IS 14680 (1999): Landslide Control - Guidelines [CED 56: Hill Area Development Engineering]

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IS 14680 : 1999
(Reaffirmed 2004)

भारतीय मानक

भूस्खलन नियंत्रण — मार्गदर्शिका

Indian Standard

LANDSLIDE CONTROL — GUIDELINES

ICS 93.020

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 1999 **Price Group 7**

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hill Area Development Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

Landslides are being increasingly viewed as natural hazard. The concern regarding the lanslide problem is understood in the light of the fact that a majority of the landslides are triggered by natural causes including substantial rain falls, cloud bursts, earthquakes, etc and as such these are difficult to predict.

However, the landslide problem has increased in magnitude due to man-made activities as well. Large scale construction works involving dams, hydroelectric projects, mining activities, housing projects, extensive expansion of road network, as well as deforestation resulting from the exploitation of the forests, have all taken their toll of the fragile eco-systems of hill ranges. At the same time, increasing needs for defence of the country, development of hilly areas, providing uninterrupted communication systems to the isolated and far-flung areas, have all created a very high demand potential for developing and keeping the road communication network in hills always open. This standard has been formulated with a view to understand the landslide phenomenon, their evaluation and control methods for effective correction measures.

The composition of the technical committee responsible for the formulation of this standard is given at Annex A.

Indian Standard

LANDSLIDE CONTROL — GUIDELINES

1 SCOPE

This standard covers the guidelines for selection of various landslide control methods for effective correction measures to avoid landslides in hill areas.

2 REFERENCES

The following Indian Standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1498 : 1970	Classification and identification of soils for general engineering purposes (*first revision*)
1892 : 1979	Code of practice for subsurface investigation for foundation (*first revision*)
14458 (Part 2) : 1997	Retaining wall for hill area — Guidelines : Part 2 Design of retaining/breast walls

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions shall apply.

3.1.1 *Landslide*

Landslide denotes downward and outward movement of slope forming materials under the action of its own weight.

3.1.2 *Main Scarp*

A steep surface on the undisturbed ground around the periphery of the slide, caused by the movement of slide material away from the undisturbed ground. The projection of the scarp surface under the displaced material becomes the surface of rupture.

3.1.3 *Crown*

The material that is still in place, practically undisturbed and adjacent to the highest parts of the main scarp.

3.1.4 *Toe*

The margin of displaced material most distant from the main scarp.

3.1.5 *Flank*

The side of the landslide.

3.1.6 *Head*

The upper parts of the slide material along the contact between the displaced material and the main scarp.

3.1.7 *Foot*

That portion of the displaced material that lies downslope from the toe of the surface of rupture.

3.1.8 *Displaced Material*

The material that has moved away from its original position on the slope.

3.1.9 *Zone of Depletion*

The area within which the displaced material lies below the original ground surface.

3.1.10 *Zone of Accumulation*

The area within which the displaced material lies above the original ground surface.

3.1.11 *Toe of Surface of Rupture*

The intersection (sometimes buried) between the lower part of the surface of rupture and the original ground surface.

4 LANDSLIDE CLASSIFICATION

The five principal types of mass movements such as falls, topples, slides, lateral spreads, flows and sixth as complex which is a combination of two or more principal types of movements and the recommended control measures are summarized in Table 1.

5 INVESTIGATIONS REQUIRED

5.1 Subsoil profile and soil characteristics up to the depth of failure plane or up to dense/hard rock strata as per the requirement shall be collected. The information shall be obtained by conducting soil investigation as per IS 1892.

5.2 Suitable number of static/dynamic cone penetration test shall be conducted up to the depth of failure plane/ hard rock strata as per the requirement. These shall

Table 1 Landslide Classification System

(*Clause* 4)

Type of Movement		Type of Material			Recommended Control Measures
		Soils		Bed Rock	
		Predominantly fine	Predominantly coarse		
Falls		Earth fall	Debris fall	Rock fall	Geotextile nailed on slope/spot bolting
Topples		Earth topple	Debris topple	Rock topple	Breast walls/soil nailing
Slides	Rotational	Earth slump	Debris slump	Rock slump	Alteration of slope profile and earth and rock fill buttress
	Translational	Earth block slide	Debris block slide	Rock block slide	Reinforced earth or rock reinforcement in rock slope
		Earth slide	Debris slide	Rock slide	Biotechnical measures
Lateral Spreads		Earth spread	Debris spread	Rock spread	Check dams along gully
Flows		Earth flow	Debris flow	Rock flow	Series of check dams
		(Soil creep)		(Deep creep)	Rows of deep piles
Complex		Combination of two or more principal types of movement			Combined system

form the basis for deciding the location and number of bore holes.

5.3 Engineering properties of subsoil shall include index properties, shear parameters, compressibility characteristics, etc, as per IS 1498.

5.4 Information shall be obtained with respect to nature of structure, if any, above the slide prone area, intensity and nature of loading and area covered by it.

6 RECOMMENDED REMEDIAL MEASURES/ METHODS

6.1 Landslide preventive techniques are divided in two groups:

a) Direct methods, and

b) Indirect methods. Direct methods are further subdivided into:

   i) restraining structure, for example; retaining walls, anchored walls, restraining piles etc;

   ii) easing of pressure by excavation;

   iii) reconstruction of slope using reinforced earth; and

   iv) rock reinforcement.

Indirect methods involve erosion control measures, improvement in surface and sub-surface drainage.

6.1.1 *Restraining Structures*

Restraining structures are generally used to control slope stability problems (height $\leq$ 4 m). The properly designed and constructed rigid restraining structures are suitable where space is restricted. Retaining walls are erected to bring greater stability to dangerous slopes or to support existing landslides. The construction of retaining walls requires a great deal of manual and skilled work as well as expensive planking.

6.1.1.1 *Dry, banded and mortar masonry walls*

Retaining walls up to 3 m height are constructed in random rubble dry stone masonry. Retaining walls above 3 m height are built in lime/cement mortar masonry bands laid at a distance of 3 m centre to centre apart both in the horizontal and vertical directions with 0.6 m top width. Masonry courses shall be normal to face with the front batter of 1 (Horizontal) in 3 (Vertical) and the back vertical face may be left rough. The coping shall consist of large stone, laid or pointed in cement mortar. The top of coping shall be weather sloped.

6.1.1.2 *Gabions/sausage walls*

Apart from the masonry or concrete retaining walls, timber, metal or concrete cribwalls and gabions/ sausage walls are also used as restraining structures. Cribwall is formed in a wooden crib/mesh, in which dry stone masonry is built. Gabions/sausage walls are made by forming sausages of steel wire-netting of 4.00 mm diameter or geogrid having 100 mm square or hexagonal holes and filling the sausages with hard local boulders/stones and wrapping the wire net at the top. The process is carried out *in-situ*, where the sausage walls are to be installed on the slide. The gabions/sausage walls have the advantage of being able to withstand large deformations without cracking. Further, because of the open structure, they allow free drainage of water. Geogrids, which are made of polypropylene, have high resistance to impact and weathering besides possessing good strength and elongation characteristics.

6.1.1.3 *Concrete retaining walls*

The concrete gravity walls are very expensive and are advantageous for important structures and locations. Such walls require a foundation in bed rock or good soil below the slip surface and shall be safe from scour, frost and surface water. Proper drainage measures shall be provided to prevent water accumulating behind the wall. Both the design of the stem of the wall and the stability of the whole body of the wall are to be considered in the design. The body of the wall is taken to include the mass of soil directly above the heel of the cantilievered wall and earth pressure. The formula for the safety factor may be used to estimate resistance required to lateral thrust. The standard practice is to include weep holes in designing the wall. The design consideration of retaining walls shall be as per IS 14458 (Part 2).

6.1.1.4 *Restraining structures using empty bitumen drum*

Temporary low cost restraining structures up to a maximum height of 3 m are constructed as a short term measure using empty bitumen drums, landslide debris and nominal reinforcing materials. The top and bottom covers of the bitumen drum are removed and the cylindrical shell is utilized. These are arranged in two rows one behind the other. The drums are interconnected both vertically and horizontally by mild steel plates, rods and bolts (*see* Fig. 1). The drum

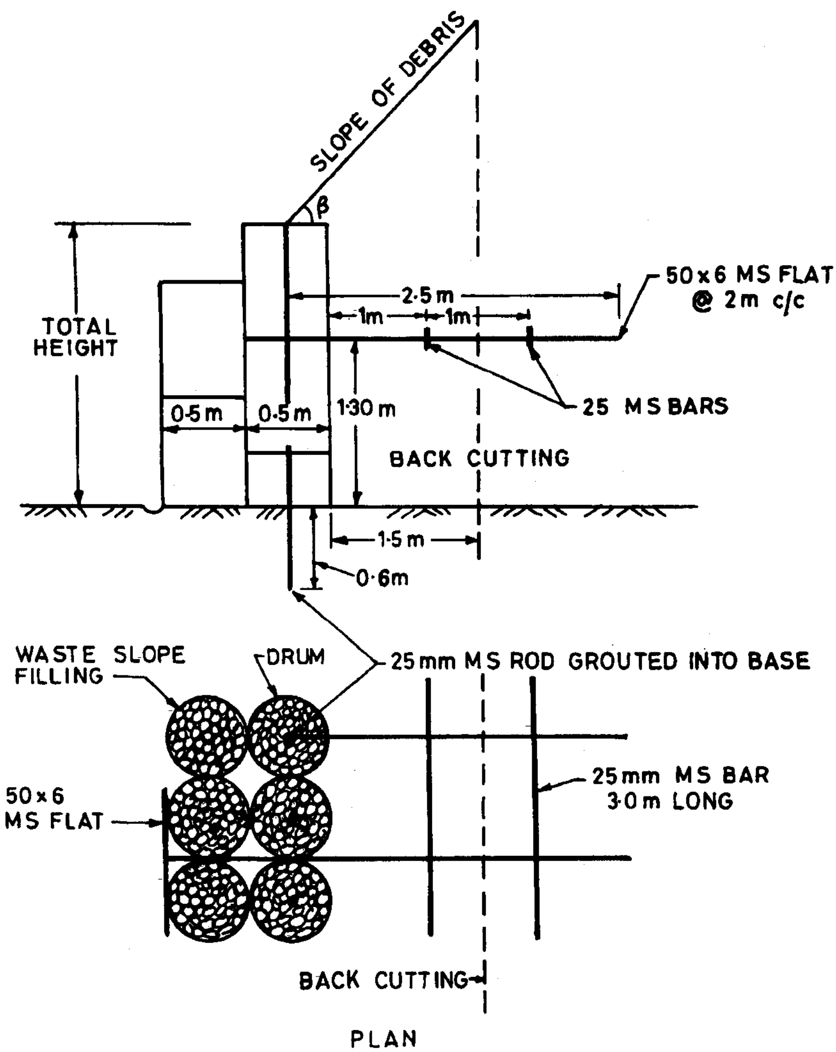


FIG. 1 ANCHORED DRUM DIAPHRAGM WALL BUILT OF SLOPE WASTE AND EMPTY BITUMEN DRUM

wall is suitably anchored at the base and also to the back fill for preventing sliding and tilting. These drums are then filled with debris and boulders to give weight and stability.

6.1.1.5 *Anchored walls*

a) Free-standing gravity walls have an upper limit of about 10 m and slides of only modest proportions may be prevented or stabilized using this type of structures. Stabilization of a slope where the failure surface is deep or where the forces are larger than which may be carried by a gravity wall may be effected by the installation of anchors up to a stable zone.

b) Stabilization by deep, prestressed anchors is generally applied to soil slopes. Walls with prestressed anchors, have a major advantage by actively opposing the movement of the soil mass, rather than having passively as unstressed anchors and gravity structures. These are employed either in conjunction with retaining structures or alone to reduce the driving forces of a landslide and to increase the normal effective stresses on its slip surface. Improvements in slope stability against even small movements/settlement may be achieved by using ground anchors, restraining piles or similar techniques.

c) Tie-back wall design uses the basic principle of carrying the backfill forces on the wall by a 'tie' system to transfer the imposed load to an area behind the slide mass where satisfactory resistance can be established. The ties may consist of pre or post tensioned cables, rods, wires or some form of anchor back to develop adequate passive earth pressure. Current practice in the design of tied-back wall to stabilize a slope is based on either a consideration of factor of safety alone or a combination of deformation and limit equilibrium considerations.

6.1.1.6 *Restraining piles*

Restraining piles are used where, due to the limitation of space, it is not possible to flatten the slopes or use other gravity type structures to improve the slope stability. Piles are installed in the sliding soil mass and bed rock through boreholes in the sliding mass to stablize a landslide through resistance and are used to prevent small scale landslides. These piles shall consist of steel or reinforced concrete piles. The pile is defined as a bending pile since its length is long compared to its diameter.

6.1.2 *Excavation Methods*

Excavation methods contribute to increased stability of the soil mass beneath a slope. The main methods used for landslide control are removal of unstable materials, flattening of slopes, benching of slopes, change of line or grade and alteration of slope geometry (*see* Fig. 2).

6.1.2.1 *Removal of unstable materials*

Complete or partial removal of the unstable material is considered among other alternative design methods. The removal of potentially unstable material shall vary from simple stripping of a surface layer by a few meters to depths as great as 50 m. For shallow soil profiles, consideration shall be given to a permanent solution involving the entire removal of the slide. For deep soil profiles, the removal of material at the top of the slide increase stability as it reduces the activating forces. This method is suitable for rotational slides.

6.1.2.2 *Flattening of slopes*

This method consist primarily of proper slope design followed by proper surface drainage measures. These are best suited to slides moving downslope towards a road and not for slides that undermine a road on its downward slope. A uniform slope is adopted from ditch line to the top of the slope. The surface of failure and method of analysis depend upon whether the slope is infinite or a finite one. Most talus soil are likely to be stable on 2 : 1 slopes for a cut up to 6 m in height but may require 3 : 1 slopes for cuts greater than 9 m in height.

6.1.2.3 *Benching of slopes*

This method involves straight slopes separated by near horizontal bench. Benching increases stability of slopes by dividing the long slope into segments or smaller slopes connected by benches, the proper width of bench shall be estimated by analysis of stability of slopes for a given soil. The width of bench shall not be less than 8 m to enable the slope segments to act independently. In this method, construction becomes easier since steeper slopes are feasible with benches. The slope angle between the benches can be either uniform or variable. The benches shall be constructed with a V-shaped or gutter section with a longitudinal drainage grade and with suitable catch basins to carry the water down the slopes. The ditch shall be lined or paved to reduce erosion or to prevent percolation of water into pervious areas on the benches.

6.1.2.4 *Change of line or grade*

In the early design stage, generally cut and fill slopes

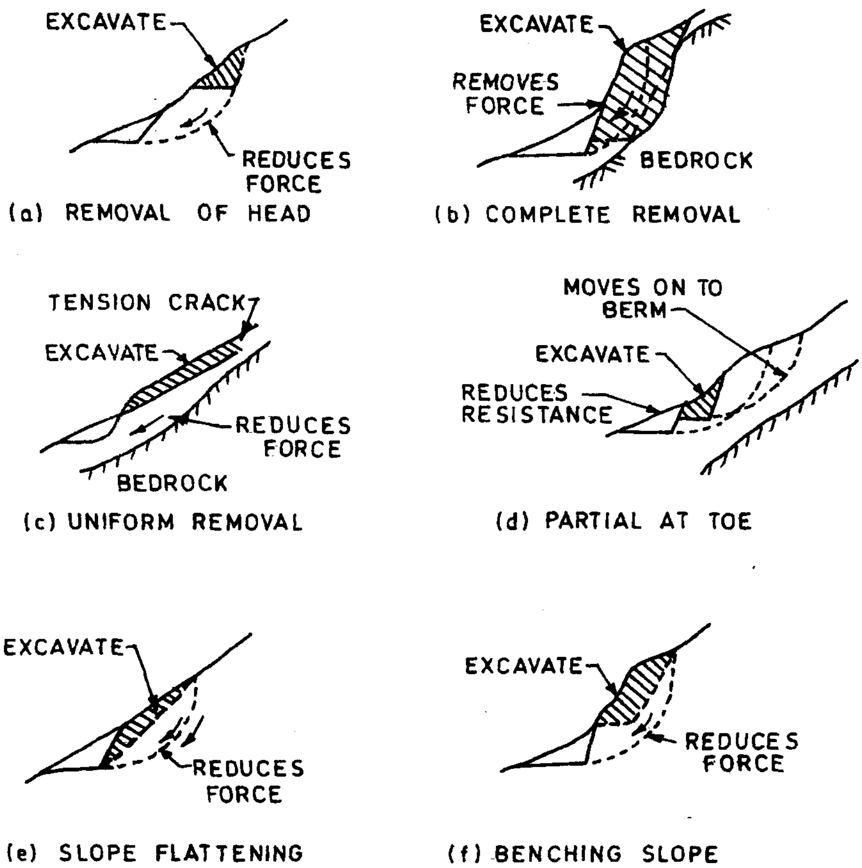


FIG. 2 EXCAVATION TECHNIQUES

are evaluated for potential stability. However, adjustment to the line and grade are effected to minimize or completely eliminate the slope stability problem. Line or grade changes are generally done to reduce the driving forces.

6.1.2.5 *Alteration of slope geometry*

Altering the geometry of a slope is also one of the most efficient method to improve the stability of deep seated slides. One of the simple method is to remove all the unstable material and if necessary replace it with stronger material. The other common approach is to either remove some of the material near the top of the unstable zone or to add material at the toe. Once the toe has been loaded, the factor of safety increases with time due to dissipation of the undrained pore pressures.

6.1.3 *Reconstruction of Slope Using Reinforced Earth*

6.1.3.1 *Reinforced earth using metallic stripes*

A reinforced earth retaining wall has three ingredients, such as, the selected granular backfill material, the reinforcing elements usually strips and the precast concrete panels of the facing called skin panels. Reinforced earth wall acts as a gravity structure placed on a stable foundation and shall be designed to resist overturning, internal shear and sliding at or below the base.

NOTES

1 Reinforced earth wall is economical where height is more than 5.0 m.

2 Reinforced earth walls in seismic region shall be used with caution as the friction between reinforcement and soil may be reduced during earthquake.

6.1.3.2 *Geofabric reinforcement structure on slopes*

Geofabric and geogrids are used in a similar manner like steel strips in the reinforced earth method. Stress-strain-time characteristics of the soil and the geofabric shall be studied carefully before adopting parameters for analysis and design of reinforced earth structure. The allowable tensile force corresponding to the maximum allowable strain of the reinforcement shall be adopted. Care shall be taken in the design of settlement sensitive structures near the crest of geosynthetic reinforced slopes.

6.1.3.3 *Slope reinforcement by soil nailing*

This technique consists of improving the soil slopes sometimes near vertical cuts by the inclusion of elements which are resistant to tensile, compressive, shear and/or bending forces. Steel rods/bars or angled sections are installed into the predrilled holes of soil slopes to produce composite action in combination with a shotcrete face panel. Soil nailing offers a neat and economic solution to the problem of providing support to slopes/excavation, in particular for very compact granular soils.

6.1.3.4 *Micro-piles, rootpiles for slope stabilization*

Stability of hill slopes is increased by installing a network of small piles. The piles may be wooden piles or sand/cement grout with a single 25 to 30 mm diameter reinforcing bars cast *in-situ*. A number of these piles installed in different directions are connected with a section varying from 0.4 m × 1.0 m to 0.75 m × 2.0 m reinforced concrete capping beams running along the contours. The actual diameter of micro-piles may vary from 100 to 125 mm and the length may be up to 15 m or so.

6.1.4 *Rock Reinforcement*

Rockslides and rockfalls can be stabilized by rock reinforcement.

6.1.5 *Erosion Control Measures*

6.1.5.1 Plantation of grasses and shrubs to restore the vegetative cover on denuded slope help in arresting the surface erosion. Some of the techniques of establishing a vegetative cover on hill slopes are :

a) *Asphalt mulch treatment*

For this treatment, the proposed slope area is prepared into vast seed beds by sounding off the tops, regrading or reshaping and finally raking the top soil about 20 mm thick. Seeds and the root slips of locally available grasses are dibbled 150 to 200 mm apart, root to root and row to row. An asphalt emulsion (mulch) of a suitable grade is then spread by a sprayer. The optimum rate of application of the emulsion is 0.9 litre/m^2 which is about 1.0 mm thick film. The asphaltic film gradually disintegrates and its place is taken by a carpet of green vegetation.

b) *Slope treatment by jute/coir netting*

The slopes are initially demarcated, graded and uniformally levelled. Seeding at the rate of 5 kg per acre or dibbling of the root slips of locally available grasses 150 mm apart row to row and plant to plant is done. The rolls of the coir/jute netting are then spread out on the slope prepared as above. The edges of the netting are firmly anchored in the ground using 150 mm iron nails. Due to the 'check dam' action, erosion of soil is prevented during rains and the danger of seeds and nutrients being washed away along with top soil is stopped. Thus, vegetation takes roots quickly and grows to cover the entire slope.

c) *Bally benching*

This technique is used for control of surface erosion on slide areas and in preventing the deepening of gullies/chutes, caused by the eroding action of flowing water. Wooden ballies (posts) of 120 to 150 mm dia and 2.0 to 2.7 m long are vertically driven in rows into the slope. The spacing of ballies range from 0.60 to 1.20 m centre to centre. The ballies are embedded into the slope by about 1.0 to 1.50 m and protrude out by about 1.0 to 1.20 m. The vertical posts are tied with three tiers of horizontal runners about 80 to 100 mm dia from uphill side with the help of 6 mm dia and about 200 to 250 mm long nails or braced with galvanised wires of about 4.00 mm diameter. Finally the uphill side of gullies/chutes is backfilled with boulders to avoid erosion.

6.1.6 *Surface Drainage*

6.1.6.1 Control of surface water consists of two main parts:

a) the collection of run-off at the uphill boundary of any unstable area,

b) maximising run-off from the unstable area and controlling and collecting the run-off.

Catch water or interceptor drains, side drains and cross-drains constitute some of the important types of drains used in a system of surface drainage.

a) *Catch water or interceptor drains*

In order to intercept and divert the water from the hill slope, catch water drains shall be located very carefully, after the topography of the ground is studied in detail. Catch water drains shall be lined and properly maintained and shall be given a gradient of 1 in 50 to 1 in 33 to avoid high water velocity and possible wash out. A number of inter-connecting lined catch water drains may need to be reconstructed on the slope to collect the surface run-off if the area of slide is large. Water from the catch water drains shall be diverted into a chute or a natural hill-side drain or diverted by sloping drains and lead into culverts at a lower level finally to be lead through chutes into the nearest natural water course.

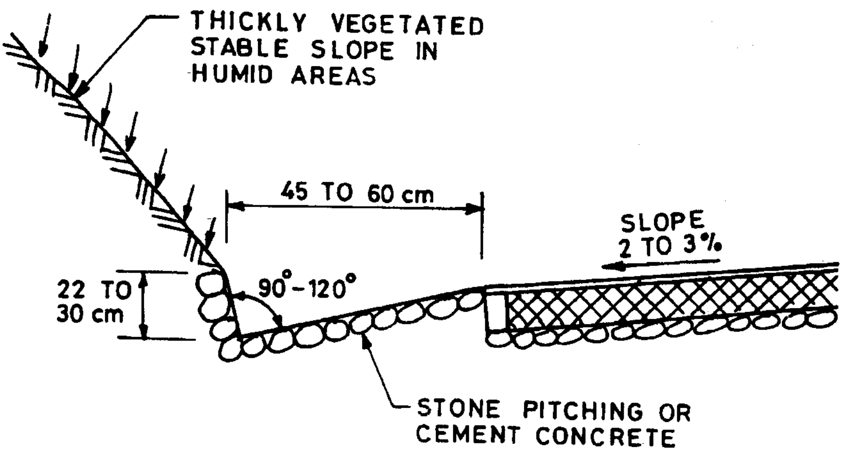
b) *Road side drains*

i) Road side drains are provided on the road side at the foot of the hill slope to drain out water from the road surface and the water from the portion of the hill slope below the catch water drains. Road side drains are constructed of dry rubble stone masonry with semi-circular saucer, rectangular, trapezoidal, angle drain and kerb and channel drain in sections. Angle or kerb and channel drains (*see* Fig. 3) are suitable where road width available is restricted and in emergencies, it serves as an extra width and not easily damaged.

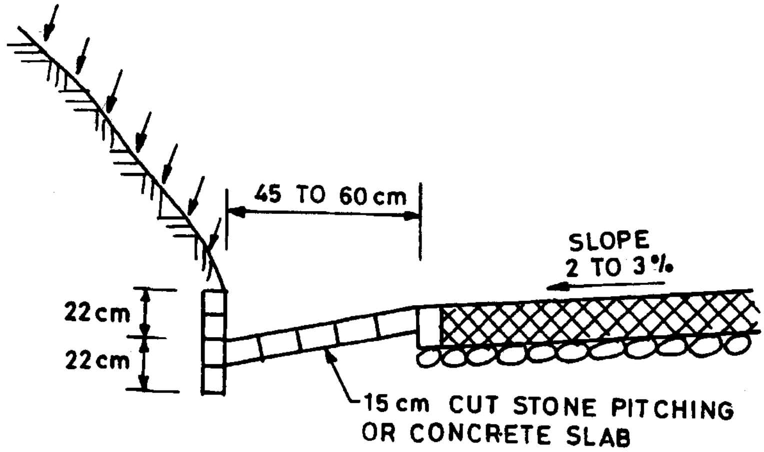
ii) The slope of the bed shall be 1:20 to 1:25 to allow water to flow at self-cleaning velocity. If the grades are rather steep, the side drains shall be stepped to break the velocity of water or provided with small dry rubble stone masonry check walls to provide falls to minimize bed scour. A shoulder of 0.3 m width may be provided between the edge of the drain and the hill slope. Generally, lined side drains shall be constructed. However, unlined side drains are sometimes provided on hard/stiffer strata.

c) *Cross drains*

Cross drainage shall be provided at intervals of 4 to 6 per km depending upon the nature of the terrain, to prevent the road side drains from being overloaded and flooding the road surface. These shall be provided at every point of natural *nallah* and water crossing. The cross drainage structures, are culverts, scuppers, causeways and minor or major bridges.



(a) Angle Drain



(b) Kerb and Channel Drain

FIG. 3 ANGLE AND KERB AND CHANNEL DRAIN

i) *Culverts*

A catch pit is provided at the mouth of the culvert towards the hill slope (*see* Fig. 4). The minimum size of the vent of the culvert is kept generally 0.9 m wide and 1.5 m in height, so as to clean them before and after the rainy season. Adequate protective works are required at the discharge point towards valley side, which shall preferably be in the form of stepped toe walls to dissipate the kinetic energy of the discharged water outfall. Different types of culverts are described below:

Arch culvert

An arch culvert consists of abutments, wing walls, arch, parapets and the foundations. The construction materials commonly used are stone masonry or concrete. Floor and curtain wall shall be provided to avoid the erosion of the foundation soil, thereby preventing the damage to the culvert.

Slab culvert

A slab culvert consists of RCC slab with or without beams or a stone slab or steel girders to cover the span across the abutments and piers. The deck slab shall be designed as one way slab.

Pipe culvert

Pipe culverts are provided when discharge of stream is smaller or sufficient height of bank is not available. Usually one or more RCC pipes of 0.50 m or 0.90 m diameter are placed side by side. Exact number and diameter of pipes depends upon the discharge and height of bank. Splayed type wing walls are provided for easy approach of water. Concrete bedding shall also be given below the pipes and earth cushion of sufficient thickness on the top to protect the pipe. The gradient of the pipes shall not be flatter than 1 in 30.

ii) *Scupper*

It is an economical type of culvert or cross drain where masonry retaining wall is provided for the road. The water collected through side drains or *nallah*, is discharged to the valley side through a small cross drainage structure 0.9 to 1.0 m wide made of random rubble dry masonry abutments. The top of the abutments are corbelled with a few layers of stones and a stone slab is laid on the top. Retaining walls are provided on both ends of scupper.

iii) *Causeways*

At places where the crossing streams carry debris or the channel are not defined and the spread of water is large with shallow depth and the velocity is within reasonable limits, then solid or vented masonry causeways are provided. A causeway allows flood to pass over it. There are two types of causeways:

a) Low level causeway, and

b) High level causeway.

Low level causeways

Banks of small rivers or streams which remain dry for most part of the year, are

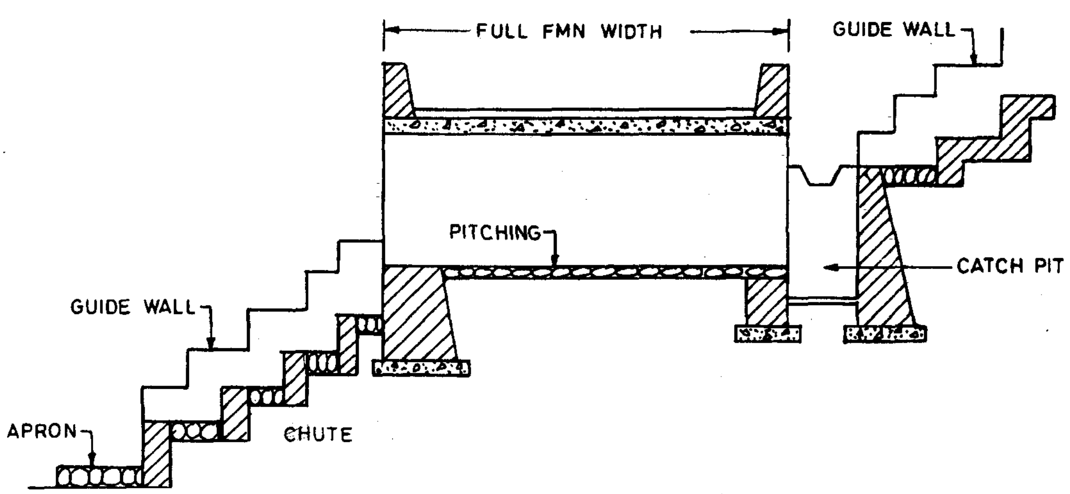


FIG. 4 CULVERT WITH CATCHPIT, CHUTE GUIDE WALL AND APRON

cut down at an easy slope. Stream or river having sandy beds, are generally provided with the stone paving on substantial bed of concrete with upstream and downstream out off walls to prevent possible scour (*see* Fig. 5).

High level causeways

High level causeway is submersible road bridge designed to be overtopped in flood (*see* Fig. 6). This involves heavy earth work in cuttings for bridge approaches. Its formation level is fixed in such a way as not to cause interruption to traffic during flood for more than 12 hours at a time and not for more than six times in a year.

6.1.7 *Sub-Surface Drainage*

6.1.7.1 Sub-surface drainage is usually more effective for deep seated landslides because it leads to a decrease in pore water pressure directly at the failure plane and tends to produce a more stable condition of slide area. Sub-surface drainage methods are the installation of horizontal drains, vertical drainage wells, deep trench drains and drainage tunnels.

a) *Horizontal drains*

i) Horizontal drains are made up of 50 mm diameter perforated/slotted rigid PVC pipes. Generally, the upper two-third portion of the pipe section is perforated/ slotted (*see* Fig. 7). The pipes are installed in a pre-drilled boreholes at a negative gradient of 5 to 15 degrees to the horizontal into a hill or an embankment for removing ground water of the sub-soil with poor permeability. Light weight drilling rig mounted on crawler tractor, capable of drilling boreholes at angles 30 degree up and 30 degree down from the horizontal is required. To avoid the risk of PVC pipes sliding out or being withdrawn, a check valve is fitted permanently on the first length of the PVC pipe before introducing into the pre-drilled hole.

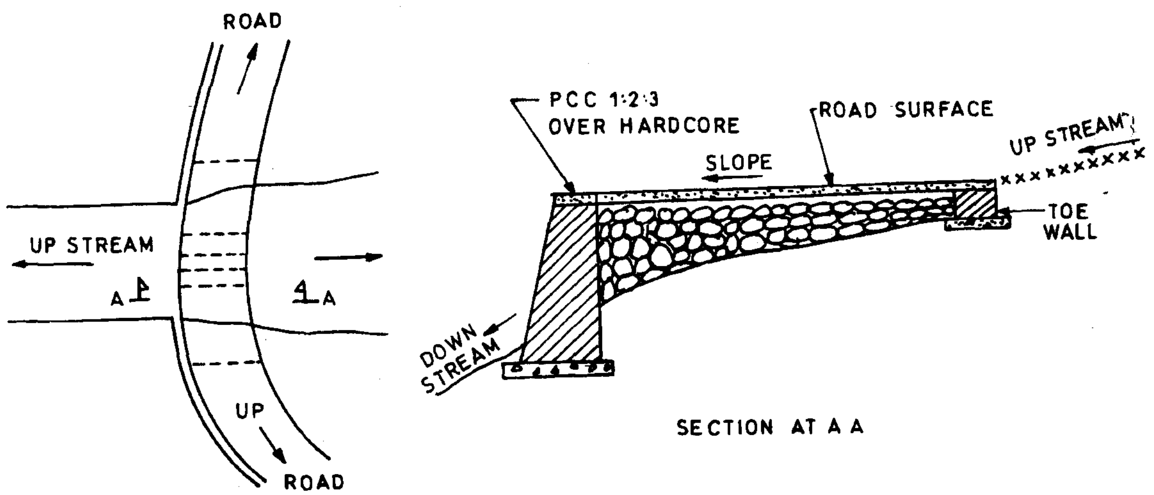


FIG. 5 PLAIN OR LOW LEVEL CAUSEWAY

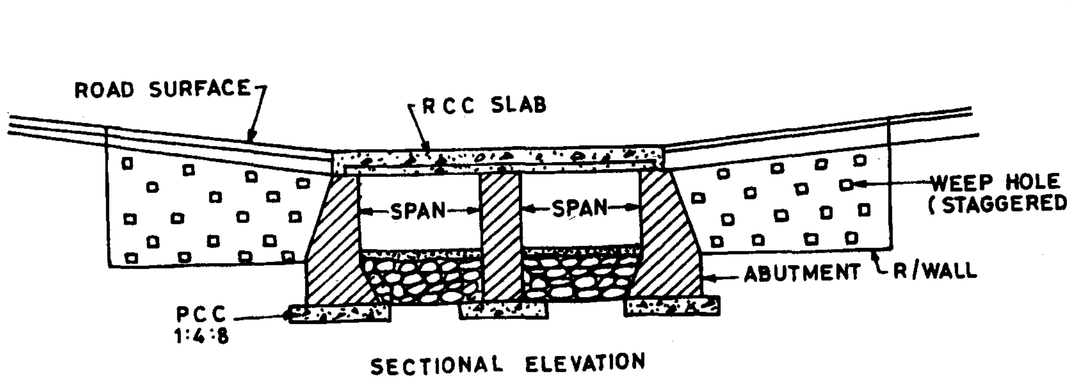


FIG. 6 VENTED OR HIGH LEVEL CAUESWAY

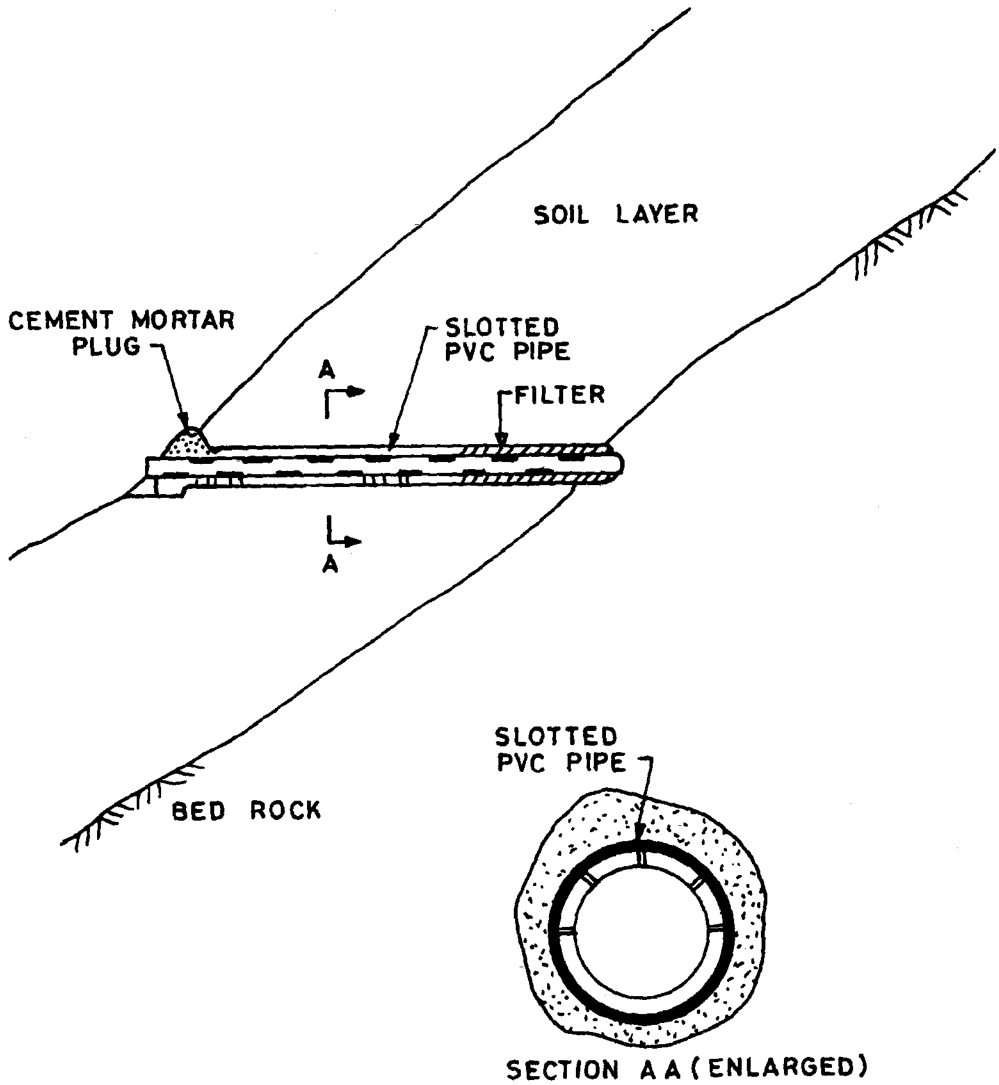


FIG. 7 HORIZONTAL DRAIN CONSTRUCTION

ii) It is also recommended to shroud the pipe by a suitable geotextile so that the soil particles are prevented from entering into the perforations/slots thereby reducing the possibility of its clogging.

b) *Deep trench drains*

Deep trench drains are used where water can be intercepted at depths less than 5 to 8 m. Filter-fabric covered trench drains consist of a permeable gravel core, surrounded by a filter fabric to prevent clogging (*see* Fig. 8). The gravel size is either 16-32 mm or 35-70 mm to ensure a sufficiently high void ratio. After the trench has been excavated, the filter fabric/geotextiles is spread out into the channel and then backfilled with clean gravel upto the top water-bearing layer. The geotextile is then overlapped before the top layer can be backfilled by local soils.

7 EQUIPMENT AND ACCESSORIES

The equipment and accessories shall depend upon the method of landslide remedial measures adopted. In practice, the type of equipment employed can vary considerably depending upon the design and resources required and depends upon slide to slide. However, it is important that the equipments shall be capable of reaching the difficult terrain, steeper slopes and heights.

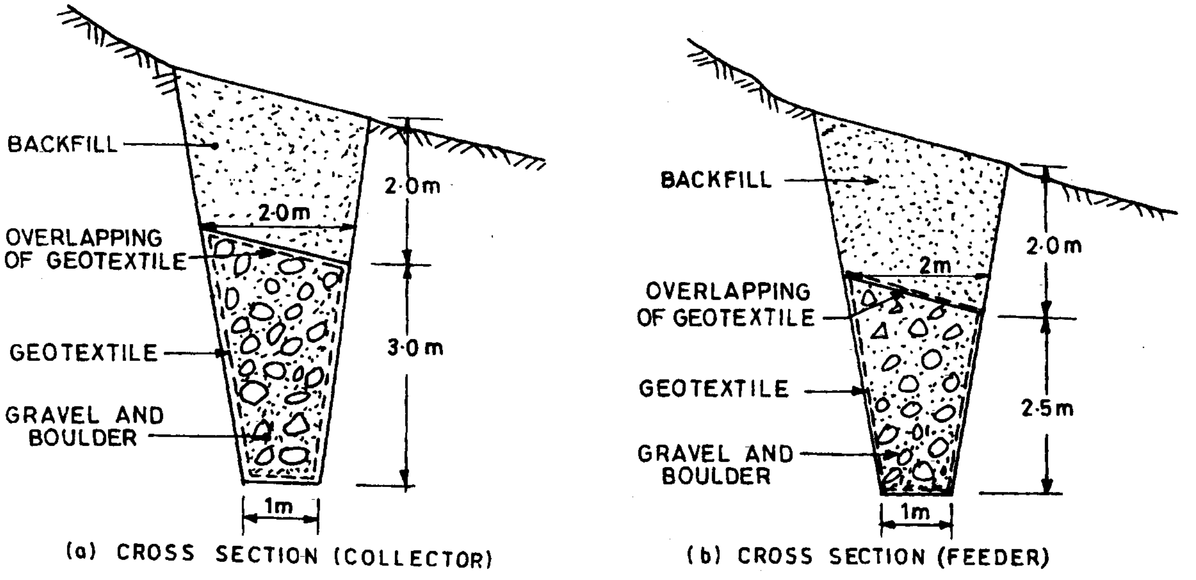


FIG. 8 CROSS SECTION OF TRENCH DRAINS

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Hill Area Development Engineering Sectional Committee, CED 56

Chairman	*Representing*
DR GOPAL RANJAN	University of Roorkee, Roorkee
Members	
SHRI SHEIKH NAZIR AHMED	Public Works Department, Jammu & Kashmir
PROF A. K. CHAKRABORTY SHRI R. C. LAKHERA (*Alternate*)	Indian Institute of Remote Sensing, Dehra Dun
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This Indian Standard has been developed from Doc : No. CED 56 (5581).

Amendments Issued Since Publication

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Printed at New India Printing Press, Khurja, India