

MANUAL OF FOREST ROAD MAINTENANCE AND SOIL EROSION CONTROL

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DECEMBER 1992



Sabah Forestry Development
Authority



Japan International Cooperation
Agency

Sabah Re-Afforestation Technical Development
And Training Project

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MANUAL OF FOREST ROAD MAINTENANCE AND SOIL EROSION CONTROL

This manual of Forest Road Maintenance and Soil Erosion Control contains three main sections. The first section discusses the basic structural design of forest road and the causes of its destruction. The second section covers the aspect of controlling water flow and the last section covers the various techniques in slope protection.

SECTION I

Forest road

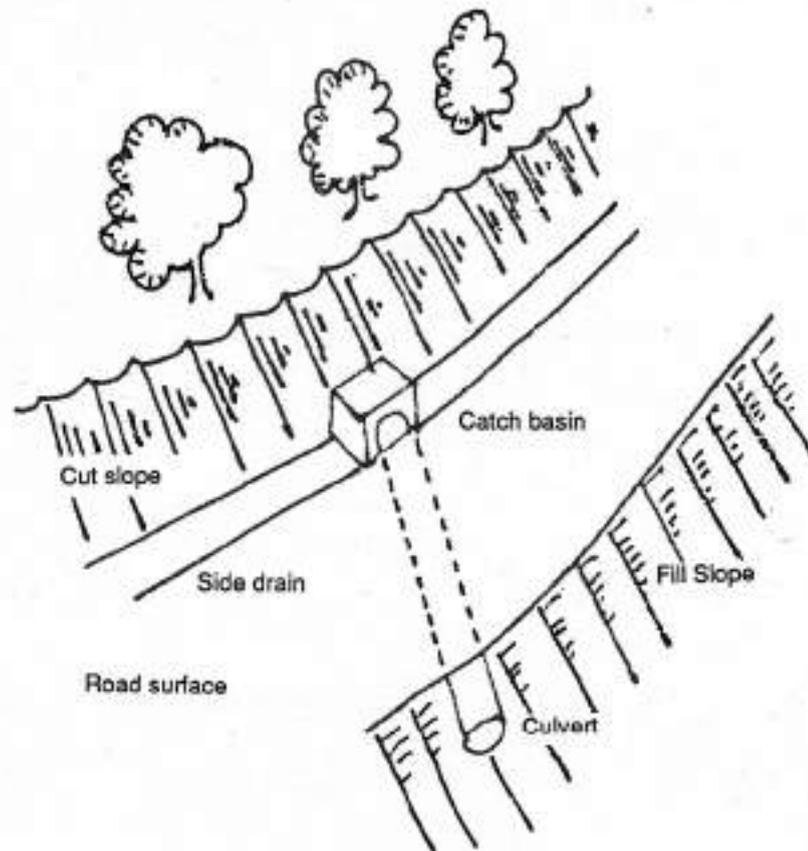
Forest roads are an indispensable means for carrying out daily plantation works and also for emergency cases like fire fighting. Therefore it is justifiable that forest road be kept and maintained in good condition always.

A. Road inspection patrol

To ensure that forest roads are in good condition, it is advisable that forest roads be patrolled at regular intervals or after heavy downpours. By doing so we can identify and locate any bad sections on the road at an early stage.

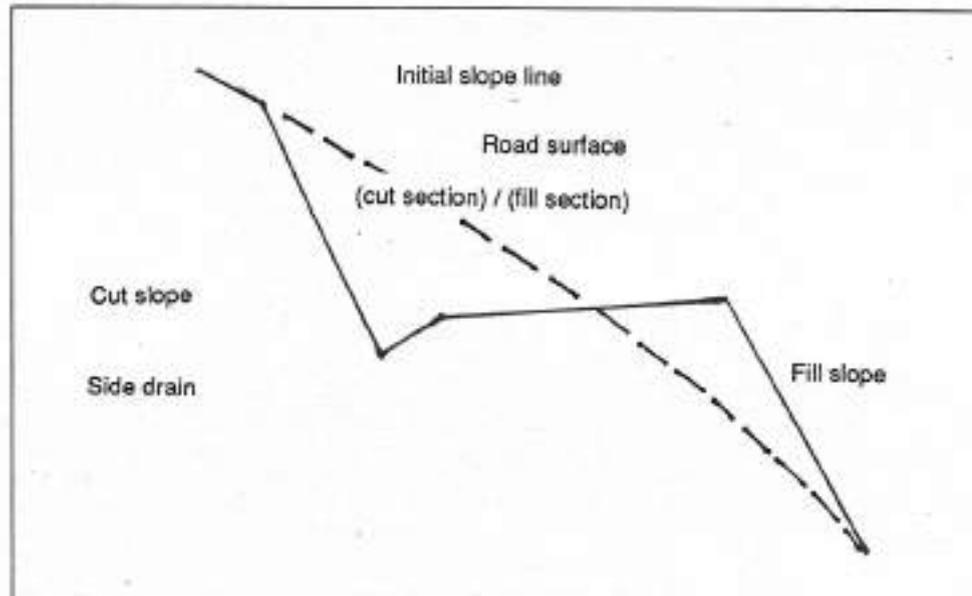
It is important for the patrolling staff to be familiar with the road structure, causes of road destruction and points that need to be checked when patrolling. Standard forest road structure is shown in Figure I.

Figure I. Standard forest road structure.



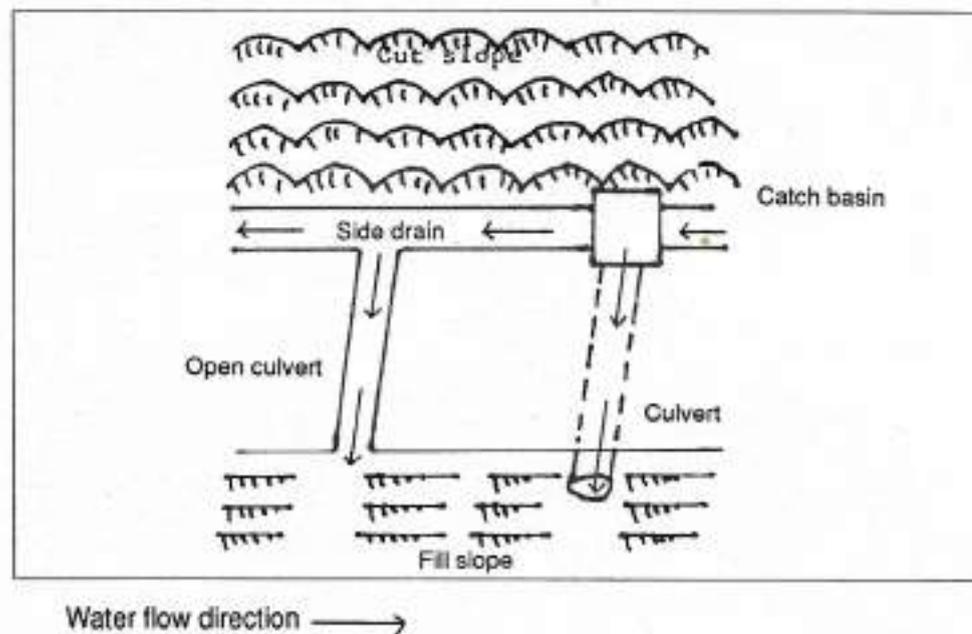
Road is normally constructed on hilly terrain by cutting an upper slope and filling (banking) a lower slope. Therefore the road surface consists of two sections; cut section and fill section. The fill section is less stable than the cut section. See Figure 2.

Figure 2. Cross section view of forest road.



The side drain and the culvert control the water flow thus making the road drier. Rainfall gathered in the drain and are discharged through the culvert. See Figure 3.

Figure 3. Plane view of forest road.

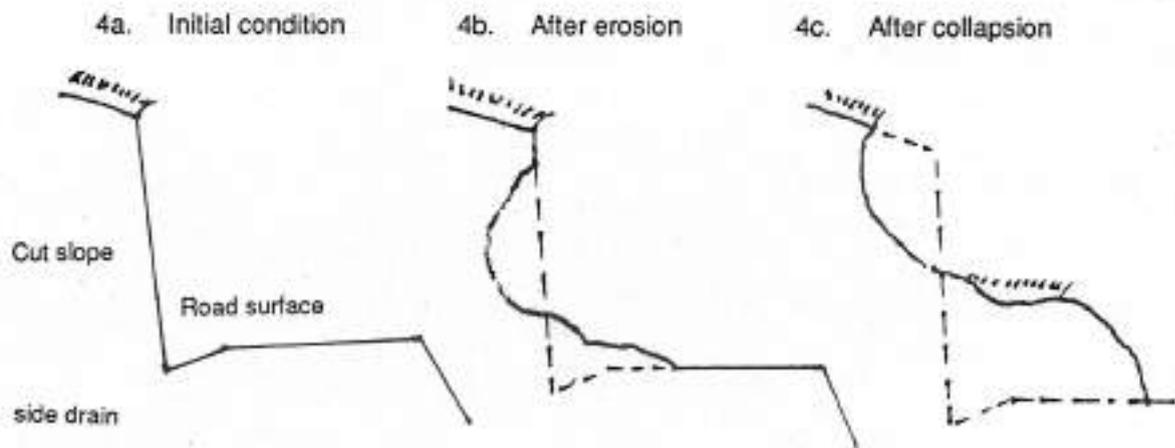


B. Causes of road destruction.

(i) Cut-slope.

The collapse of cut-slope happens through the gradual weakening by rain water erosion. See Figure 4a, 4b and 4c and Picture 1.

Figure 4a, 4b and 4c. Stages in the development of a collapse cut-slope.



PICTURE 1



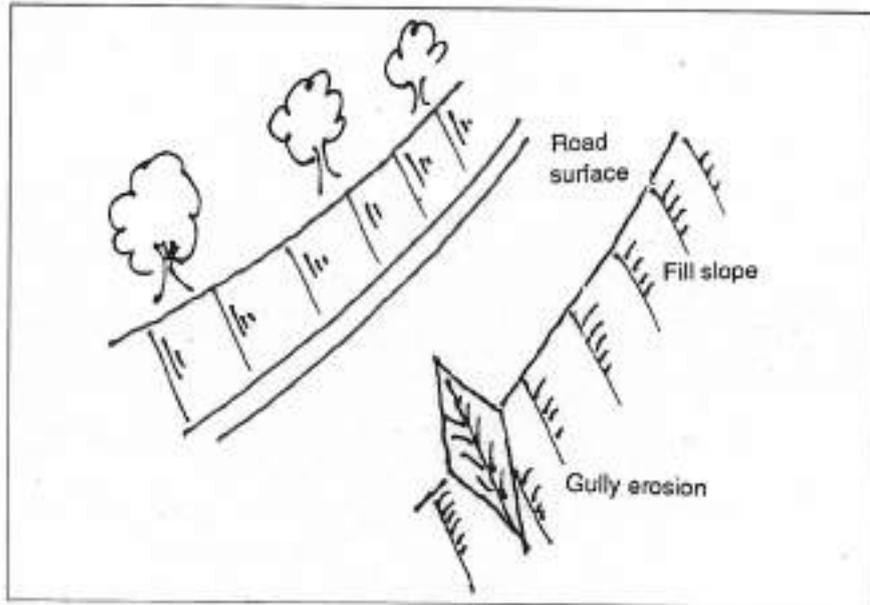
The collapse cut-slope makes vehicles impassable at times. Water flow is also obstructed because of covered drain.

Covered side drain could result in road surface erosion.

(ii) Fill-slope.

Fill-slope erosion is more serious compared to cut-slope erosion. Typical fill slope erosion is that of gully erosion. See Figure 5 and Picture 2.

Figure 5. Fill-slope erosion.



PICTURE 2



Underground water scouring is also the main cause of fill-slope destruction. Road surface cracks tend to form between the cut-and-filled surface. Water seeps through these cracks and finally a land slide occurred. See Figure 6a and 6b.

Figure 6a. Initial condition

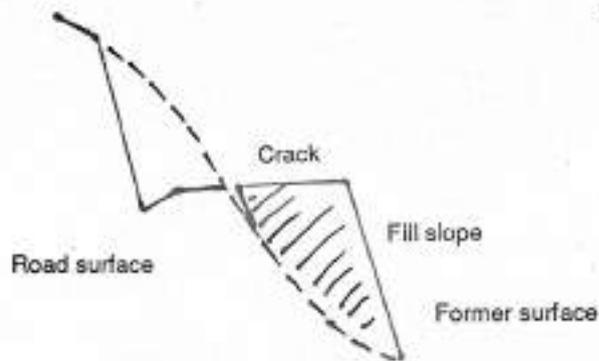
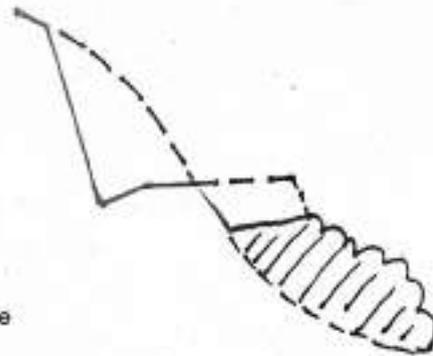


Figure 6b. After landslide



(iii) Drainage system.

Side drains on steep road section (more than 10% grade) tend to be heavily eroded. The erosion can sometimes makes it dangerous for vehicles to pass through. On gently graded sections, sometimes water cannot flow through because of soil deposits in the drain. Water will flow onto the road surface and makes it muddy or eroded. See Picture 3 and 4.

PICTURE 3



PICTURE 4



C. Road patrolling purposes.

The following points must be checked for when conducting road patrolling:

- a. Cut-slope - erosion, collapse and landslide.
- b. Fill-slope - erosion, cracks and landslide.
- c. Drain - erosion, soil deposition and debris.
- d. Road surface - erosion, and cracks.

SECTION II

The techniques and methods of controlling water flow.

The ten water-flow control examples given in this manual are specifically designed for large scale forest conservation project. But these examples can be modified to fix a smaller and simple design for application to road maintenance.

Example 1. Concrete check dam.* See Figure 7a, 7b, 7c and Figure 5.

Functions:

1. To make the slope of the valley floor gentler.
2. To stabilize the foot of mountain (hill).
3. To decrease downstream deposition of soil.

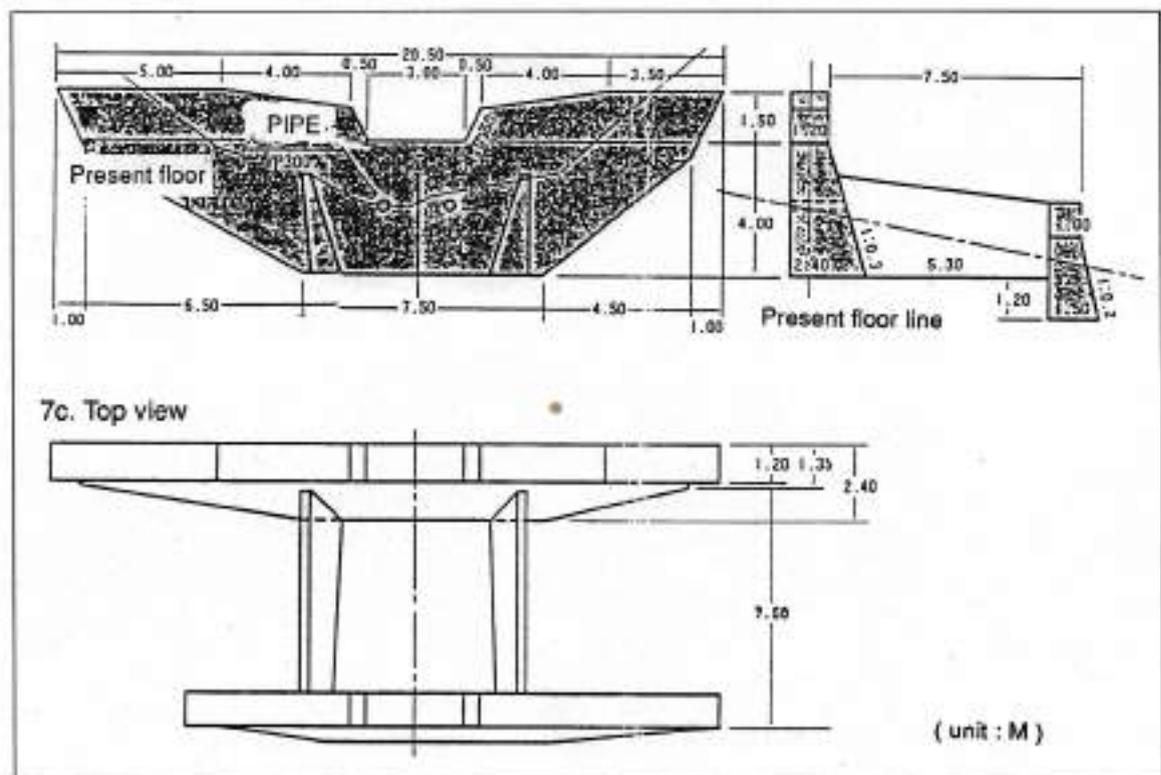
Remarks:

1. Concrete check dam is most effective if installed in group like stairs arrangement.
2. The height of check dam must be lower than the former floor before erosion.

Figure 7. Design of concrete check dam.

7a. Front view.

7b. Side view



PICTURE 5.



Application of check dam to road maintenance:

Instead of concrete check dam, gabions or round logs can be utilize as the construction material but the durability becomes less. See Figure 8a and 8b, and Figure 9a and 9b.

Figure 8a and 8b. Check dam using gabions and rocks.

8a. Front view.

8b. Side view.

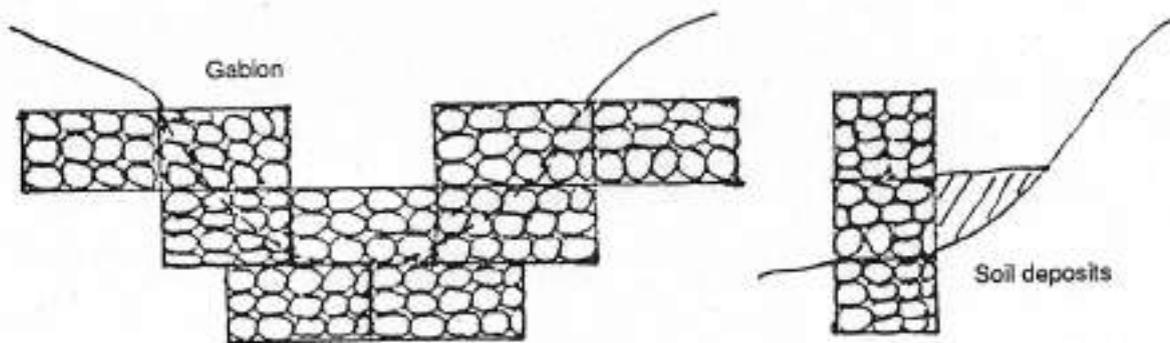


Figure 9a and 9b. Check dam using logs.

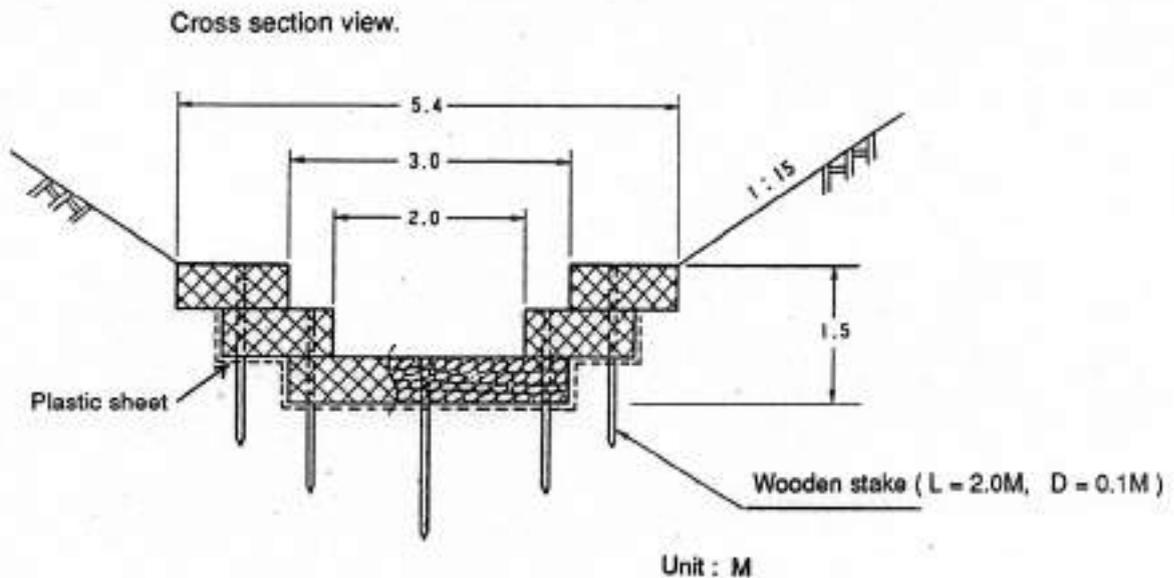
9a. Front view.

9b. Side view.



2. Gabions must be fixed well onto the ground with longer stakes in steep sections, because gabions tend to slide down.
3. On stable ground, the plastic sheet covering sandwiched between the gabion the soil can be omitted.

Figure 11. Design of gabion drain.



Amount of material for 6 M long gabion drain:

1.	Gabion (13CM mesh)	120 x 50 x 200 CM	=	4 pieces.
		120 x 50 x 300 CM	=	5 pieces.
		120 x 50 x 400 CM	=	4 pieces.
2.	Wooden stakes	D = 10 CM, L = 2 M	=	17 pieces.
3.	Plastic sheet		=	38.4 M ²
4.	Rocks	Size 15 to 30 CM	=	21.06 M ³

PICTURE 6



Example 4. Log drain. See Figure 12 and Picture 7.

Functions:

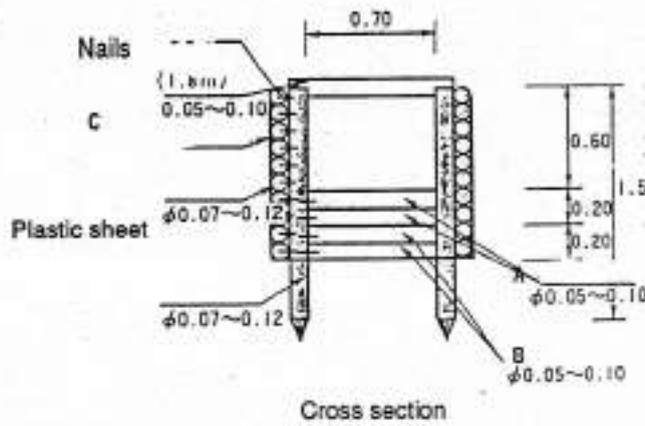
1. Protect drain from erosion.
2. Prevent water from penetrating underground.

Remarks:

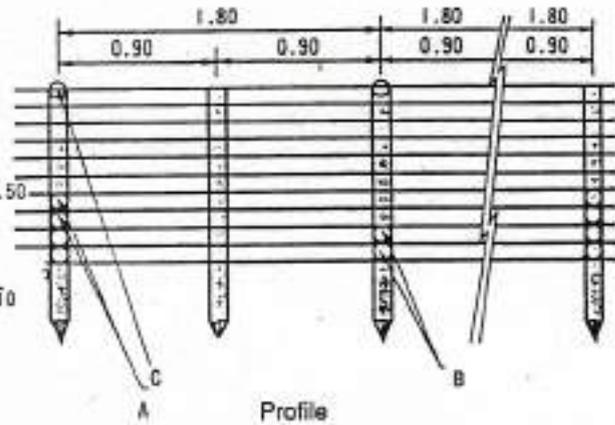
1. Due to wood flexibility, log drain is effective on unstable ground.
2. On steep section it is necessary to cover the drain's floor with stones, gabions or soil bags.
3. Since logs durability is not long, it is recommended to use vegetative-covering method in combination.

Figure 12. Design of log drain.

12a. Cross section view.



12b. Side view.



Amount of materials for 10 M of log drain:

- | | | | | |
|----|---------------|------------------------------------|---|--------------------|
| 1. | Round log | $L = 0.7 - 1.5$ M, $D = 5 - 10$ CM | = | 150 pieces. |
| 2. | Plastic sheet | | = | 29.0 M^2 |
| 3. | Nail | $L = 15.3$ CM | = | 10 KG. |

PICTURE 7



Example 5. Corrugated pipe drain. See Figure 13a, 13b and Picture 8.

Functions:

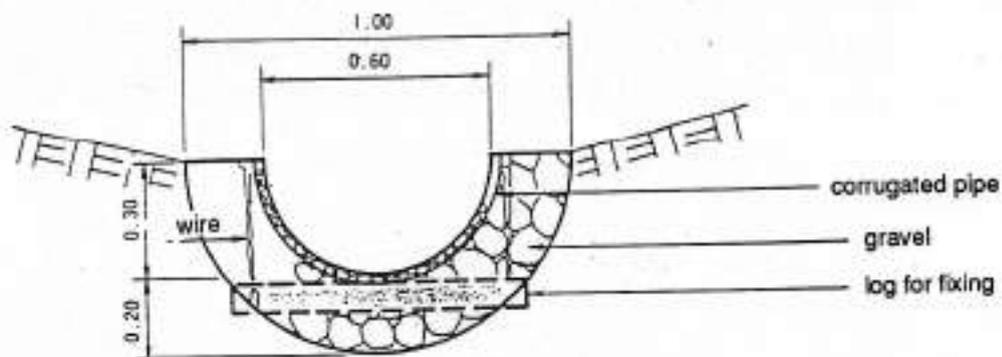
1. Protect drain from erosion.
2. Prevent water from penetrating underground.

Remarks:

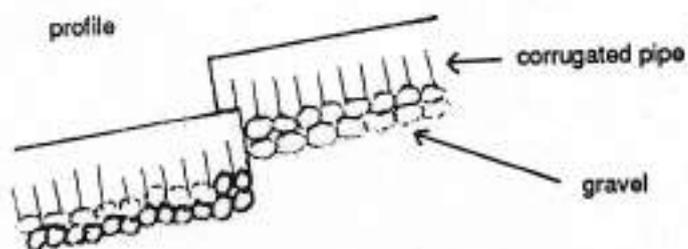
1. Corrugated pipe drain installation can be carried out easily and quickly.
2. Corrugated pipes cannot be fixed well with the ground. Gravels (20 - 30 cm in size) can be used to give the proper fitting for these culverts. The means of catching water through the gravels should be considered in the profile design.

Figure 13. Design of corrugated drain.

13a. Cross section view.



13b. Corrugated pipes arrangement on different ground level.



Amount of material for 10 M of corrugated drain:

1.	Corrugated pipe	D = 600 MM	=	10 M
2.	Gravel	D = 5 - 15 CM	=	2.5 M ³ .
3.	Log	D = 8 CM, L = 0.75 M	=	5 pieces.
4.	Wire	D = 3.2 Mm	=	0.63 KG.

PICTURE 8



Example 6. Grass mat drain. See Figure 14 and Picture 9.

Function:

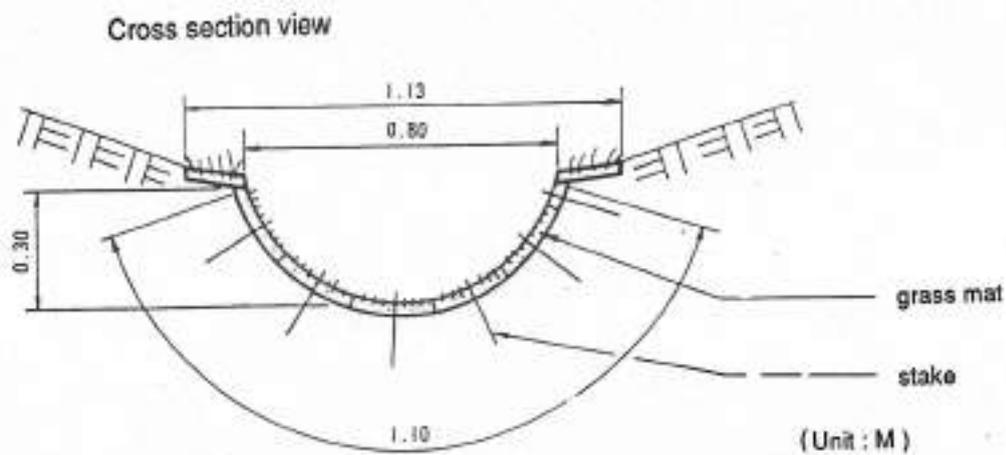
1. To protect drain from erosion on gentle slopes.

Remarks:

1. The following conditions are necessary to apply this method:
 - a. gentle slope.
 - b. small amount of water flow.
 - c. no soil deposition will occur, and
 - d. the soil is fertile.

2. Live branches of easily sprouting species like *Dillenia* spp. can be used as the fixing pegs for these grass mats.

Figure 14. Design of grass mat drain.



PICTURE 9



Example 7. Soil-bag drain. See Figure 15 and Picture 10.

Function:

1. To protect drain from erosion mainly on steep slopes.

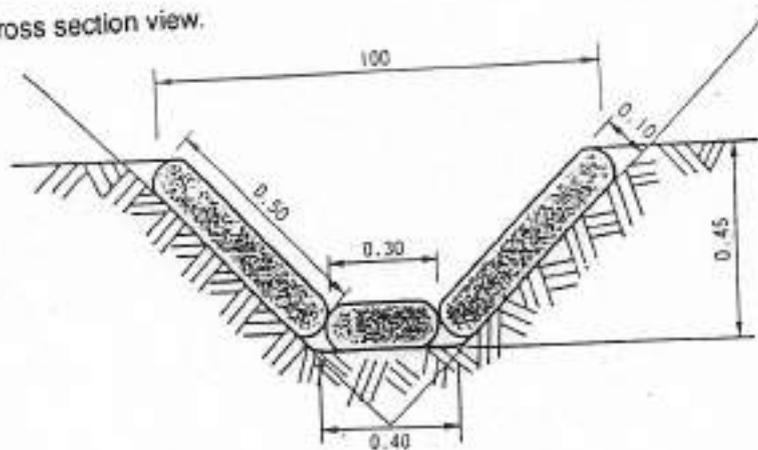
Remarks:

1. The soil bags can fit very well onto the ground.
2. The durability of soil bags are not long, it is necessary to cover the bags surface

With grass turf.

Figure 15. Soil bag drain design.

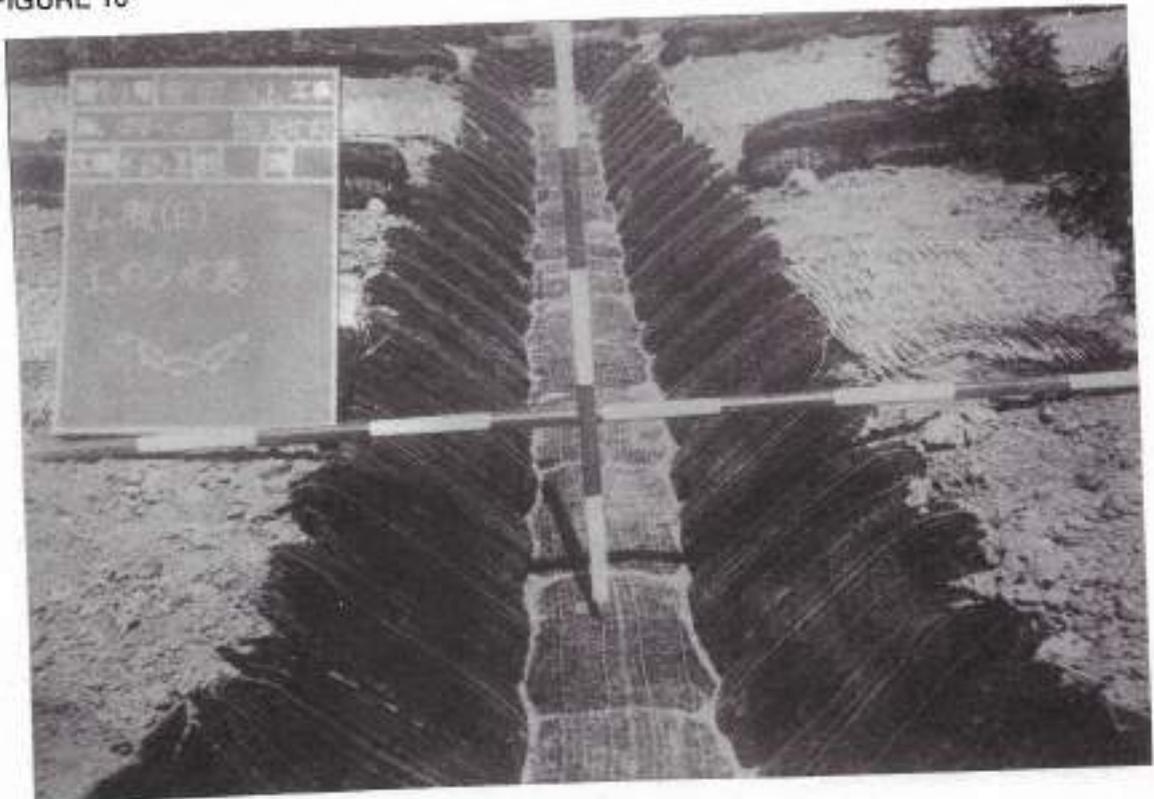
Cross section view.



Amount of materials for the construction of 10 meter long drain:

1. Soil bags with grass seeds (60 x 40 cm) = 80 pieces
2. Soil = 1.44 cubic meter.

FIGURE 10



Example 8. Gabion open culvert. See Figure 16 and Picture 11.

Functions:

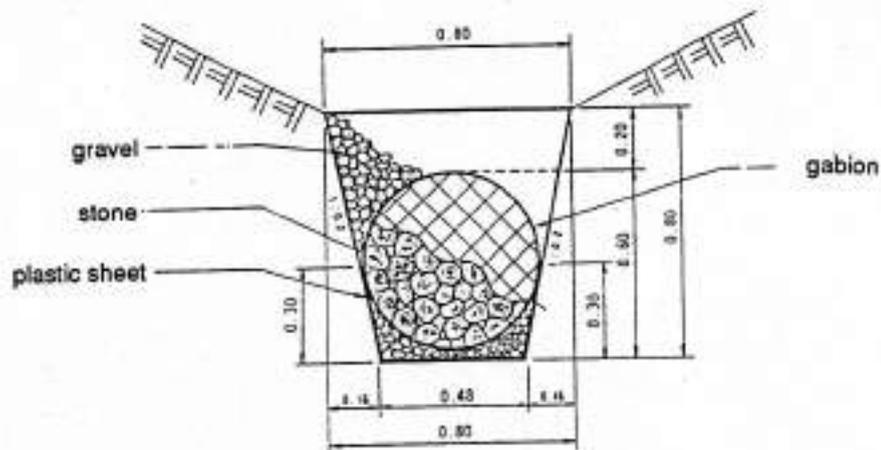
1. Drain surface and underground water in unstable ground like on landslided area.

Remarks:

1. Plastic sheet layer should be put under the gabion to prevent water from penetrating.
2. Gravels should be put on the gabion so as not to let soil be deposited in the gabion.

Figure 16. Design of gabion open culvert.

Cross section view.



Amount of material for 5 M long gabion open culvert:

1.	Gabion (mesh 13 CM)	D = 0.6 M, L = 5 M	= 1 piece
2.	Plastic sheet	1.55 MM thick	= 5.5 M ²
3.	Stones	D = 15 - 30 CM	= 1.25 M ³
4.	Gravel	D = 5 - 15 CM	= 1.25 M ³

PICTURE 11



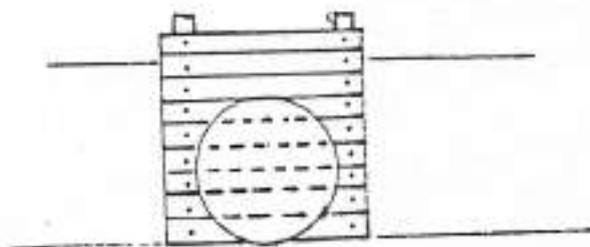
Example 9. Logs catch basin. See Figure 17a, 17b and Picture 12.

Functions:

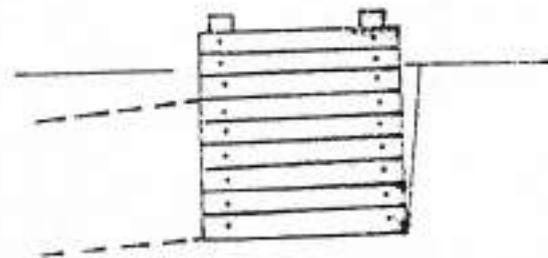
1. Protect the mouth of culverts from being filled with soil.
2. To catch the flow of water into the culverts.

Figure 17. Design of logs catch basin.

17a. Front view.



17b. Side view.



PICTURE 12.



Example 10. Simple open culvert. See Figure 18a, 18b and 18c.

Function:

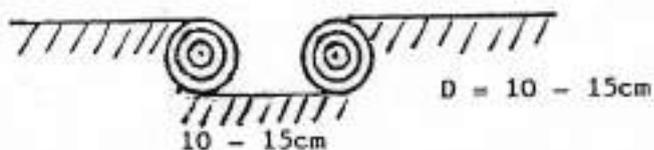
1. To drain water from the road surface.

Remarks:

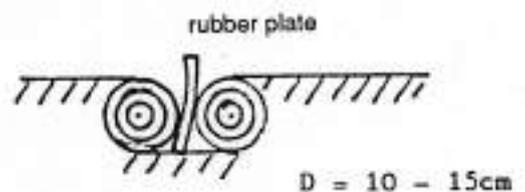
1. Open culvert should be constructed at changing points of longitudinal grade of the road.
2. The open culverts must be set at 2 - 3 % grade, this will prevent soil deposition.

Figure 18. Three different designs of simple open culvert.

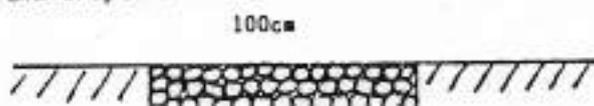
18a. Open-top pole culvert.



18b. Rubber plate with pole culvert.



18c. Gravel open culvert.



SECTION III

Slope maintenance

Slope maintenance consists of various types of work such as slope cutting, retaining wall construction, and reinforcing of slope. Some water control methods described in Section II are also necessary in slope maintenance. Eight slope maintenance methods will be presented in this section.

The first four methods are that of retaining walls.

Functions:

1. Make the slope stable and gentler.
2. Give support to channels and culverts by acting as basements.
3. Prevent surface water flow from concentrating on one way path.

Remarks:

1. Retaining wall should be constructed on solid ground because it is subjected to strong pressure from the soil and deposited soil.
2. On soft ground, light materials like wood should be used.

Method I. Wet masonry retaining wall.* See Figure 19 and Picture 13.

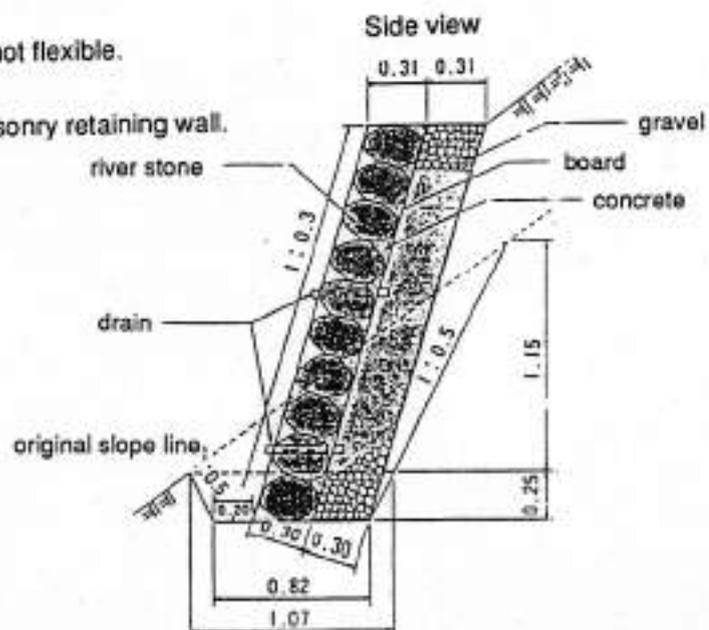
Advantage:

1. Structure is very strong and of high durability.

Disadvantageous:

1. Its high construction cost.
2. The structure is not flexible.

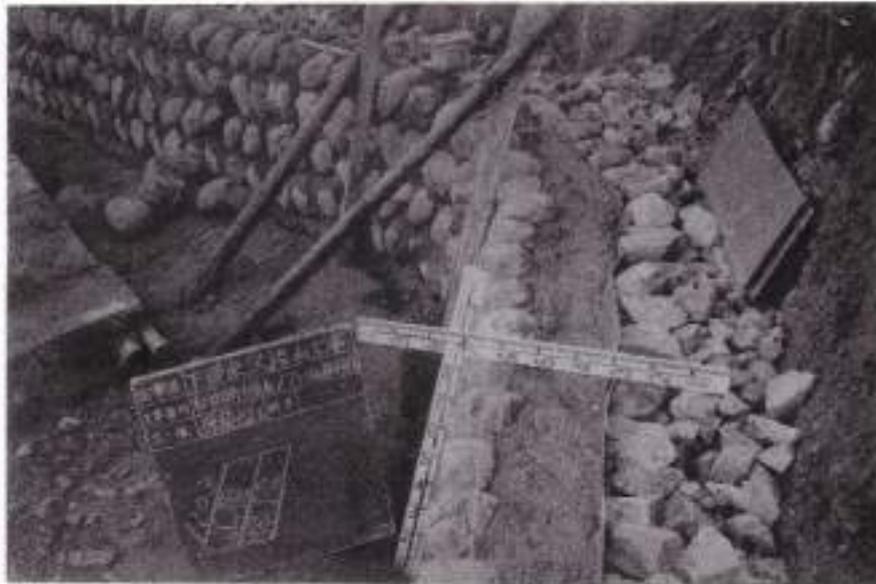
Figure 19. Design of wet masonry retaining wall.



Amount of material for 1 M² of wet masonry retaining wall:

1.	River stone	D = 30 CM	=	1.00 M ³
2.	Cement		=	0.10 M ³
3.	Gravels	D = 5 - 15 CM	=	0.30 M ³
4.	Draining pipe	D = 3.8 CM	=	0.13 M
5.	Plywood		=	1.00 M ²

PICTURE 13



Method II. Gabion retaining wall. See Figure 20 and Picture 14.

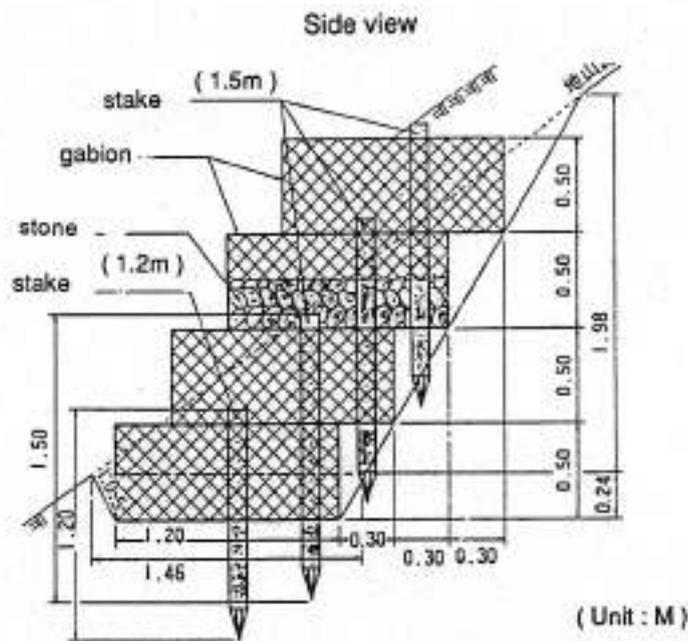
Advantageous:

1. The structure is strong and flexible.
2. Construction procedure is simple.

Disadvantage:

1. The durability is low.

Figure 20. Design of gabion retaining wall.



Amount of material for 1 M of gabion retaining wall:

- | | | | | | |
|----|-------------|----------------|--------------------|---|---------------------|
| 1. | Gabion | Mesh 13 CM | Size 0.5 M x 1.2 M | = | 4 M |
| 2. | Stake | D = 8 CM, | L = 1.5 M | = | 3 pieces |
| 3. | Stake | D = 8 CM, | L = 1.2 M | = | 1 piece |
| 4. | River stone | D = 15 - 30 CM | | = | 2.16 M ³ |

PICTURE 14



Method III. Log retaining wall. See Figure 21a and 21b, and Picture 15.

Advantageous:

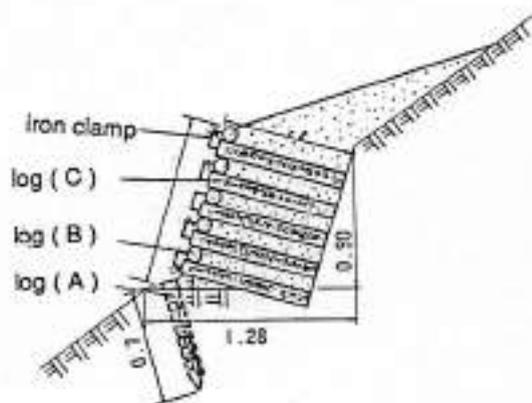
1. Simple, Light and high flexibility.
2. The construction cost is low.

Disadvantageous:

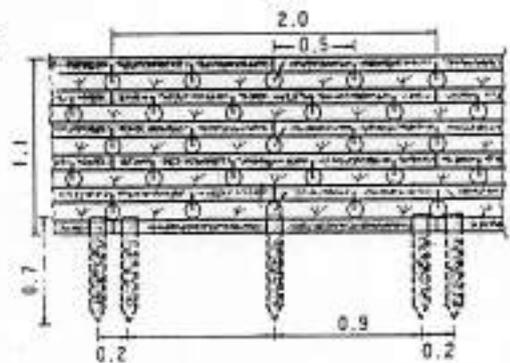
1. The durability is low. Cover plant need to be planted on wall.
2. The structure is weak.

Figure 21. Design of log retaining wall.

21a. Side view



21b. Front view



grass

PICTURE 15



Method IV. Tyre retaining wall. See Figure 22a and 22b, and Picture 16.

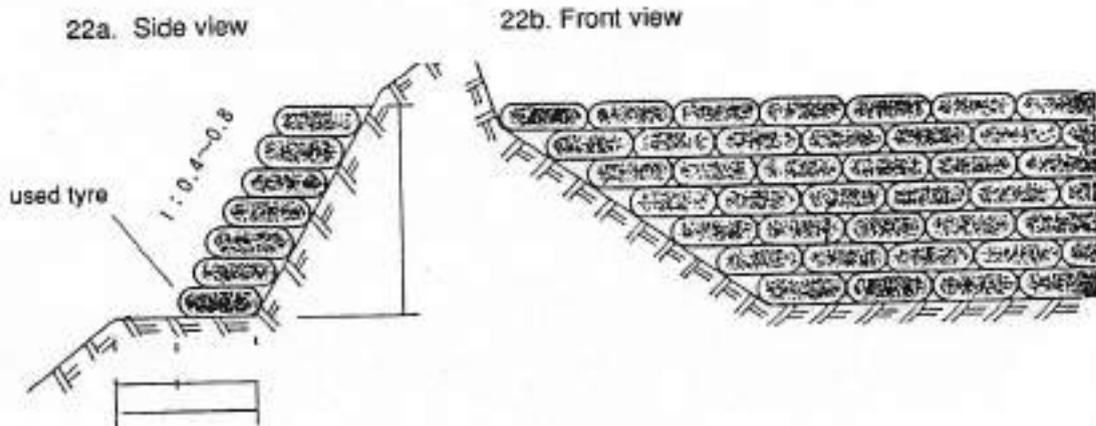
Advantageous:

1. Simple, light and high flexibility.
2. The construction cost is low.

Disadvantageous:

1. The structure is weak.
2. Many used tyres are needed for the construction.

Figure 22. Design of tyres retaining wall.



Amount of material for 10 M² of tyres retaining wall:

1. Used tyres = 90 pieces
2. Wires for tying.

PICTURE 16



Method V. Grating frame. See Figure 23a and 23b, and Picture 17 and 18.

Functions:

1. To fix the slop surface and prevent surface erosion.
2. To cover the slop surface with top soil to improve the environment for grass growth.

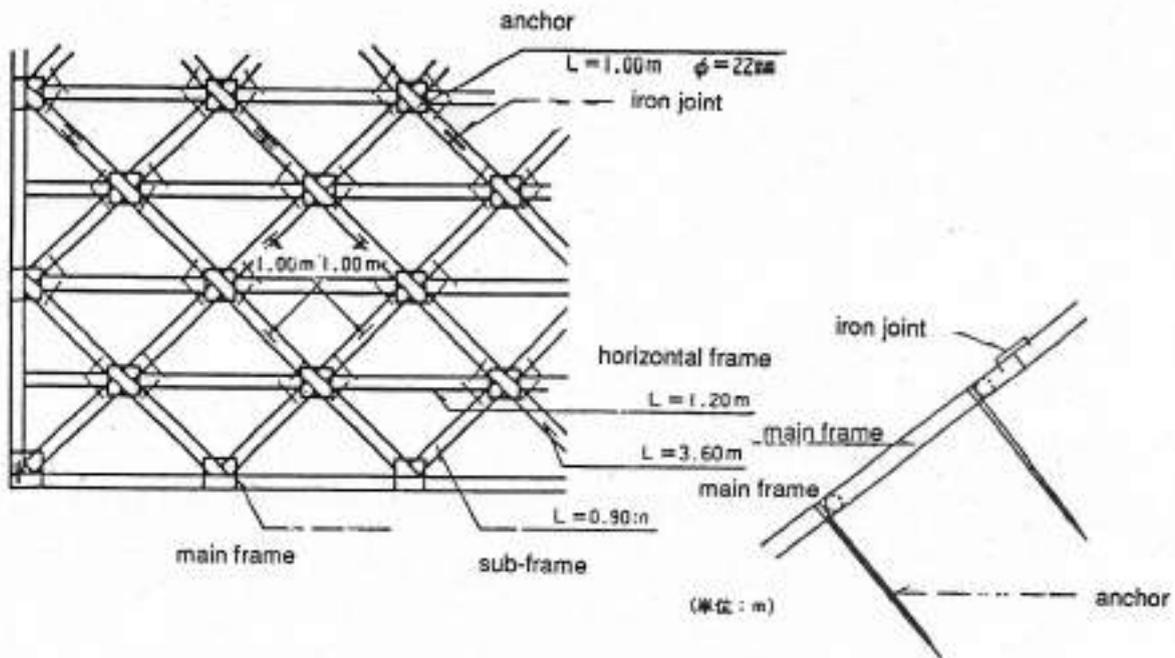
Remarks:

1. The horizontal frames should be half buried in the ground.
2. It is recommended to put seedbags or grass mats in the frames.

Figure 23. Design of grating frame.

23a. Front view.

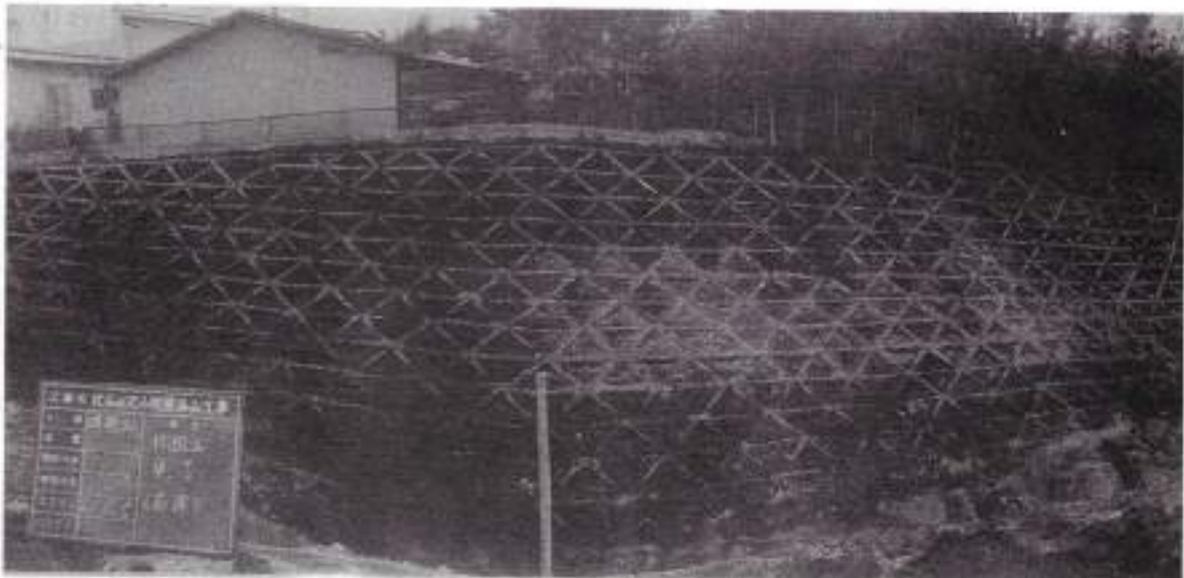
23b. Side view.



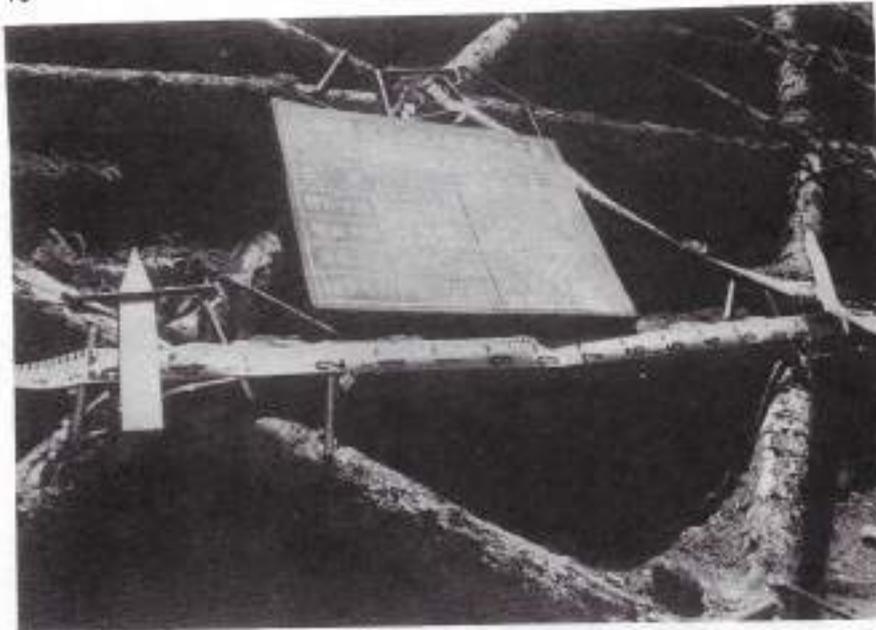
Amount of materials for 100 M² meter of grating frame:

- | | | | |
|----|-------------------------------|---|------------------|
| a. | Frame, round logs, 10 cm size | = | 1.5 cubic meter. |
| b. | U-shaped nail, 20 cm x 6 cm | = | 600 pieces. |
| c. | Anchor, 1.0 m x 22 mm | = | 100 pieces. |

PICTURE 17

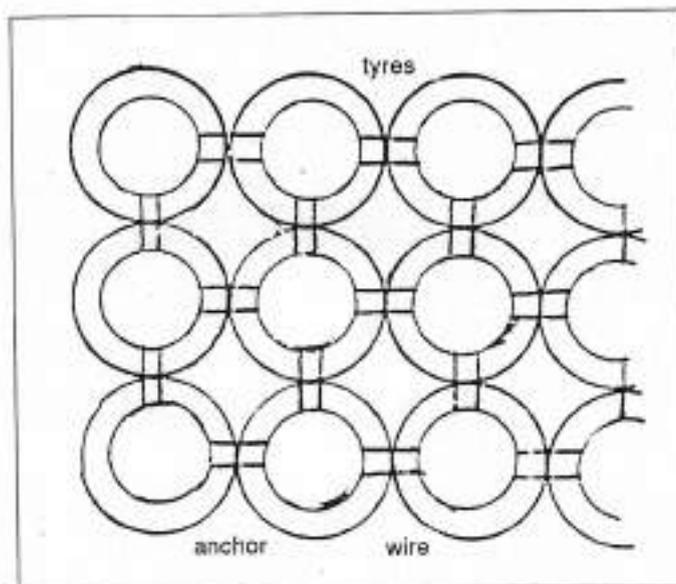


PICTURE 18



Used tyres are also good material for grating frame. See Figure 24.

Figure 24. Design of grating frame using tyres.



The following two methods describe the use of fencing in slope maintenance.

Function:

1. To prevent surface erosion and improve the environment for planted trees.

Remarks:

1. The height of fencing should be less than 50 cm, because the material used can rot easily.

2. The planting or direct sowing of seeds is necessary to keep the slope stable after the fencing rots away.
3. The fences should be built in such a way that no space is left between the bottom of the fence and the ground.

Method VI. Wattling fence. See Figure 25a and 25b, and Picture 19.

Advantage:

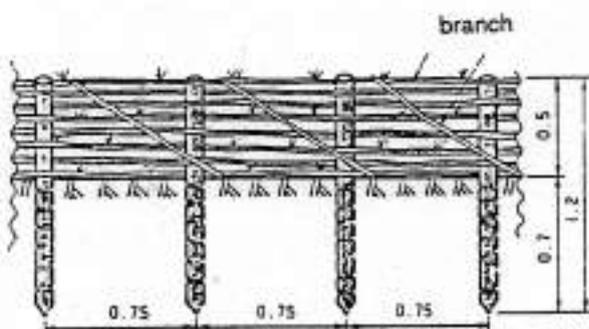
1. The materials for construction can be easily gathered from the field.

Disadvantage:

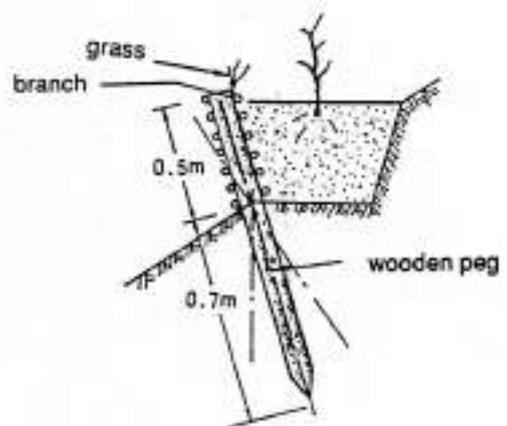
1. Tree planting or direct sowing of seeds is needed because this fencing does not last very long.

Figure 25. Design of wattling fence.

25a. Front view.



25b. Cross section view.



Amount of material for 10 M of wattling fence:

PICTURE 19



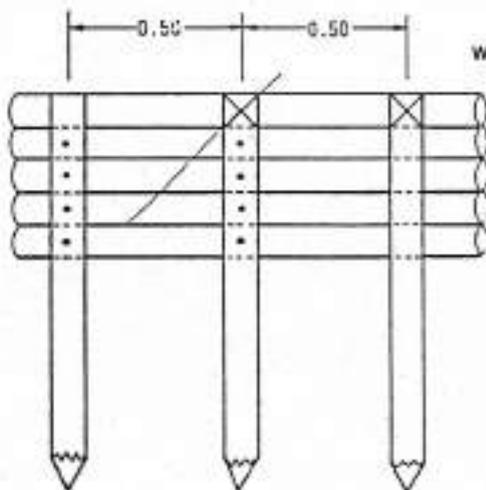
Method VII. Round logs fencing. See Figure 26a and 26b, and Picture 20.

Advantage:

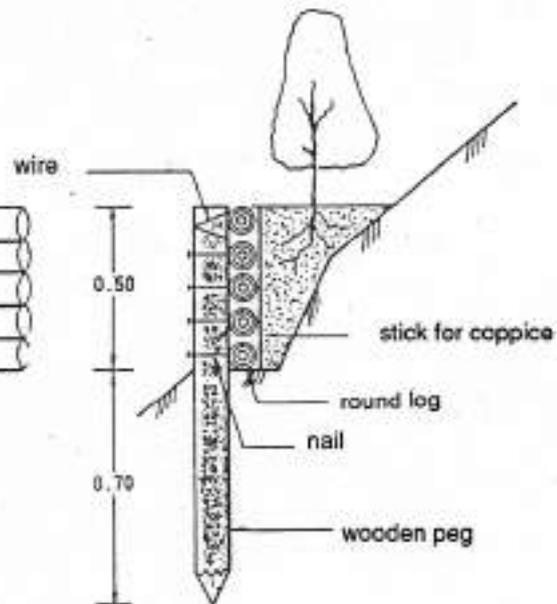
1. The round logs fencing durability is much longer compared with the wattling fence.
2. The structure design is simple.

Figure 26. Design of round logs fence.

26a. Front view.



26b. Cross section view.



Amount of material for 10 M of round logs fence:

1. Wooden stake, L = 1.2 M, D = 8 CM = 20 pieces.
2. Round logs, L = 1.8 M, D = 9 Cm = 28 pieces.
3. Branches for coppice planting,
4. Wire, = 1.5 KG.
5. Nail, L = 15 CM = 1.9 KG.
6. Seedling, = 20 seedlings.

PICTURE 20



Method VIII. Vegetation belt with soilbags. See Figure 27.

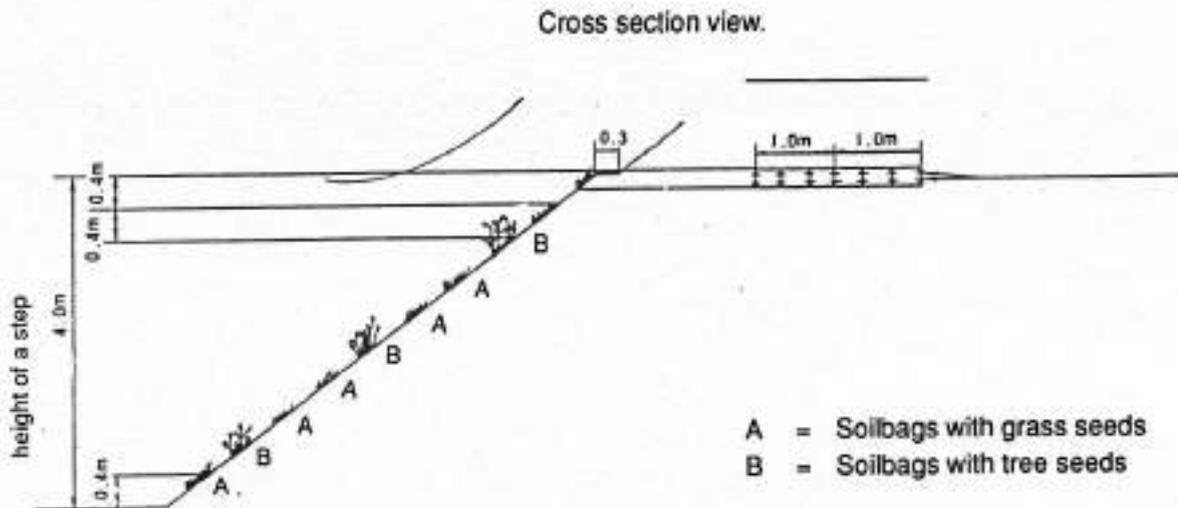
Function:

1. Vegetation belts make water flow evenly on the slope.

Remarks:

1. The interval between successive belts is about 1.5 m in vertical length.
2. The soilbags should be fixed on the ground using live tree branches.

Figure 27. Design of vegetation belts and soilbags with grass seeds.



Amount of materials for 1000 pieces of soilbags:

- | | | |
|---|---|------------------|
| a. Soilbags (33 x 16 x 4 cm) | = | 1000 pieces |
| b. Fertilizer (NPK Blue) | = | 30 KG. |
| c. Soil | = | 2.3 cubic meter. |
| d. Litter | = | 250 KG. |
| e. Peg (live tree branches, 15 cm long) | = | 2000 pieces. |
| f. Seeds | = | 3.5 KG. |

Literature review

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