CHAPTER 7

GEO - ENVIRONMENTAL MANAGEMENT PLAN

Geo-Environmental Management Plan is formulated to protect and/or improve the reservoir zone and to provide stability to the reservoir. The important issues, which need considerations from the environmental point of view, are discussed in this chapter. In the vicinity of the reservoir area around 60 nos. of landslide zones / unstable slopes have been identified.

7.1 LANDSLIDE CONTROL

The total numbers of landslides in the project area are classified into small, medium and large categories based on their dimension and area (Table: 7.1).

Table 7.1 Categories and types of landslides encountered in the reservoir area of Dibang Multipurpose Project

Size of Landslide	Approximate area in sq m	Approximate Dimension (width × height) (sq m)	No. of Landslides	Type of Material
Small	Up to 1250	25 x 50	10	Mostly in overburden. Few in rock
Medium	1250 to 20,000	25 x 50 to 100 x 200	38	Both rock and overburden
Large	More than 20, 000	More than 100 x 200	12	Rock in general

7.1.1 Landslide Control Measures:

The following control measures can be adopted to stabilize the landslide.

1. Capture and drainage of surface water flowing into the slide area or emerging in the head scarp area.
2. Pumping of water from all wells in the slide area and from any undrained depressions.
3. Filling and compacting of the fill in all open cracks, which could be entered by, surface water. This particularly concerns deep cracks which develop during slope movement and which reach down to the slide plane.
4. In the case of slow, creep-like slope movements, the packing of open cracks may also have an impeding effect, because it can hinder upslope propagation of slope deformation.

The scheduling of corrective measures must pay due regard to weather conditions. The individual operations should be scheduled with action so that the remedial works would not remain unfinished. In such a case it is better to postpone the operations to spring time.

All corrective installations must be regularly checked and maintained. If regular maintenance is not carried out, or if the agreed programme for developing and using the slide area is not adhered to, then extensive and costly corrective measures may come to naught and within a short period new movements may start up. The schedule of inspection and the maintenance work should be included in the overall planning of the corrective measures.

7.1.2 Treatment of slope conformation

The stability of a slope may be increased either by reducing the volume at the head or by expanding the volume at the toe.

The presence of a lower layer possessing a large shear strength angle makes building up of the toe more advantageous because a small extra weight may be sufficient to stabilize the slope foot. On the other hand if the strength of the bottom place layer is low (e.g. in unconsolidated surface layers), it is also possible to place a fill in front of the slope, as is frequently done in open pit coal mines. An important factor, which gives a good buttressing effect from the fill, is proper drainage of its base, particularly if the fill rests on clayey material. The best drainage can be accomplished with a gravel layer of 0.6 to 1 m thick.

The use of the drained fill also works well in the toe areas of moving slopes, where saturation of soils is the chief problem. Generally, there is insufficient time for installing horizontal drainage boreholes, whereas the fill can be dumped in a very short time, even overnight. Owing to the velocity of the movement, the gravel fill may need to be placed some distance from the current position of the toe of the slide. The overt rusting material at the front of the sliding mass becomes drained and cessation of the movement follows. A successive treatment of the sliding mass with horizontal boreholes can therefore be postponed.

A protective fill dumped on the surface of slopes excavated in clays is another effective measure, if carried out in good time. The coefficient of initial lateral stress is assumed to be unity and the presence of ground-water was assumed. Therefore, the sooner the protective fill is put in place, the greater is the safety of the slope. This is a point that needs to be emphasized in engineering-geological remediation. The design of the protective gravel fill should take into account of the foregoing considerations, and therefore the fill should be designed as a self-supporting beam. Thicker protective fills work well where the banks of reservoirs are concerned.

7.2 THE DRAINAGE OF LANDSLIDE

i) Surface drainage

The surface of any area affected by sliding is generally uneven, hummocky, and traversed by deep fissures. In the depressions and fissures water accumulates and wet ground develop. Therefore one of the remedial measures is the surface drainage of the slide areas. Although surfaced drainage by itself is seldom sufficient to stabilize a slope which is in motion, it can contribute substantially to the drying out, and thus also to the control of the landslide.

First of all, all streams and temporary watercourses are diverted from the threatened area. In addition, all springs issuing within the slide area, especially those at its head, must be contained and diverted away from the slide. For an immediate, provisional diversion of flowing water any available pipes may be used. In the first stages of a landslide when the movement and changes in the relief are appreciable, surface pipes have the advantage of being easy to move and they are inexpensive. In winter, however, they prove less suitable because they do not protect the drainage water from freezing.

After partial stabilization of the landslide, open ditches of adequate dimensions and gradient are excavated for discharging rain-water. At the same time, the ground surface is leveled and undrained depressions filled along with all cracks so that a continuous run-off of surface water is ensured. During these operations the grass cover must not be disturbed unnecessarily, since grass reduces the tendency of water to percolate down into the slope.

The arrangement of ditches depends on the soil type; their banks and floors must be sufficiently firm so as to resist erosion. They are paved either with natural stone of suitable properties, or with concrete tiles set in a sand foundation, the joints being sealed with cement or sod. Water infiltration into the sand bed is directed along the ditch by establishing low steps. In sandy soils, the ditch sides and bottom may be consolidated with asphalt, bitumen or oil sprinkle.

In some cases ditches of reinforced concrete have proved suitable for surface drainage. These tiles are slightly narrowed at one end so that they can be inserted into one another. Compared with paving, gutters of reinforced concrete have the advantage of being less pervious; they can withstand slight movements of the slope. Wooden troughs, which are occasionally used, can easily be set out and then repositioned if necessary, but with frequent moistening and drying out, the wood deteriorates and becomes more leaky.

In addition to ditches constructed in the slide area, peripheral ditches above the head scarp are sometimes dug so as to divert surface water flowing down adjacent slopes into the potentially unstable area. They must be provided with impervious paving and have a uniform gradient to prevent deposition of material on the bottom the slope, and may seriously upset the stability, even in the case of a slide which is temporarily at rest.

ii) Subsurface drainage

As ground water is one of the major causes of slope instability, subsurface drainage is a very effective form of remedial treatment. It complements or may even render unnecessary the shape adjustment of slopes, since a drained slope may be stable at a steeper angle than an un drained one. The disadvantage of subsurface drainage is that the drainage system cannot be designed until after geological and hydro-geological research has been completed, with the result that it come into operation somewhat belatedly.

Drainage galleries are conventional deeply situated structures such as were built in the first railway construction schemes of the last century. They have several advantages, first of all serving as a means of investigating water percolation through the rock, and thus helping to ascertain precisely the hydro-geological conditions of the slope. They are capable of discharging a large amount of water. Their effectiveness may be increased by making long or short drainage borings in the walls, floor or roof of the gallery. Thus, galleries can be constructed below the slide plane for the purpose of collecting water from the overlying layers through vertical boreholes. If the water seems to derive from the more permeable bed in the floor of the gallery, a shaft or a trench may be dug. The course of the gallery may be changed so as to follow the influx of water, or to make contact with the lower ends of vertical drainage boreholes. The diameter of galleries is generally so large that they discharge water even when partly disturbed.

In spite of these disadvantages, galleries still represent an indispensable method of draining deep slides in which the distances to be drained are greater than 250 m. Boreholes were drilled inside the gallery in order to drain saturated pockets of terrace gravel.

The cost borehole is largely reduced on account of the shorter construction time which depends upon suitable machinery being available, and almost no need for pumping costs compared with pumping wells. There are four drawbacks involved in drainage borings: (a) It is difficult to guarantee that a borehole will contact those water-bearing beds in which the pressure of the ground-water is responsible for impairing the stability of the slope. (b) Even if an appropriate layer is contacted, the reduction achieved in the uplift force may not be sufficient to increase the shear resistance. (c) The maximum length of effective borings is 250 to 300 m, tended position by several metre. Fine sands or sandy gravel often do not permit the drilling of boreholes longer than 100 m, because the fine grains jam the drilling tool. (d) Drainage boreholes have a limited useful life.

As far as items (a), (b) and (c) are concerned, the following observations may be made: Unless the most permeable layer within the slope has been reached, the drainage process will not be fully effective. Effective drainage by attacking the less permeable talus loams requires several times the number of boreholes that would otherwise be needed for draining the underlying rock debris or permeable bedrock.

In the entire reservoir area overall 60 number of active landslide zones forming unstable slopes has been identified.

7.3 LAND SLIDE POTENTIALITY

7.3.1 Mitigation Measures

Following are the Mitigation Measures suggested for controlling the Landslide in the Project area

a. Rock anchoring, carving out of slopes, shot creting etc. should be planned.

b. The impact of landslide on the project could be managed by arresting the potential landslides zones through suitable engineering treatments, afforestation etc.

c. Landslide Control with Coir-Geotextile

Looking into the nature of the landslide in the Dibang Project Site Following technique is suggested for the landslides.

If an area roughly measuring 20 m x 31 m along the slope is chosen the slope length is divided by constructing two unbounded stone masonry walls of 22 m long and with a maximum height of 1.20 m at the bases of the steep slopes. This is to be carried out to arrest the debris movements and yet to provide sufficient drainage.

The installation procedure is generally similar to that used for other types of geo-textile materials for surface erosion control. However due to the steepness of slope and the changes of high runoff occurrence and additional precautionary measure should be used. This includes typing the coir netting in the position using coir ropes, which are anchored, into the ground. The detailed procedure of installation is as follows:

The soil on the surface of slope is first graded to remove the unevenness present, where possible. There may still some patches of exposed rock/boulders. Wedge shaped trenches of 30 cm x 30 cm is to be dug to anchor the coir nets at the top and the bottom **(Figure 7.1).** The area may be seeded with very limited quantity of *Pennisetum* sp. / *Vetiveria* sp., grasses known for quick and easy growth and have root depth nearly equaling the existing soil cover, i.e. around 40 to 50 cm.

Rolls of the coir matting is first anchored in the top trench and then unrolled along the slope. Each slope is given an overlap of minimum 15 cm with the adjacent ones and anchored firmly into the ground by mild steel staple, spaced to form a grid of 2m in either direction. Coir ropes of 20mm diameter were used to tying the coir matting, which is anchored in tension in a criss-cross pattern at around an angle of 90^o, making a grid of 1m size. Steel staples are driven at each joint of the coir rope **(Figure 7.2)** type. A matting is used on the upper half having a slope of 60^o and type B matting were used on bottom half with 40^o slope. Culms of locally growing bamboos species may also be used for anchoring the jute net/ geo-textile. Over a period of time the roots from the bamboo will develop and will further provide stability to the slope.

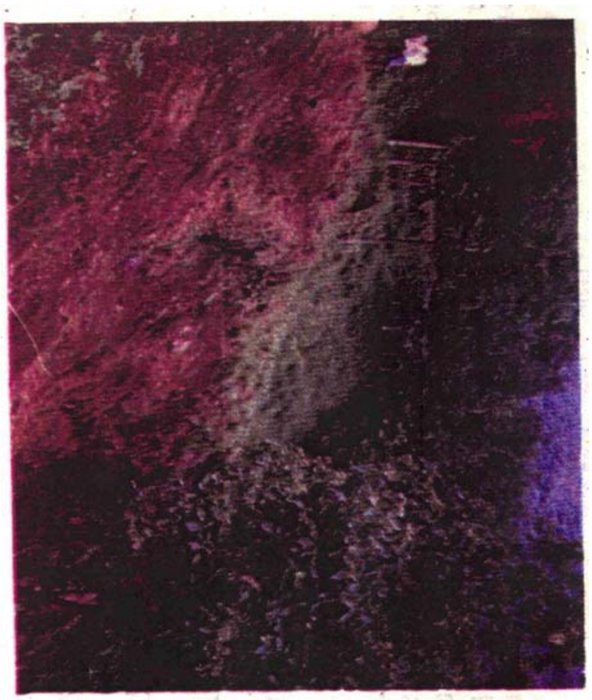


Fig. 7.1: Wedge shaped trenches

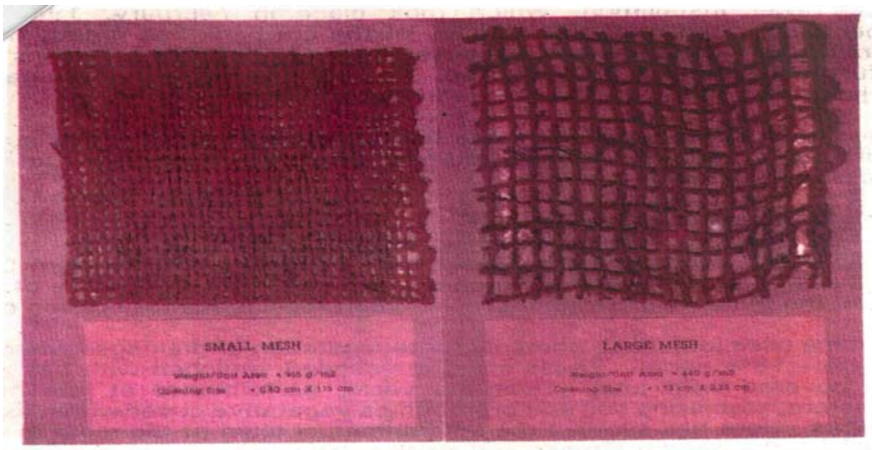


Fig. 7.2: Coir Rope

Photo 7.1: Landslide L 60 near Airi Pani confluence with Dibang river (about 2 km u/s of Dam axis)

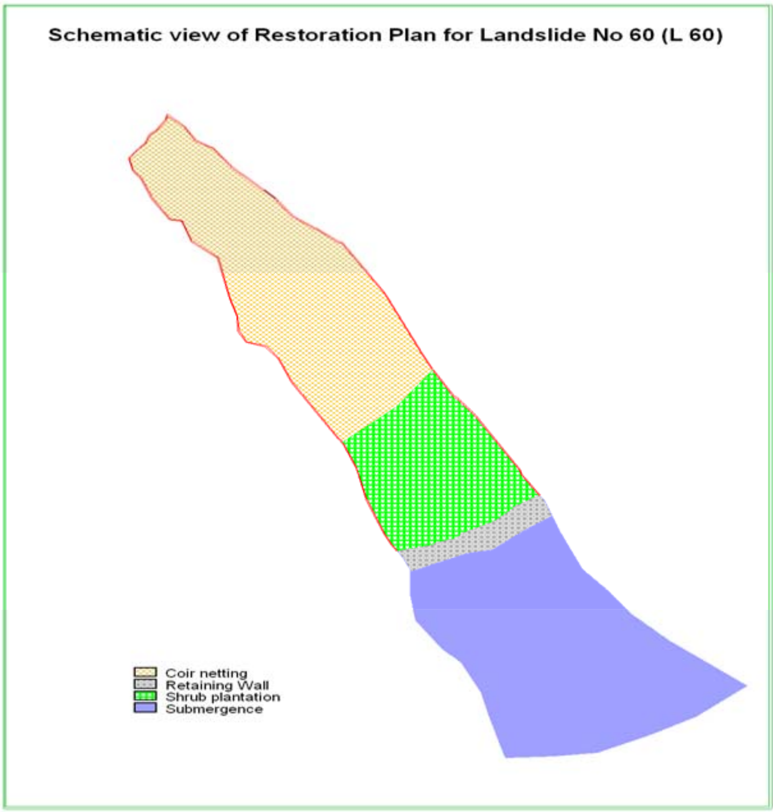


Fig. 7.3: Schematic view of restoration plan for landslide L 60

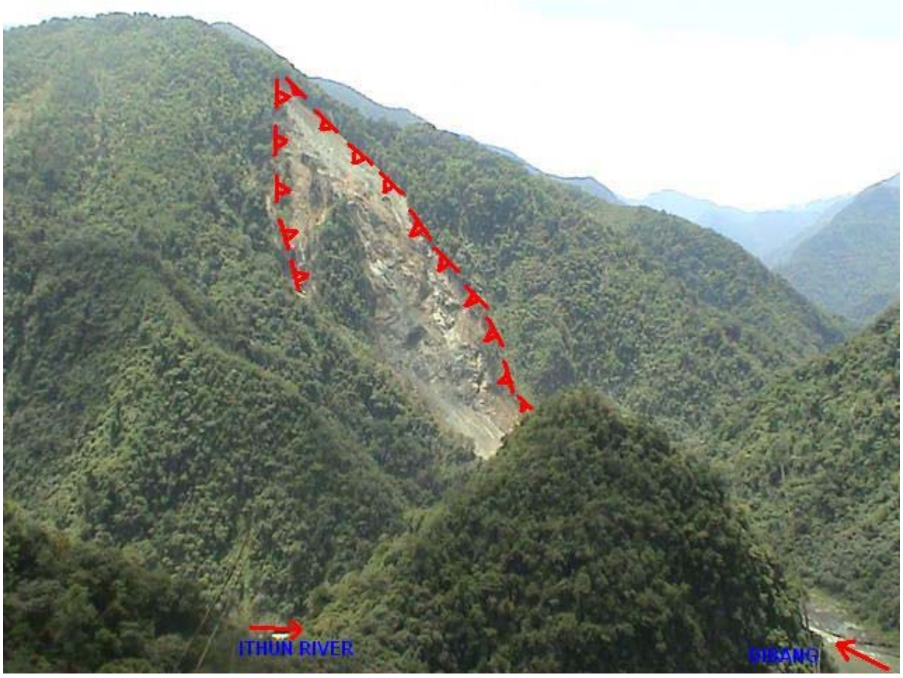


Photo 7.2: Landslide L 39 on left bank of Dibang at the confluence of Ithun and Dibang river

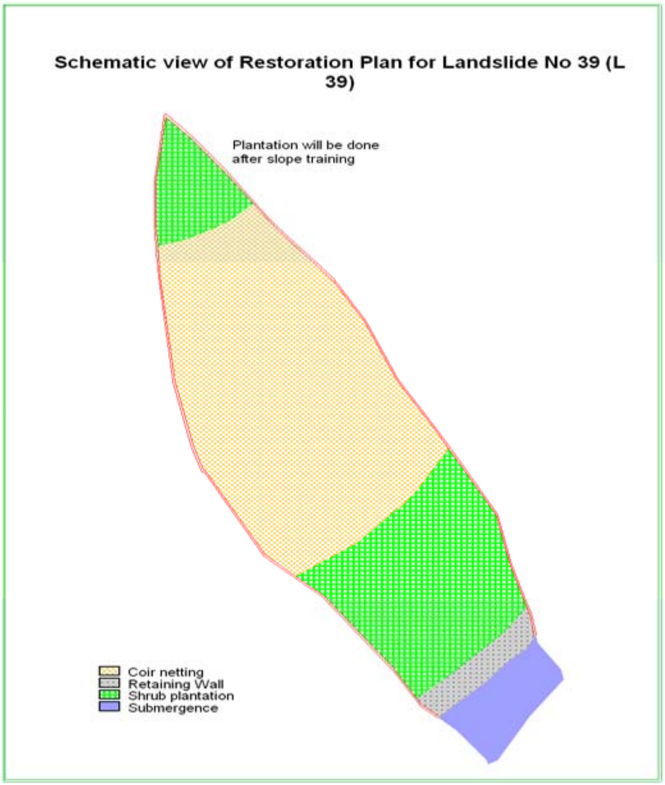


Fig. 7.4: Schematic view of restoration plan for landslide L 39

Photo 7.3: Landslide L 13 on left bank of Dibang about 1.2 km downstream of Enne nala

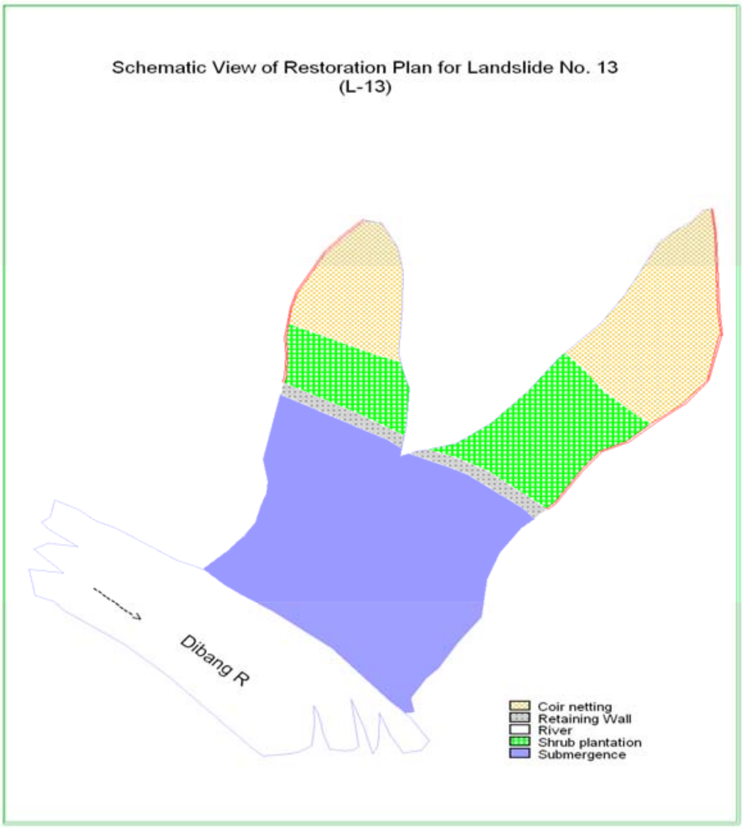


Fig. 7.5: Schematic view of restoration plan for landslide L 13

For the medium and large category of landslides the retaining wall method along with concrete slab will be used for landslide control. The schematic view is given in fig. 7.4, 7.5 and 7.6. The cost estimation for the Geo-textile is presented in the following table no 7.3.

Table 7.2: Cost estimates for Geo-textile

Sl. No.	Area to be treated with geo-textiles	Rate per sq m (Geo-textile)	Amount (Rs.)
1.	Geo-textile – 1250 sq. m. x 10 small landslides	Rs. 700/-	87,50,000
2.	Plantation of *Pennisetum* sp. / *Vetiveria* sp., 1250 sq m	Rs. 500/-	625,000
		Total	**93,75,000**

Detail estimate of a R. C. C. Retaining Wall of 30 m in length whose cross section is enclosed below-

Table 7.3: Details of Measurement and Calculation of Quantities

Item No	Particular of item	No	Length (m)	Breadth (m)	Height or Depth (m)	Quantity	Unit
1.	R. C. C. work 1:2:4: excluding steel and its bending but including centering and shuttering and binding steel						
	Base slab (Toe and Heel)	1	30.00	3.00	.50	45.00	
	Stem	1	30.00	$\frac{.60+.20}{2}$	6.00	72.00	m^3
					Total	117.00	
	Steel bars including bending in reinforcement- Right side 22 mm Dis Bars-------						
	22 mm Dis. Main bars @ 40 cm c/c (full height) No= $\frac{30cm\text{-}covers}{0.40}$ +1 = $\frac{2990+1}{0.40}$ =76 nos	76	7.53	=572.28 m L= 6.50-top cover-bottom cover+ 2 hooks+ 0.75 = 7.53m			
	22mm Dia main bars upto 3.60m ht @ 40 cm c/c (remaining bars) No= $\frac{22.90-2\times.20}{.40}$ +1 =75 nos	75	5.13	=384.75m L= 7.53-2.40=5.13m			
	22 mm Dia main bars upto 1.80 m ht @ cm c/c (remaining bars) No.= $\frac{29.90\times.10}{.20}$ +1 = 150 nos.	150	3.33	=499.50m L= 7.53-4.20= 3.33m			
		total	of 22mm	Dia bars 1456.35 @2.98 kg =4340.46 kg			

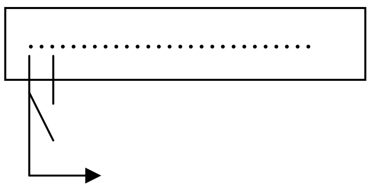
Ite m No	Particular of item	No	Length (m)	Breadth (m)	Height or Depth (m)	Quantity	
	14 mm Dis Bars----- 14 mm Dis. Distributing bars right side of item @ cm c/c….. No = 9.50-.05-.07 +1=26 1 .25 2 =27 nos.	27	31.18	=858.06 mm	L= 30.00-2covers+2 overlaps+6 hooks =30.00-10(2×40×0.14)+(6×9×.014) =31.78 m (Assuming two joints)		
	14mm Dia vert. Bars left side of stem @ 30 cm c/c No= 30.00-10 +1 = 101nos. .30	101	6.63	=669.63 mm	L= 6.50-Top and bottom covers +2 hooks =6.50-(.05+.07)+(38×0.14) =6.63m		
		Total	of14mm	Dia bars =1527.69m @ 1.21kg	1848.50 kg		
	10 mm Dis Bars- 10 mm Dia bars distributing bars left side stem @ 30 cm c/c No= 6.50-.05-.01 + 1 =22 no. .30	22	31.24	=687.28 m	L= 30.00-2 covers +2 overlaps ×6 hooks =30.00-.10+(2×40×.10)+(6×.01) =31.24 cm (Assuming two joints)		
	BASE SLAB 10mm Dia Distributing bars at bottom (Toe) @ 25 c/c No = (.75+.60+.30)-.05 +1 .25	7	31.24	218.68m	Length same as above		

	=7nos. 10mm Dia Distributing bars at bottom (Hecl) @ 20 c/c No =(1.56+.60+.25)-.05 +1 .20 =13 nos.	13 Total	31.24 of10mm	=406.12 m Dia bars =1312.08m @0.62 kg	Length same as above. =823.49kg
	16 mm Dia. Bars – 16 mm Dia. Main bars at bottom (Toe) @ 15 cm c/c No.= $\frac{30.00 – 10}{15}$ + 1 = 200 nos	200	1.89	=378.00	L =(.75+.60)+.30-.05 +(18x.016)=1.89 m
	16 mm Dia. Main bars at top (Heel) @ 10 cm c/c No.= $\frac{30.00 – 10}{10}$ + 1 = 200 nos	300	2.74	=822.00 m	L=(1.65+.60+.25)-05 +(18x.016)=2.74 m
		Total of 16 mm Dia bars = 1200.00 m @ 1.58 kg = 1896 kg			
	Grand total	All bars = 8898.45 kg = 88.985 q			

7.4 ESTIMATION OF CONCRETE SLAB FOR 30 METER LONG DRAIN

Size – 1.00 x 1.00 x 10 cm

←—— 1.000 cm ——→



8 mm @bars 10 cm c/c

10 mm @ bares 10 cm c/c

Cement concrete work = 1.00 x 1.00 x 0.10 cu m

= 0.10 cu m

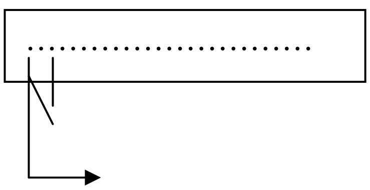
Reinforcement @ 0.8% of R.C.C. works

= 0.10 x 0.8% x 78.5

= 0.0628 qtls.

Size –1.20 x 1.20 x 10 cm

←—— 1,20 cm ——→



8 mm @bars 10 cm c/c

10 mm @ bares 10 cm c/c

Cement Concrete work = 1.20 x 1.20 x 0.20 cu m

= 0.144 cu m

Reinforcement @ 0.8% of R.C.C. works

= 0.144 x 0.8% 78.5

= 0.0904 qtls

7.5 ABSTRACT OF COST

(1) Retaining Walls

1. R.C.C. work 1:2:4 excluding steel and Its bending including centering an Shuttering and binding steel 117.00 cu m @ 3165.64 per cu m

   = Rs. 370422.00

2. Steel bars including reinforcement 88.985 q @ 3464.70 per q

   = Rs. 308385.00

   Total Rs. 678807.00

Studying the nature of the landslides and dimensions, the total length of retaining wall to be prepared is estimated as 2720m.

Hence total cost for construction of Retaining Wall =Rs. 6,78,807 x 2720 m / 30 m

= Rs. 6,15,45,168/-

(2) Slab of 30 m long Drain

Particulars of items

1. R.C.C. work 1:2:4 excluding steel and Its bending including centering an Shuttering and binding steel 0.244 cu m @ 3165.64 per cu m

= Rs. 772.42

2. Steel bars including reinforcement 0.1532 q @ 3464.70 per q

= Rs. 530.79

Total Rs. 1303.21 (for one meter)

Grand total = (Rs. 1303.21X30)

= Rs. 39096.19

These slabs for trench will be required for the landslides where shippage is prevalent and it is estimated from studying the total no. of landslides, total length of 2260 m drains will be required to be constructed.

Hence total cost for construction of slabs will be = Rs. 1303.21 x 2260 m

= **Rs. 29,45,255/-**

(3) Turfing of slopes

Turfing of slopes by grasses on 800 sq m (i.e. 0.08 ha) @ Rs. 30,000 per ha

Cost of turfing = 800 x 500 = **Rs. 2,400/-**

(4) Cutting of heads

A lump sum provision of Rs. 1 lakh has been kept for cutting of heads of landslides.

7.6 FINANCIAL OUTLAY

Table 7.4: Financial outlay for Geo-environmental management plan

S. No.	Item	Cost (Rs.)
1	Construction of retaining wall	6,15,45,168.00
2	Construction of drain	29,45,255.00
3	Geo-textile measures	93,75,000.00
4	Turfing	2,400.00
5	Cutting of heads	1,00,000.00
	Subtotal	7,39,67,823.00
5	Maintenance cost @ 2%	14,79,356.00
	Total	**7,54,47,179.00** **Say Rs. 755 lakhs**