species: ---------- **Identity no:** ---------- **Sowing date:**----------

Bed no: ---------- Amount sown:----------

Pre-treatment:----------

Germination Date started: --------- Approx. number:----------

Transplanting Date carried out: --------- Number:----------

Bed no: ----------

Root pruning Dates:----------

Spacing out Date:----------

Diseases/pests:----------

Other notes:----------

Distribution record

Date	Number	Location	Notes

Nursery registers

Seed Identification Register

Name of nursery: ----------

Date supplied	Identity number	Species	Quantity (kg)	Source: location and seed lot	Supplier	Date collected

Session-22

Site Preparation and Spoil Disposal

Site preparation

Site preparation is the preparation of the site ready for civil structures and for planting under the required bio-engineering treatment.

The surface should be clean and firm, with no loose debris. It must be trimmed to a smooth profile, with no vertical or overhanging areas. The slope should be ready for planting

Site preparation

Why is site preparation important for bio-engineering?

- Plants need a good environment in which to become established;
- Bio-engineering measures take a few years to reach full strength, so the slope surface should be stable enough to survive during this period;

Site preparation

Why is site preparation important for bio-engineering?

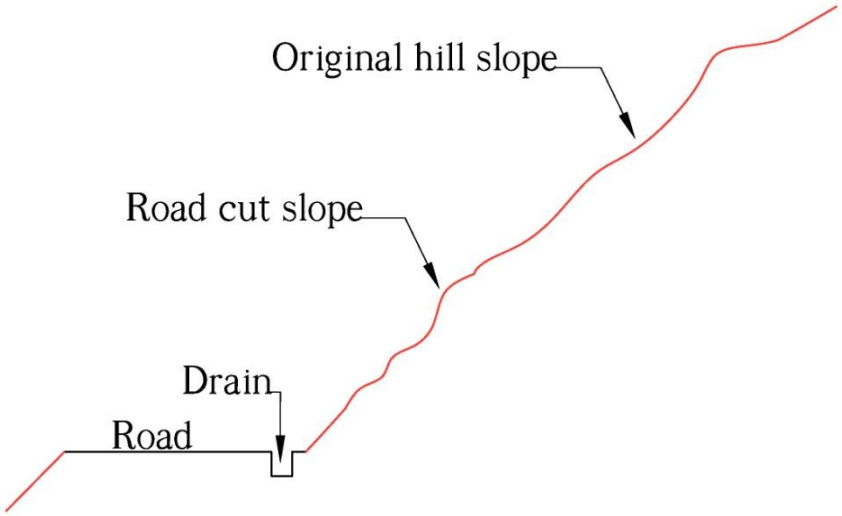
- Vegetative structures generally have a lower factor of safety and the slope stability is more marginal. Therefore careful preparation is more important than for civil works, which are usually over-designed to increase the factor of safety,
- Care should be taken over all site preparation works, not just for bio-engineering.

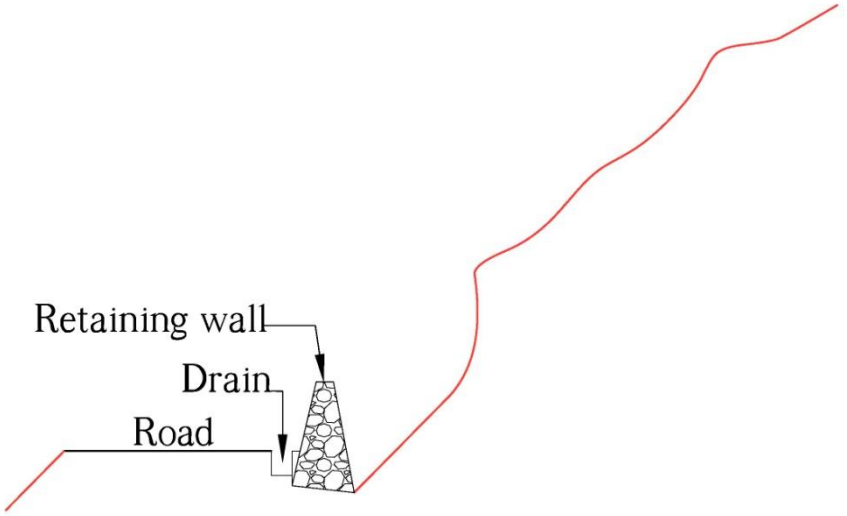
Site preparation

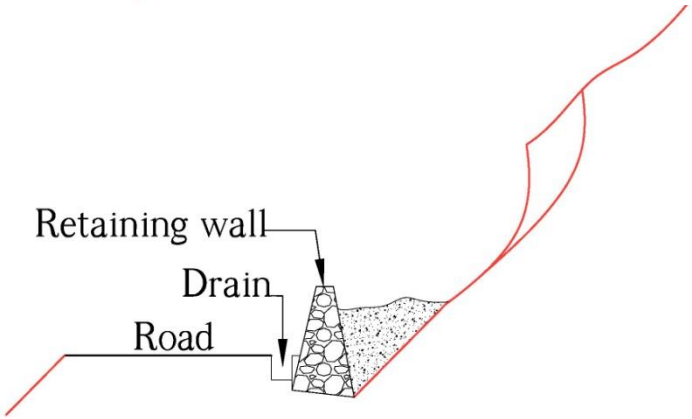
Activities involved in site preparation

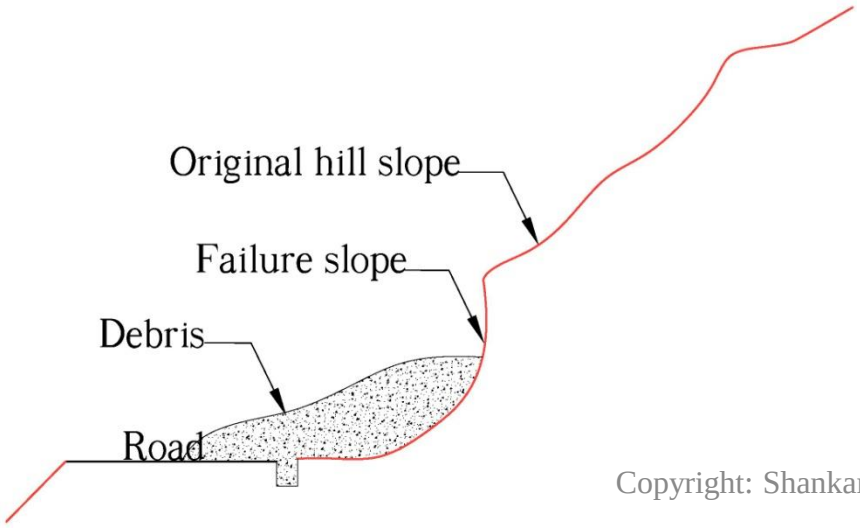
- trimming the slope;
- backfilling of structures;
- cleaning the surface, particularly to remove all loose debris;
- final tidying ready for planting.

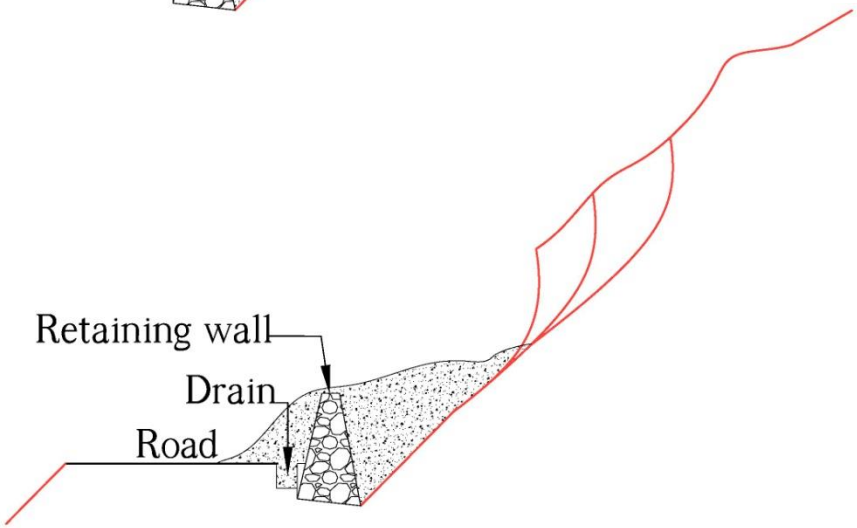
Site preparation



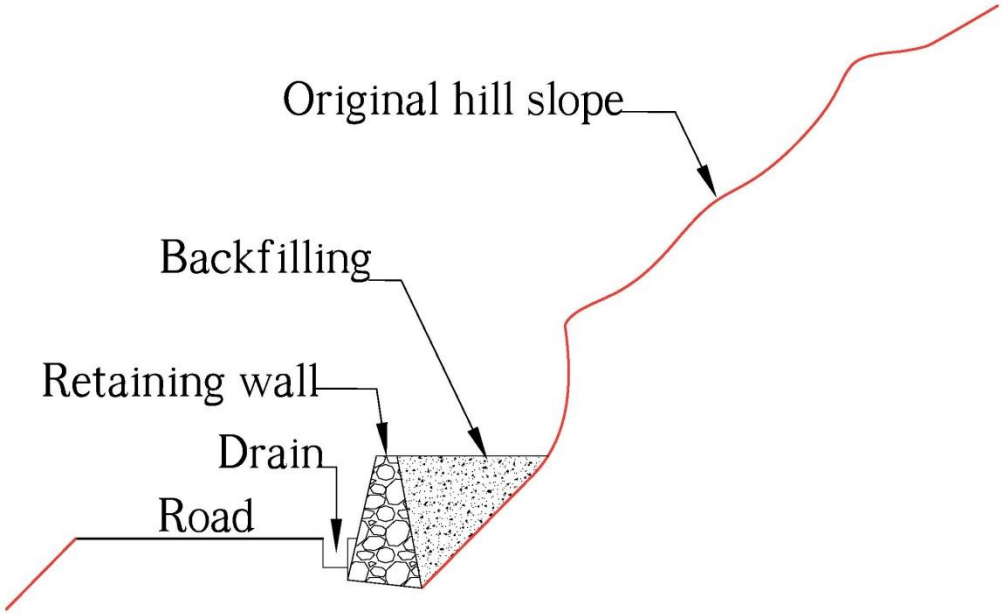


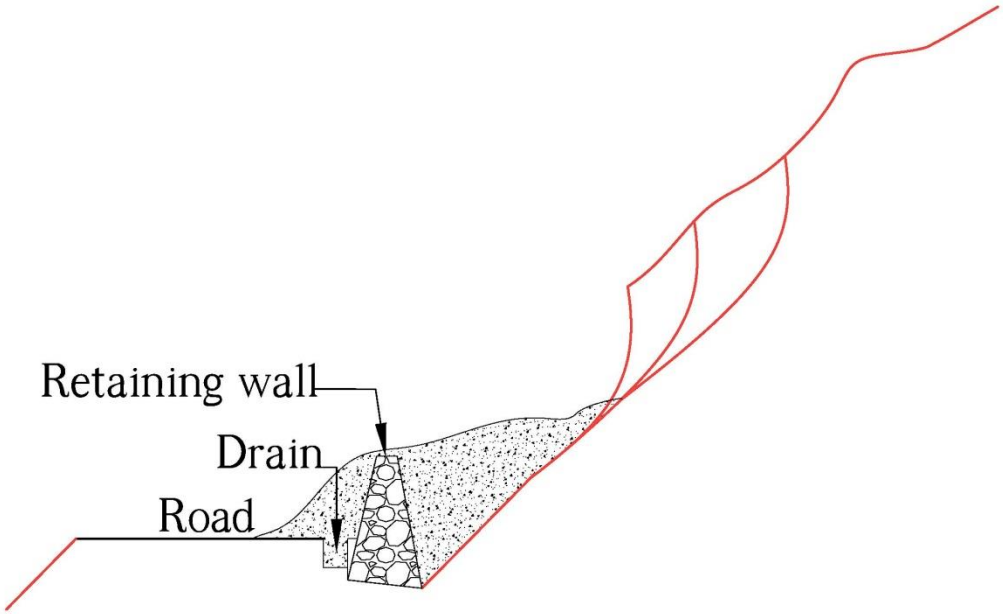




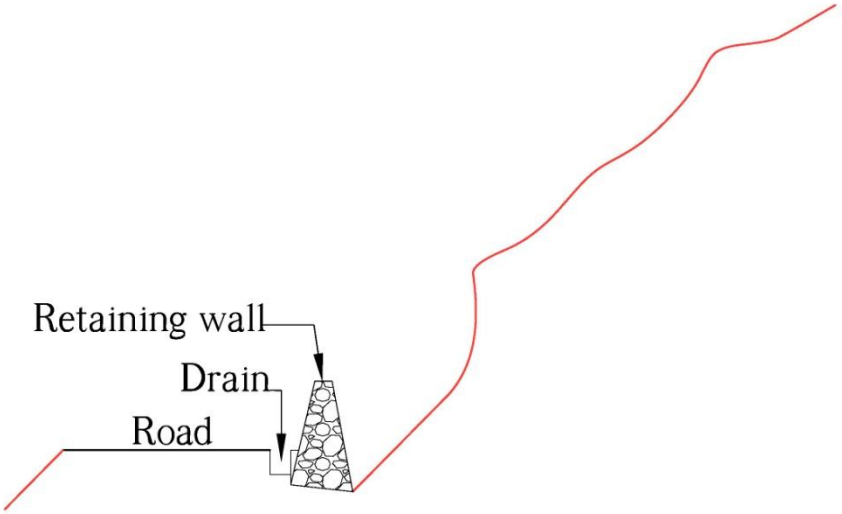


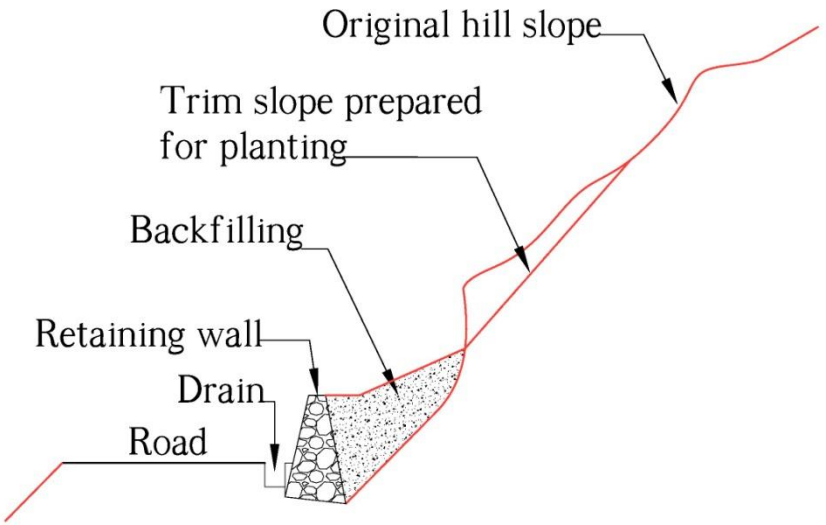
Site preparation

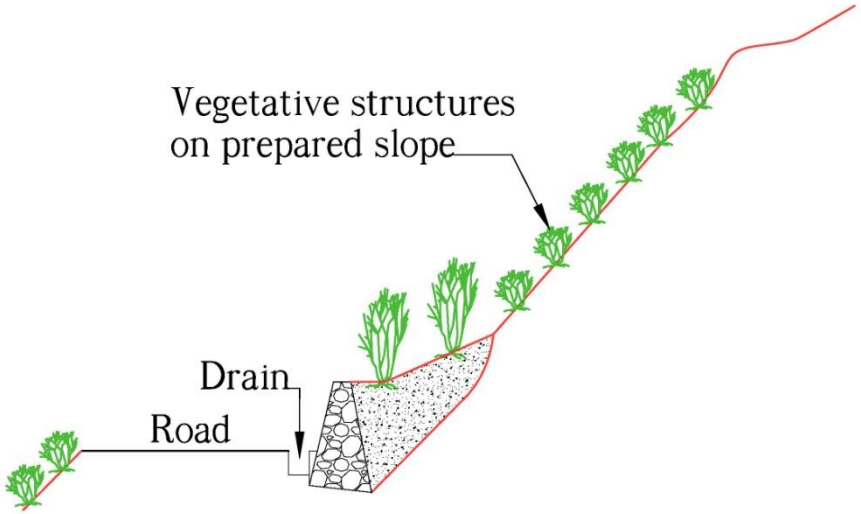




Site preparation







Site preparation

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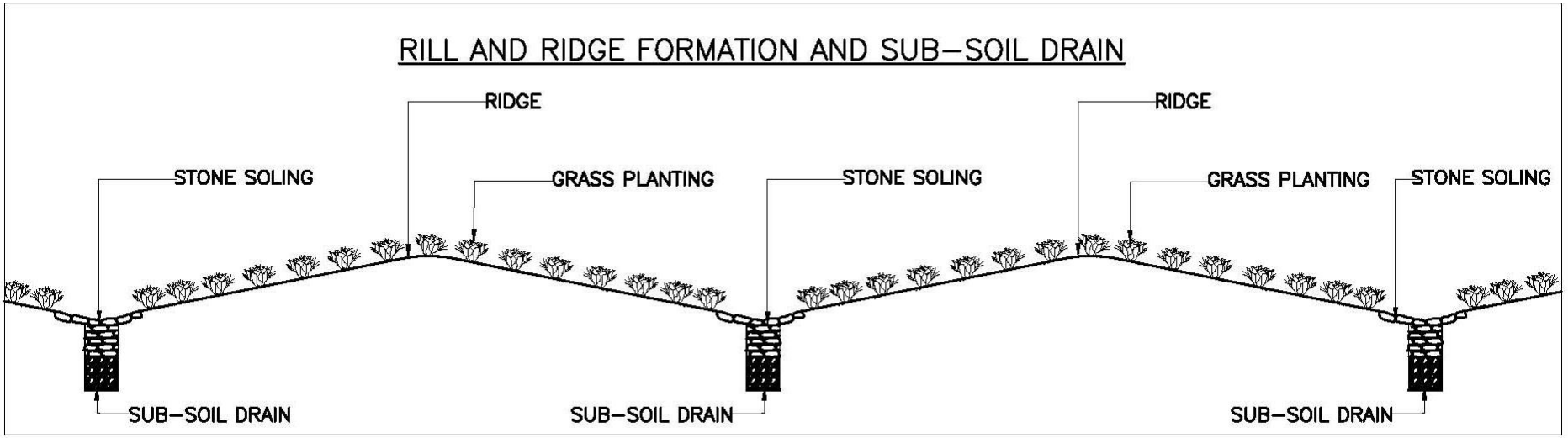
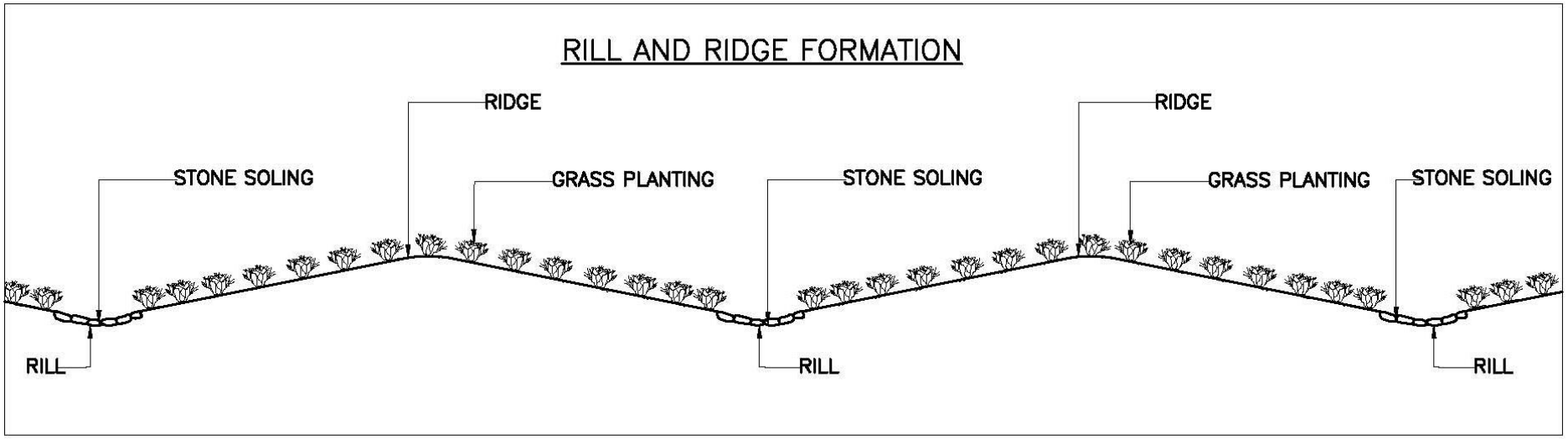




Spoil disposal

What most often triggers erosion, triggers shallow plane failures below roads and causes huge amounts of damage to neighbouring land?

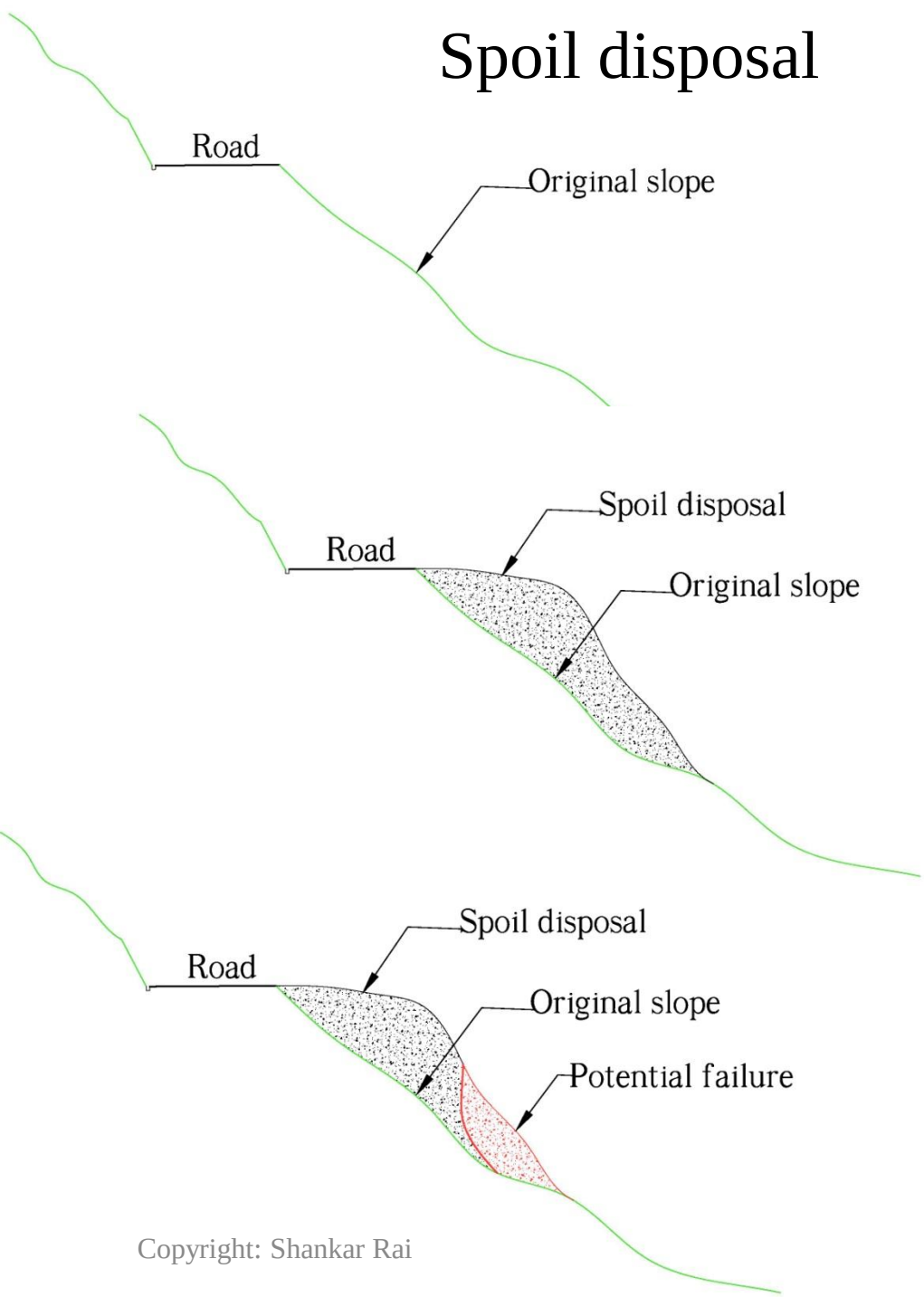
Careless disposal of spoil.

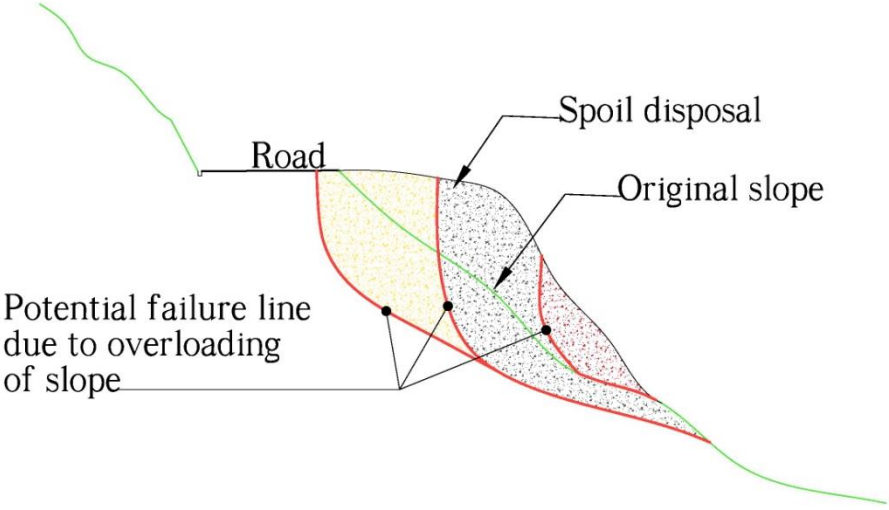
Spoil disposal

Spoil disposal

Spoil disposal

Spoil disposal





Session-23

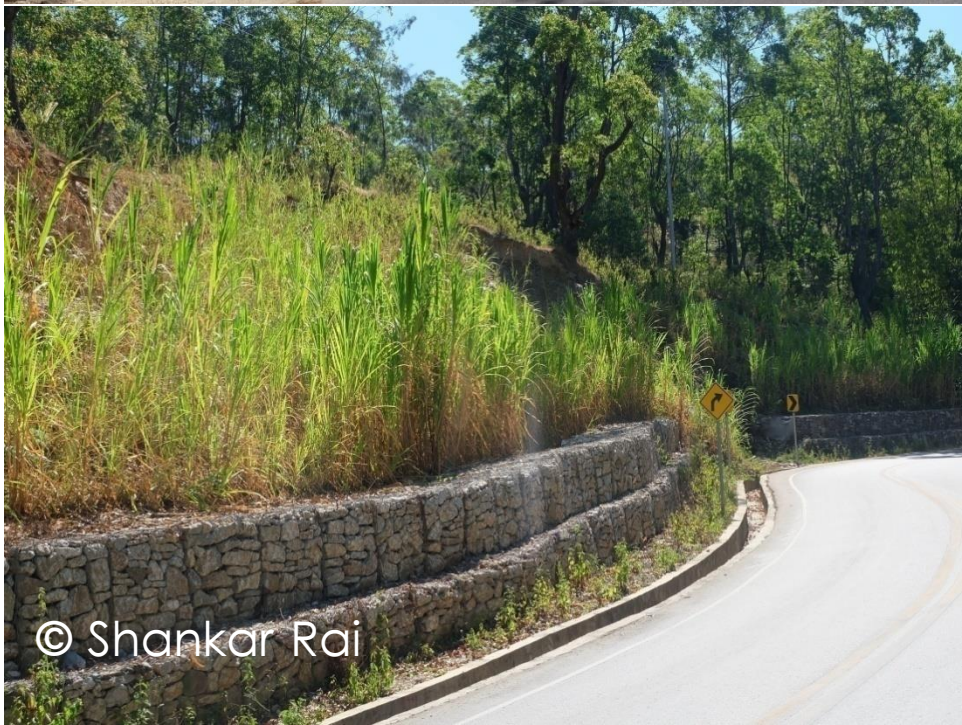
Construction of Vegetative Structures

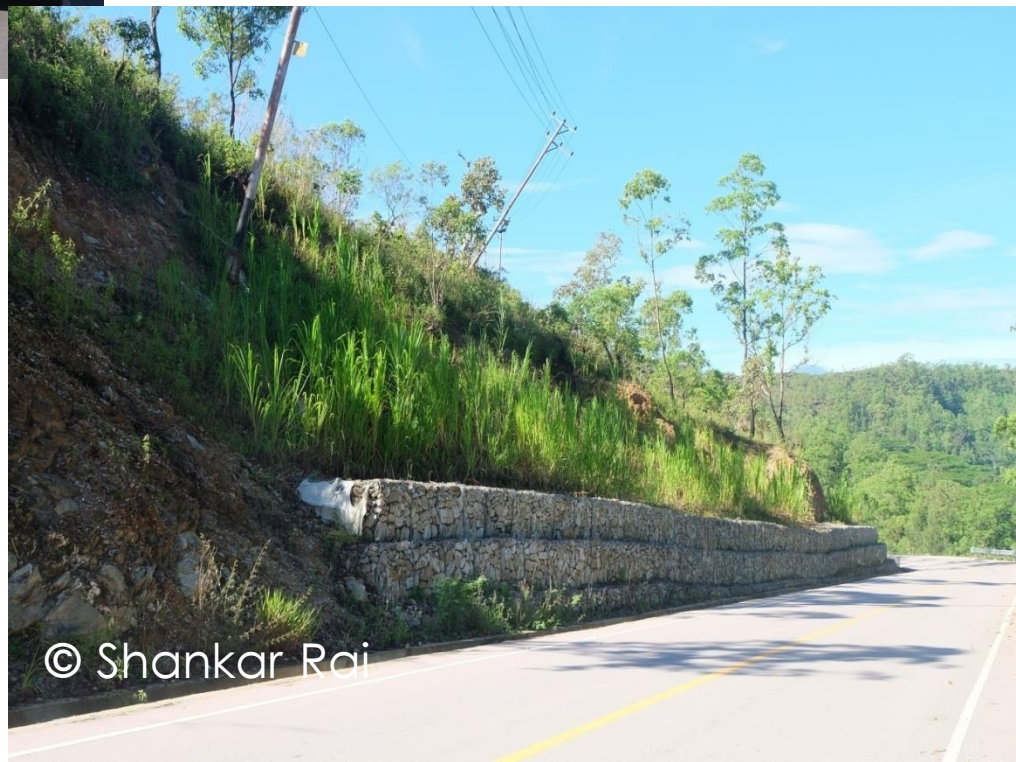
Construction of vegetative structures

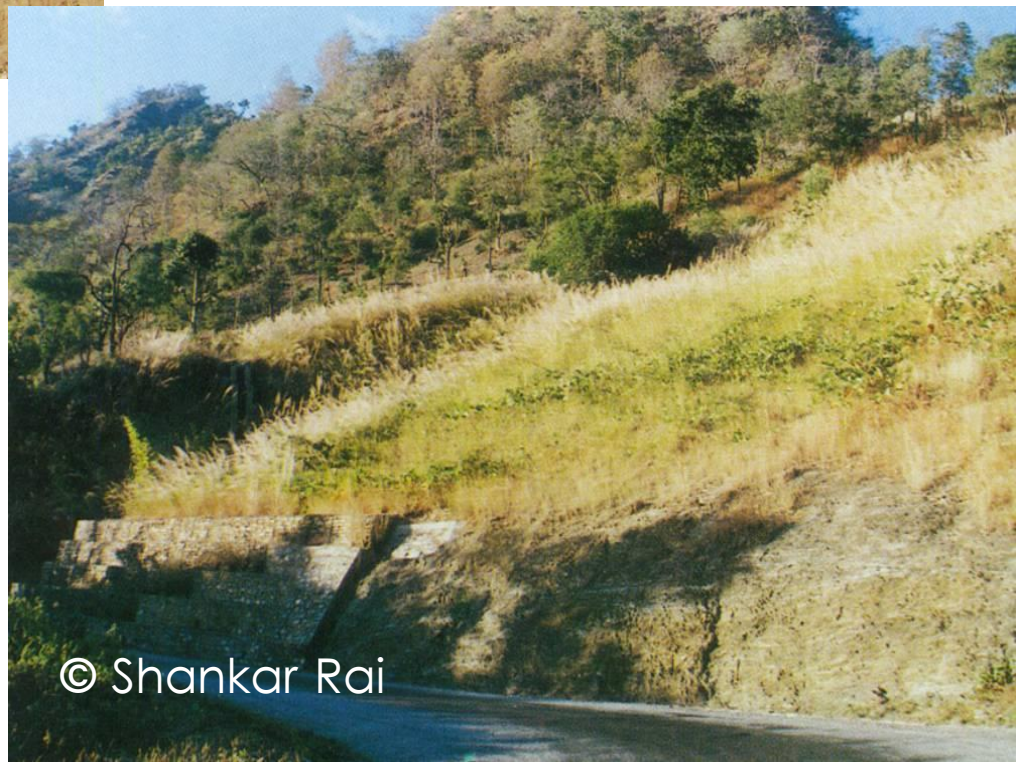
Construction of vegetative structures video

Session-24

Application of Bio-engineering Works





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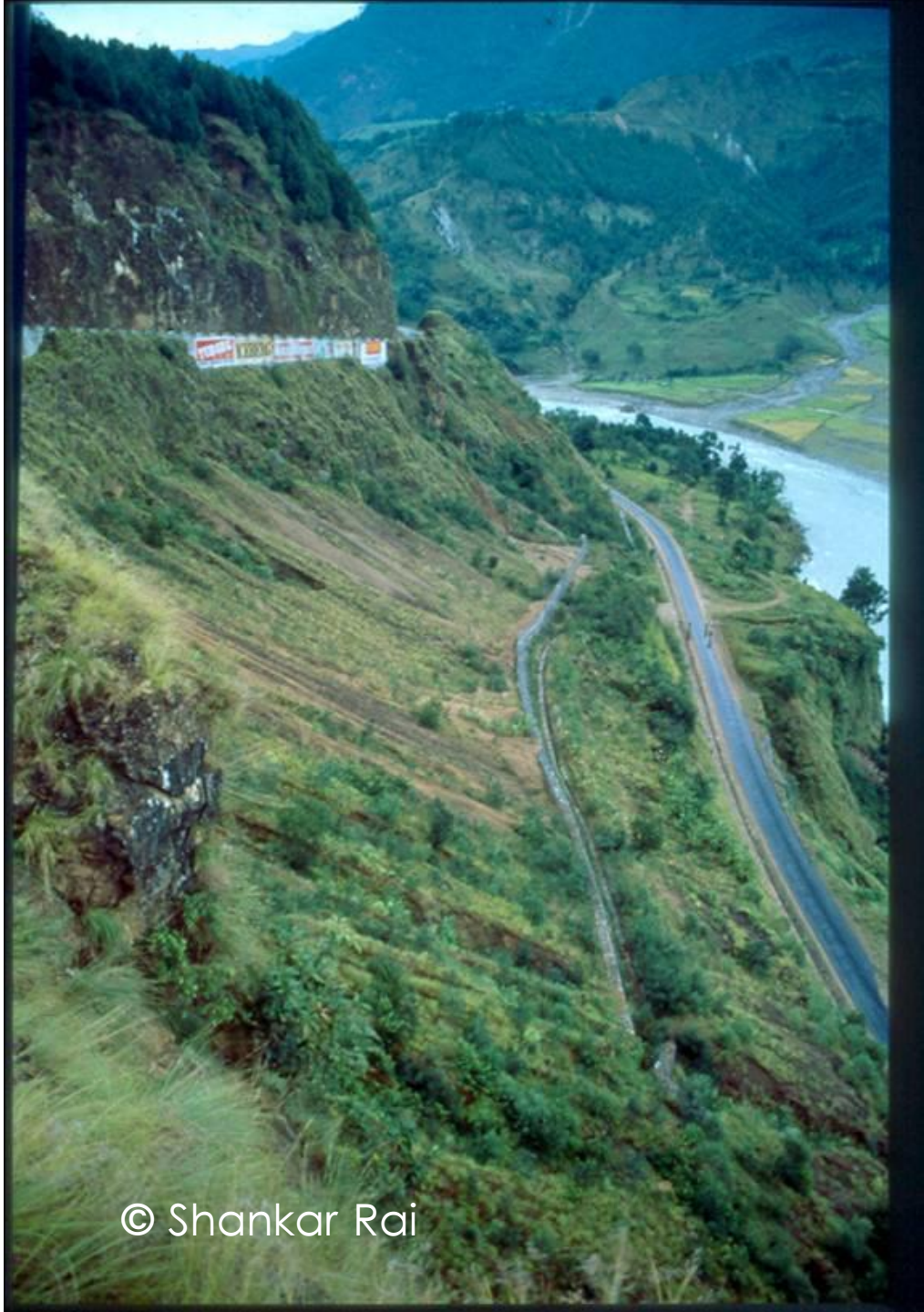
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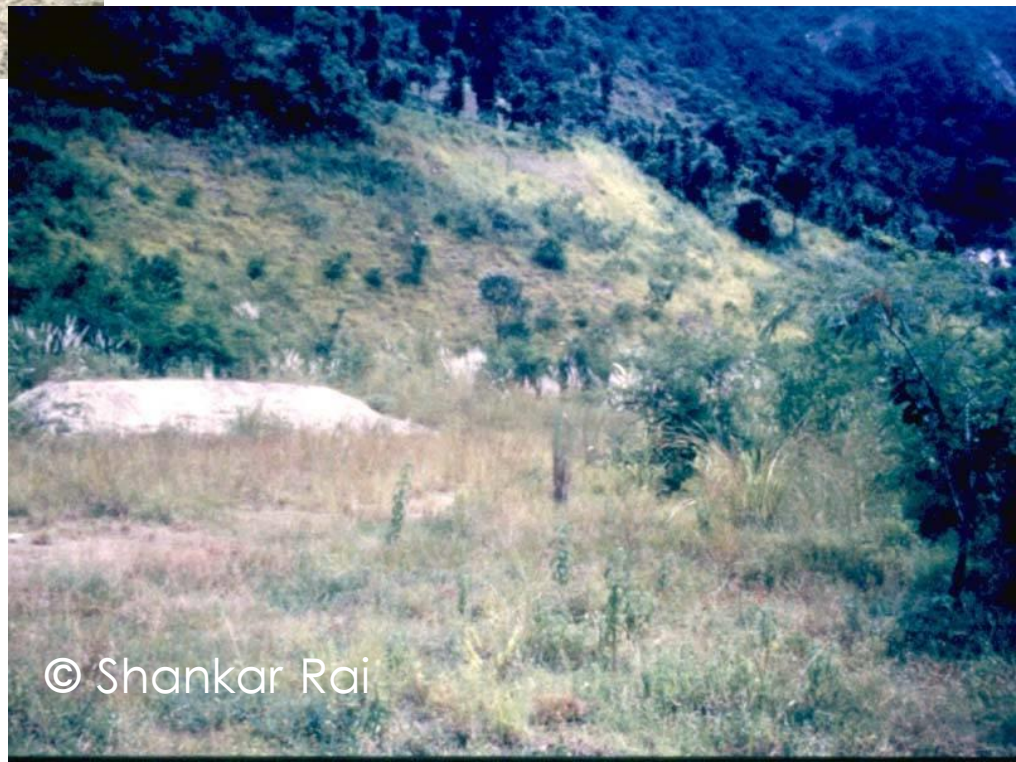
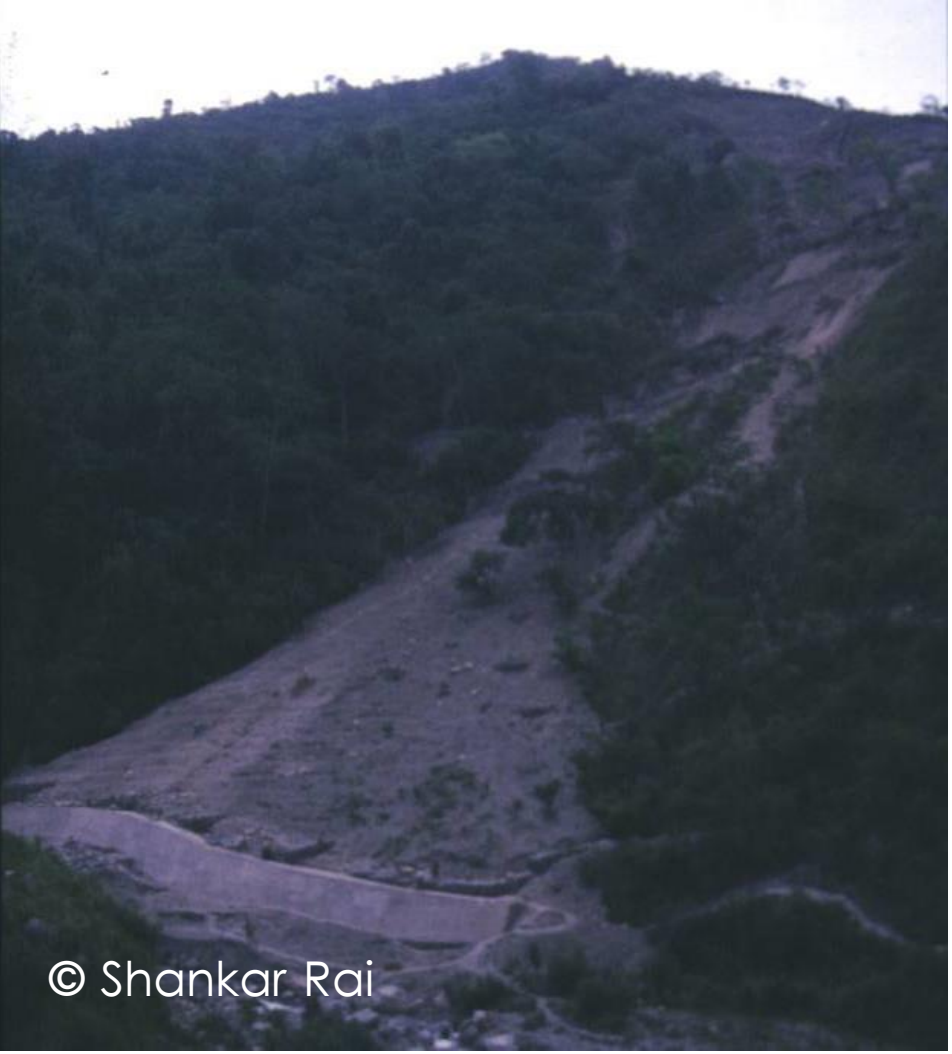
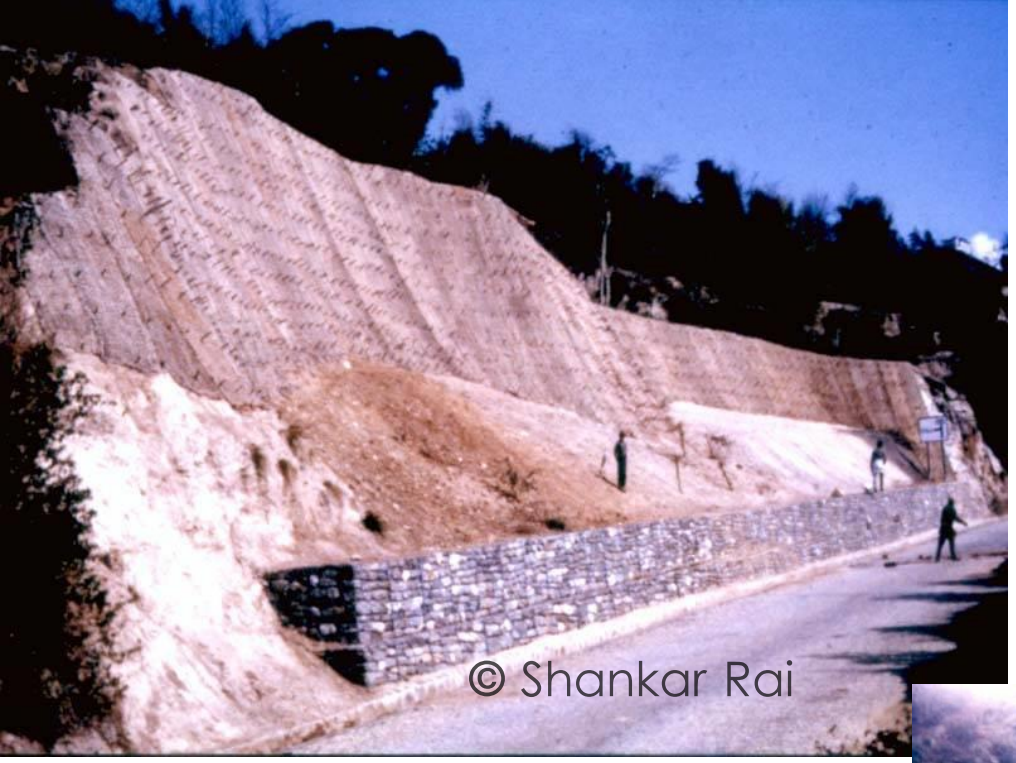






Session-25

Application of Rate Analysis Norms and Standard Specifications for Bio-engineering Works

Application of rate analysis norms and standard specification for bio-engineering works

- Bio-engineering Rate Analysis Norms
- Bio-engineering Rate Analysis Norms

Bio-engineering design and cost estimation

- Type of instability: Translational slide
- Initial cause of failure: Toe cutting

  Dimension of slide :

  - Length = 30 m
  - Breadth = 15 m

- Cause and mechanism of failure after main failure:

  Segment 01 = Surface water : undermining bottom slope

  Segment 02 = Surface water : Rill erosion

  Segment 03 = Surface water : Undermining road

Bio-engineering design and cost estimation

- Engineering function required for slope protection work:

  Segment 01 : Support, Catch

  Segment 02 : Drain, Armour, reinforce, Catch

  Segment 03 : Support

- Proposed bio-engineering measures for slope protection work:

  Segment 01 : 1) Toe wall at bottom of slope;

  2) Bamboo planting above and below toe wall.

  Segment 02 : 1) Slope trimming;

  2) Rill and ridge formation in slope and stone soling in gully floor;

  3) Grass planting in chevron pattern (fodder);

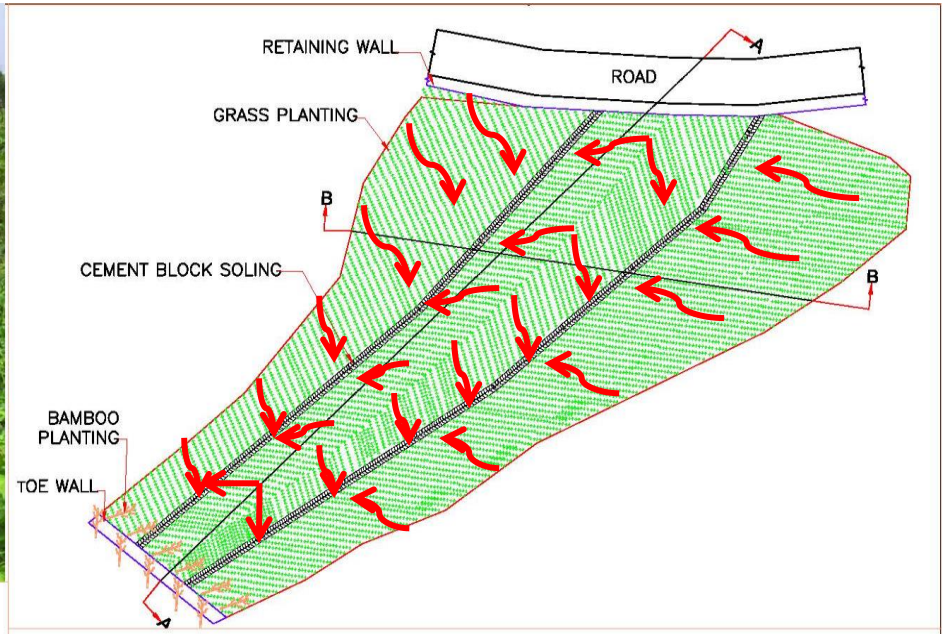
  4) Shrub planting (fruit).

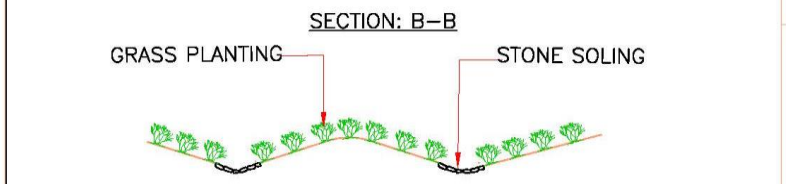
Bio-engineering design and cost estimation

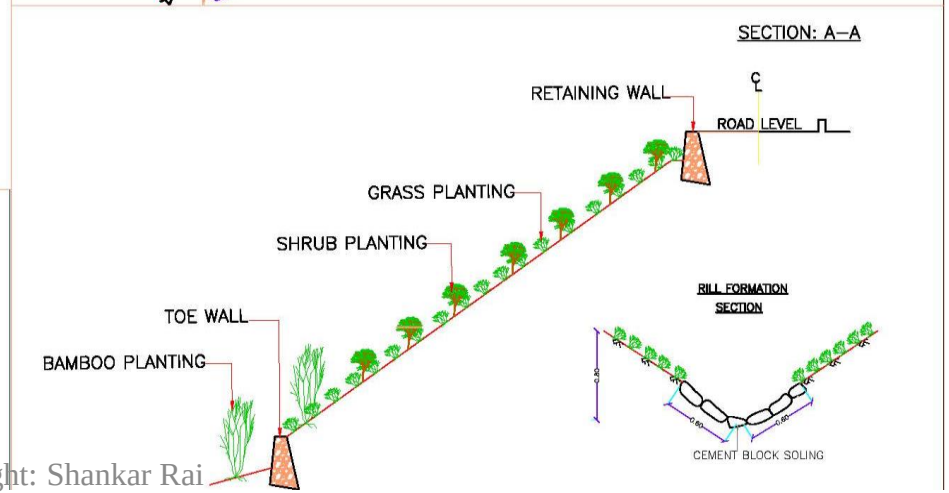
- Proposed bio-engineering measures for slope protection work:

  Segment 03 : 1) Retaining wall at valley side of road to protect and support the road bench by building below the water movement.

Bio-engineering design and cost estimation







Bio-engineering design and cost estimation

Rate Analysis for bio-engineering works

Standard specifications for bio-engineering works

Standard specification for bioengineering works


BREAK
TIME

Open Discussion

Feedback on Training

Feedback on Training by Participants

Thank you for your kind attention

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