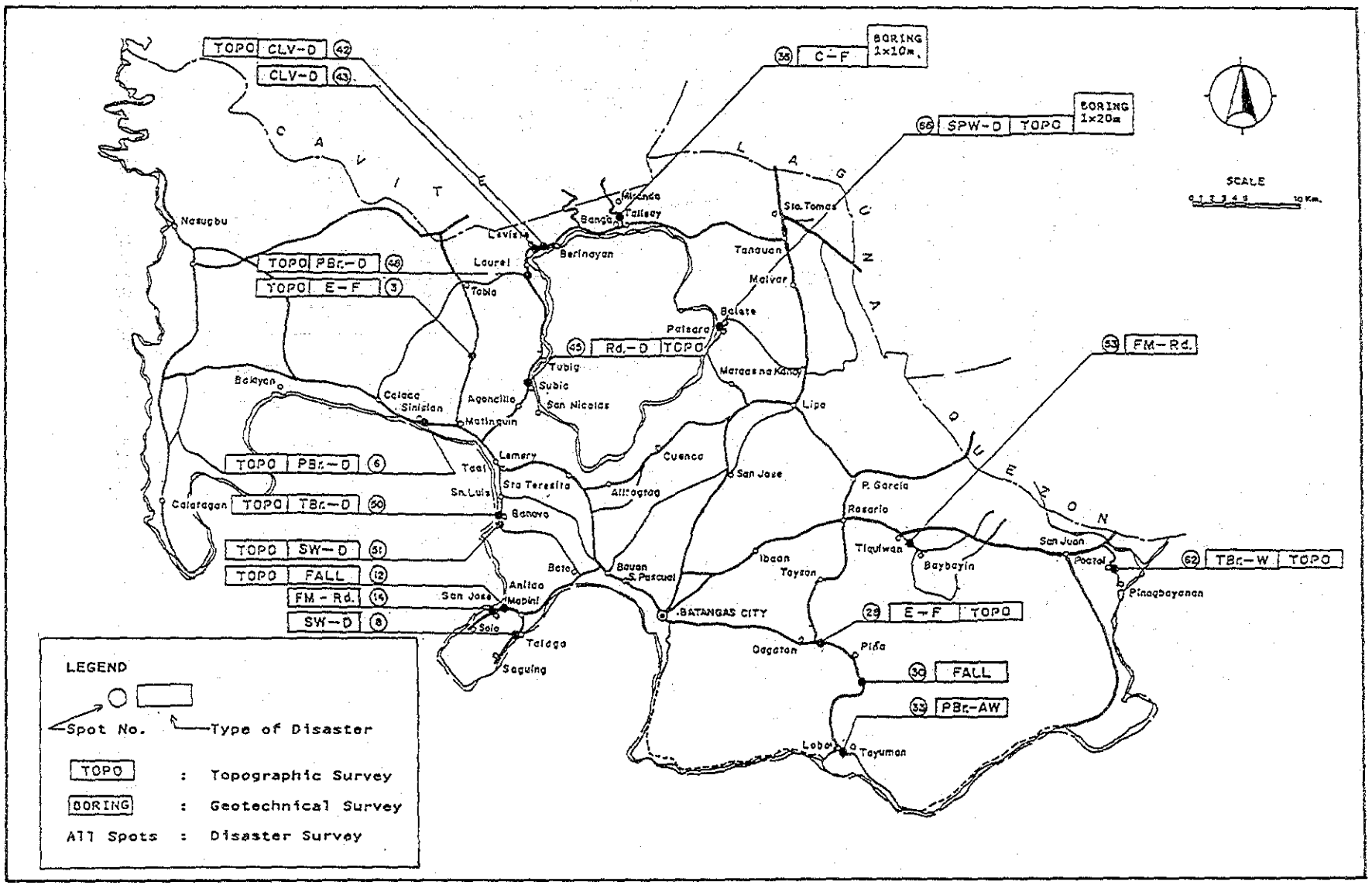


FIGURE 10.1-2 LOCATION MAP OF SPOTS FOR ENGINEERING SURVEY (BATANGAS)

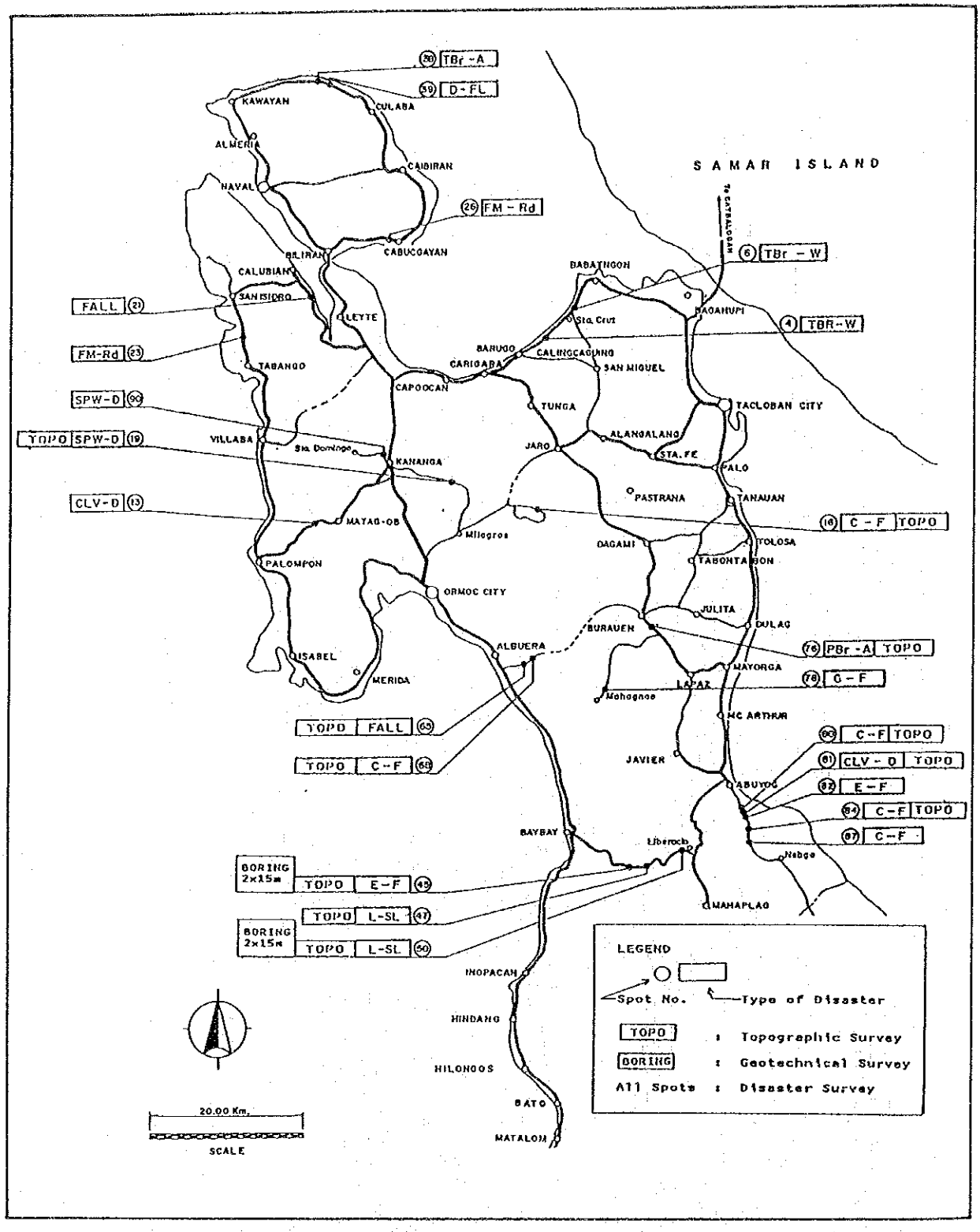


FIGURE 10.1-3 LOCATION MAP OF SPOTS FOR ENGINEERING SURVEY (LEYTE)

10.2 TOPOGRAPHIC SURVEY

The topographic survey was conducted at 31 spots which were selected in consideration of the following:

- Those spots with high and steep slopes such as C-F, E-F and L- SL.
- Those spots wherein flow of surface water must be examined such as CLV-D.
- Meandering rivers wherein direction of river channel must be analyzed.
- Those spots wherein details of structures are needed in the analysis such as SW-D.

Number of spots subjected to the topographic survey by type of disaster is summarized in Table 10.2-1.

Topographic map was prepared by the off-set survey method with a scale of 1:250 and a contour interval of one (1) meter.

At least four (4) cross sections were surveyed for each spot and were drawn with a scale of 1:100 or 1:200, depending on the magnitude of damage.

TABLE 10.2-1 NUMBER OF SPOTS SUBJECTED TO TOPOGRAPHIC SURVEY

Type of Disaster	No. of Spots			
	Benguet	Batangas	Leyte	Total
C-F	3	-	4	7
E-F	4	2	1	7
FALL	-	1	1	2
L-SL	1	-	2	3
Rd-D	-	1	-	1
PBr-A	-	-	1	1
PBr-D	-	2	-	2
TBr-W	-	1	-	1
TBr-D	-	1	-	1
SPW-D	-	1	1	2
CLV-D	1	1	1	3
SW-D	-	1	-	1
Total	9	11	11	31

10.3 GEOTECHNICAL SURVEY

The geotechnical survey was conducted at six (6) spots, two (2) spots for each province, where slope stability analysis and confirmation of embedment depth of foundation are needed for design of restoration works. A total of nine (9) boreholes were drilled and standard penetration test (SPT), soil sampling and laboratory tests were undertaken. Number and length of boreholes are as follows:

Province	Spot No.	Type of Disaster	No. of Boreholes	Length of Boreholes
Benguet	11	L-SL	2	2 x 15 m = 30 m
	20	E-F	1	10 m
Batangas	36	C-F	1	10 m
	66	SPW-D	1	20 m
Leyte	45	E-F	2	2 x 15 m = 30 m
	50	L-SL	2	2 x 15 m = 30 m
Total:	6 spots		9	130 m

Results of borings and laboratory tests are presented in Appendix 10-1.

10.4 DISASTER SURVEY

The disaster survey was conducted for all disaster spots selected for the feasibility study.

Following works were involved in the disaster survey:

- Assessment of present condition of the damaged portion and its surrounding area
- Assessment of potential causes of disaster
- Preparation of rough plans and cross sections
- Collection of other relevant information

10.4.1 Assessment of Present Condition and Potential Causes of Disaster

1) The following were observed and described:

   - general road condition (road name and class, width, surface type and condition, location of the disaster spot, etc.)
   - site features (topography, terrain, geology)
   - details of damage (phenomenon and its magnitude/extent degree of traffic interruption, etc.)

2) The check items listed in Table 10.4-1 were inspected.

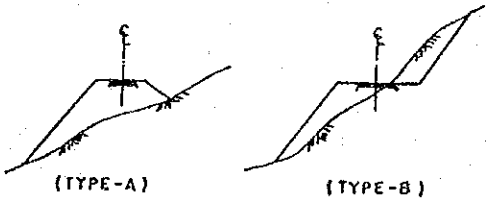
3) Potential causes of damage were assessed. In general, a disaster occurs as a result of composition of the following two kinds of cause:

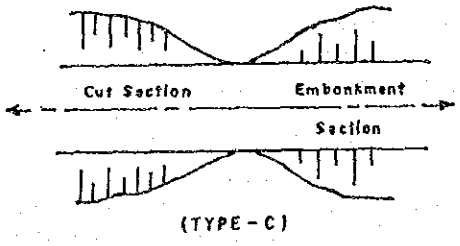
   - Potential Causes: unstable slope gradient, concentration of surface water, insufficient bridge length, etc.
   - Triggering Causes: heavy rain, sea wave, etc.

   In the disaster survey, the potential causes were mainly investigated. General potential causes are listed in Table 10.4- 1.

The description of each spot is included in Volume IV: Drawings.

TABLE 10.4-1 CHECKLIST AND GENERAL POTENTIAL CAUSES

Type of Disaster	Check Items	General Potential Causes
1. Cut Slope Failure (C-F)	1) Surface water condition - Existence of gulley, sag portion of a slope which causes concentration of surface water 2) Sub-surface water condition - Existence of seepage water, etc. 3) Top soil layer depth 4) Rock formation and condition - One kind of rock of several layers of different rocks - Condition of weathering, cracks and joints	· Unstable slope gradient (too steep and too high) · Surface water runs slope surface with high velocity due to bare and steep gradient · A slope has irregular surface and water concentrates at sagged portion causing erosion · Top soils on the inclined hard layer slides due to saturated water in top soils · Weathered rocks slide due to rainfall · Rotational failure along circular slide plane with weak shear strength · Translational failure which occurs along structural weakness such as faults, bedding planes and border planes between firm bedrock and overlying detritus or soils
2. Embankment Slope Failure (E-F)	1) Horizontal alignment of the road 2) Vertical alignment of the road 3) Super-elevation of the road 4) Type and width of pavement 5) Existence of side ditches and type, dimension and sedimentation of side ditches 6) Topography of mountain side slope particularly existence of stream or valley or sagged topography 7) River current directly hits the embankment (in this case, classify as Rd-D) 8) Type of cross-section  (TYPE-A) (TYPE-B)	· Unstable slope gradient · Concentration of surface water · Failure caused by water saturation in embankment · Failure caused by saturation of water due to seepage of surface or underground water (cross section Type-A or Type-B) · Same as above, but at the boundary between cut section and embankment section (Type-C) · Slope with no vegetation and berms on which water runs with high velocity

Type of Disaster	Check Items	General Potential Causes
(EF)	9) No cross-drainage, where it should have been provided (in this case, classify as CLV-D) 10) Existence of riprap/stone masonry protection - Height, thickness, etc. 11) Damaged riprap/stone masonry - Grouted or not - Existence of foundation and depth of foundation embedment - Existence of weep holes and whether they are functioning or not - Back filling is compacted enough or not, and material used 12) Whether it is located at the boundary between cut section and embankment section  (TYPE - C)	
3. Rock Fall/ Debris Fall (FALL)	1) Rock fall or debris fall 2) Rock formation and condition - one kind of rock or several layers of different rocks - condition of weathering, cracks and joints 3) Concentration of surface water - Existence of gulley, sag portion 4) Seepage of water from slope surface	· Rocks with highly weathered or developed cracks/joints · In case of debris falls, same causes as cut slope failure
4. Landslide (L-SL)	1) Existence of cliff in a slope 2) Irregularity of road surface (sinking road surface or horizontal slide of road surface) 3) Seepage of water from a slope 4) Existence of tension cracks on a slope	· Rock landslide occurs along structural weakness in rock or in weathered rock of weak · Shear strength · Soil landslide occurs along sliding plane of colluvial soil or clayey soil or along border plane between firm rock and soils

Type of Disaster	Check Items	General Potential Causes
5. Debris Flow (D-FL)	1) Identify location of spot on 1/50,000 topo map. (Area of basin will be determined and plan will be also developed based on 1/50,000 top map at an appropriate scale) 2) Existence of deposits on the stream bed 3) Vegetation of slopes at both sides of a stream (slopes easily eroded or not)	· Deposits on stream bed made by - accumulated soils and gravels brought from further upstream - materials brought by erosion of devastated slopes - failures of slopes on one or both sides of a stream
6. Scour/ Wash-out of Road-bed (Rd-D)	1) Direction of river stream 2) High water level of a river which is obtained by interviewing local officials or nearby residents 3) Sea wave height 4) Riprap/stone masonry/sea wall (same information mentioned in E-F) 5) Flood level (how many cm from road surface)	· Meandering river frequently changes its course and river stream hits the embankment directly · Overflowing water on a road surface scoures shoulder/road bed · No protection against sea wave is provided · Improperly constructed protections
7. Flooded /Muddy Road Surface (FM-Rd)	1) Road surface elevation vs. abutting land 2) Existence of side ditches 3) Dimension of side ditches 4) Flood level above road surface 5) Road surface material	· No proper drainage facilities · Improper road elevation · Improper material of road surface
8. Permanent Bridge Wash-out (PBr-W)	1) Bridge length (Distance between abutments) 2) Span length (Distance between piers) 3) Scouring depth at abutment, piers and river-bank protection 4) River condition - Width of flood plane - General direction of river course changes - Past history of river course changes - Flood water level - River bed deposit (max and mean size of gravel/cobbles) - Tendency of river bed (rising or lowering) - Clearance between flood water level and bridge	· Too short bridge length, thus insufficient opening at bridge site, and flood discharge cannot be accomodated. Usually bridge approach encroach flood plain · Too short span length between piers which causes accumulation of trees and logs flowed from upstream · Insufficient free board which causes accumulation of trees and logs. Insufficient free board may be due to sedimentation or design errors · Local scouring at abutments, piers, approach protections and river bank protections · Insufficient embedment of foundation or improper type of foundation · Meandering river usually changes its river course, resulting in deep local scouring of unexpected portion
9.(PBr-A) 10.(PBr-D) 11.(TBr-W) 12.(TBr-A) 13.(TBr-D)	· Same check items as 8. PBr-W	· Same causes as 8. PBr-W

Type of Disaster	Check Items	General Potential Causes
14. Spill-way Damage (SPW-D)	1) Vertical alignment along road center line 2) Damaged length and width 3) Materials used for spillway - Concrete - Riprap - RCP (Diameter) 4) Length of spillway 5) River condition - Same as 8. PBr-W 6) Scouring depth 7) Condition of sedimentation 8) Cross section of spillway	· Deep local scouring at downstream side which leads to collapse of spillway · Too short spillway, thus scouring/washout of approach, then washout of spillway · Improper materials and/or construction · Cracks of spillway surface due to axle load which leads to washout of materials under spillway surface · Sedimentation at upstream side due to which function is lost
15. Cul-vert Damage (CLV-D)	1) Horizontal and vertical alignment of the road 2) Super-elevation of the road 3) Type and width of pavement 4) Existence of side ditches, type, dimension and sedimentation of side ditches 5) Topography of mountain side slope 6) Type, dimension and condition of cross-drainage facility 7) Inlet and outlet facilities and their conditions 8) Damaged condition of slopes near the cross-drainage 9) River or stream condition for both upstream and downstream sides	· Clogged culvert or insufficient capacity of culvert causes over flow of concentrated surface water over road surface and damaging embankment slopes · No outlet drainage facilities or insufficient length of apron are provided, thus water runs directly on a slope, causing deep scouring · Riprap around a culvert and a slope is poorly constructed, thus easily damaged by drained water · At curved or sagged section where surface water concentrate no drainage facilities are provided
16. Sea-wall Damage (SW-D)	1) Distance from seawall to seashore and distance from seawall to a road centerline 2) Type and width of road pavement and shoulder 3) Type of seawall 4) Damaged condition - Grouting was properly done or not - Foundation was properly constructed or not - Others 5) Wave height during typhoon (by interviewing local officials and/or nearby residents)	· Poorly constructed seawall, and is not water-tight structure · Insufficient height of seawall · Foundation embedment is not sufficient and scoured

10.4.2 Preparation of Rough Plans and Cross Sections

Disaster spots which were not subjected to the topographic survey, were surveyed by the Study Team and rough plans and cross sections were prepared. For bridge/spillway related spots, side views were additionally prepared.

For those spots where the topographic survey was undertaken, only simple sketchy plans and cross sections were prepared without measurements, for the purposes of checking topographic maps/cross sections prepared by sub-contractor as well as complementing the description of spots.

Procedures for sketching plans and cross sections were as follows:

Procedure For Sketching Plans

1) Draw road centerline alignment.

2) Draw pavement edge lines, shoulder lines and side-ditches. When there is no side-ditches, describe "no side-ditches" on the plan.

3) Indicate on the plan an approximate vertical grades in %.

4) Indicate damaged portion. Length, width, height, etc. shall be noted on the plan.

5) Topographic characteristics shall be indicated by contour lines. If steep slopes, dense contour line interval will be used.

6) Indicate all existing structures such as ripraps, cross drainages, wing walls, inlet/outlet of drainage facilities, houses, etc. Location, dimensions, depth from road surface, etc. shall be indicated on the plan.

7) Conditions such as existence of gulley, flow of surface water, sedimentary condition, clogged pipes, etc. which suggest potential causes shall be noted on the plan.

8) For bridge/spillway spots, river conditions such as listed in Table 10.4-1 shall be indicated on the plan.

9) Indicate locations of cross sections measured.

Procedure For Sketching Cross Sections

1) Select locations of cross sections to be measured (probably 2- 3 cross sections per spot will be required).

2) Measure distances from the centerline and height/depth from road surface.

3) Draw cross sections and indicate distance and height/depth.

10.4.3 Collection of Other Relevant Information

Other relevant information such as design drawings/as-built drawings for original construction/restoration works, past disaster records, etc. was collected as much as available.

CHAPTER 11

CAUSES OF ROAD DISASTER AND CURRENT RESTORATION MEASURES

11.1 CAUSES OF ROAD DISASTER

The causes of the road disasters at the selected spots were individually assessed and described in Volume IV: Drawings. This chapter summarizes the causes by type of disaster.

1) Cut Slope Failure (C-F)

The causes of cut slope failure are as follows:

- Erosion
- Weathering and structural weakness
- Scour
- Rotational failure
- Translational failure

Erosion

A slope with irregular/bare surface is eroded due to concentration of surface water which runs at high velocity on sagged portion, forming and developing gullies. Bare slope surface composed of sediment, non-cohesive sand or volcanic ash or sand is susceptible to erosion.

Weathering and Structural Weakness

Weathered rocks which are weakened, disintegrated and eventually pulverized due to frequent alternate dry and wet condition, and rocks with structural weakness like cracks, joints, bedding faults and border planes are susceptible to slope failure introduced by surface water flow during heavy rain. Soft rocks, mudstone and tuff are easily weathered and schist, diabase, serpentinite, granite, andesite, quartz and sandstone are subject to structural weakness.

Scour

Increase of pore water pressure resulting from rise of groundwater level causes loss of shearing strength of surface materials and loosen them, and thus, foot of slope is easily scoured by rain pour. Sandy soil, clayey soil, talus, metamorphic rock are susceptible to scour.

Rotational Failure

Improper configuration of slope in height and gradient in the slope composed of thick soil or highly weathered soft rock with low shear strength causes rotational failure on the occasion of rise in groundwater level. Sandy soil, clayey soil, talus, metamorphic rock are susceptible to this kind of failure.

Translational Failure

Structural weak planes such as fault, bedding plane, border plane between rock and soil causes translational failure, especially when joint or bedding plane inclines along slope surface. Sandstone, mudstone, slate, granite, porphyry are susceptible to translational failure.

2) Embankment Slope Failure (E-F)

Embankment slope failure is caused by the following:

- Erosion
- Saturation
- Scouring
- Instability

Erosion

Slope surface is eroded by concentrated surface water, especially on curved or sagged portion, causing gradual advance of surface failure when the slope is formed with erosive soil and drainage facilities are not properly provided.

Saturation

Decrease in shear strength of embankment materials due to seepage of surface water or groundwater causes deep failure, especially in embankment on inclined ground.

Scour

Foot of slope is scoured by rain pour, sea water or river flow, where the embankment slope is located on curved or sagged section, seaside or riverside.

Instability

Improper configuration of slope in height and gradient causes rotational failure.

3) Rock Fall/Debris Fall (FALL)

Rock Fall

Open cracks developed in hard rock and alternations of different rock layers are the main causes of rock fall.

Debris Fall

Unsupported pebbles, cobbles and boulders fall from slope of debris or talus, often triggered by flow of surface water and/or seepage of groundwater.

4) Landslide (L-SL)

Landslide is a movement of materials forming the slope caused by loss of balance between shearing strength and movement force along a slide plane. Thus, potentiality of landslide is in the topographical features and geological properties of the slope and an action/effect decreasing shearing strength and/or increasing movement force may cause the occurrence of landslide. In most cases, landslide is induced by rise of groundwater level due to heavy rain.

Landslide are classified into two types:

- Rock landslide
- Soil landslide

Rock Landslide

Rock landslide is apt to occur along structurally weak plane such as fault plane and bedding plane inside a bedrock. Neogene, crystalline, schist are susceptible to landslide especially in fault fracture zone.

Soil Landslide

Soil landslide is apt to occur inside weak soil such as colluvial or clayey soil or along the border of rock and soil.

5) Debris Flow (D-FL)

The potential cause of debris flow is a large quantity of deposits on riverbed which are made by accumulated soil and stones brought from upstream, or materials brought by erosion of riverbed or slope on one or both sides of the stream. Debris flow is induced by the force of flow due to heavy rain.

6) Scour/Washout of Roadbed (Rd-D)

Major causes of scour/washout of roadbed are as follows:

River Stream

River stream at curved portion directly hits a roadbed and causes its scour/washout, especially when the river rises after heavy rain.

Sea Wave or Lake Wave Action

By sea wave or lake wave action, unprotected or insufficiently protected road slope is easily scoured resulting in partial or entire washout of roadbed.

Overflow of Water

Where a road surface is lower than flood level, overflowed water causes scour/washout of roadbed.

7) Flooded/Muddy Road Surface (FM-Rd)

Major causes are as follows:

Low Road Surface

Where road surface is lower than abutting area, surface water concentrates on road surface causing it to be muddy and sometimes impassable.

Insufficient/Silted Side Ditch

Insufficient capacity of side ditch causes overflow of water and penetration of water into base/subbase/roadbed, aggravating surface condition and reducing bearing capacity of roadbed. Siltation of side ditch by deposit material results in the same situation.

Deformation of Shoulder

Rise or settlement of shoulder causes ponding and infiltration of water on carriageway or shoulder near their border. Rise of shoulder is caused by accumulation of material moved from the road surface by traffic and water or growth of grasses and bushes on unpaved shoulder, while settlement of shoulder is mainly due to softness and weakness in shoulder material.

Improper Material of Road Surface

Road surface condition easily deteriorates due to presence of clayey or fine materials in surface course, loss of gravel, contamination of surface course by lower course material, etc.

8) Permanent/Temporary Bridge Washout (PBr-W, TBr-W)

The superstructure of a bridge is washed out due to the following hydraulic actions:

- Drag force of flow acting on a submerged or partially submerged superstructure
- Impact imparted by floating debris such as logs, trees and the like

Submergence of superstructure and impact of floating debris are caused by insufficient waterway opening as found in the following cases:

- Insufficient bridge length wherein bridge approach encroaches flood plain
- Too short pier spacing causing accumulation of floating debris
- Insufficient freeboard, whether from the start of construction or as a result of rise of riverbed by sedimentation

In some cases, bridge washout is induced by collapse of pier/abutment due to scour or debris force.

9) Permanent/Temporary Bridge Approach Washout (PBr-A, TBr-A)

Major causes of erosion of bridge approach are as follows:

Change in Alignment of River Channel

Alluvial channels exhibit a natural instability which results in continuous shifting of the stream through erosion and deposition of bends, formation and destruction of islands, development of oxbow lakes and the formation of braided channel sections. Bridge approaches abutting on meandering or braided stream are subject to erosion due to natural movement of the stream.

Encroachment on Stream

Where an approach encroaches on the stream, waterway opening is reduced causing a local obstruction to flow and higher velocity, resulting in significant erosion problem on the approach embankment.

10) Permanent/Temporary Bridge Other Damage (PBr-D, TBr-D)

Bridge other damage includes scour at pier/abutment, scour at revetment, tilting of pier and raise of river bed. Major causes of these damages are general and local scour and aggradation and degradation.

Appendix 11-1 presents chronologically the progress of damage in the selected bridges.

General Scour

General scour occurs across the cross section as a result of increased velocities in the constracted section.

Local Scour

Local scour occurs at piers, embankment ends and similar obstructions in the flow. It is caused by the vortex of fluid which results from the pileup of water on the upstream edge and subsequent acceleration of flow around the obstruction.

Aggradation and Degradation

Many streams are actively aggrading or degrading and the equilibrium of relatively stable streams can be upset by man's attempts to develop water resources for beneficial use.

Degradation occurs when the sedimentation transport capacity of a stream is increased or the sediment supply is decreased, while aggradation occurs under the opposite situation.

11) Spillway Damage (SPW-D)

Spillway damages are caused by the following:

- Erosion/scour by hydraulic force
- Impact force imparted by debris
- Debris clogging in pipe culvert

12) Culvert Damage (CLV-D)

Causes of culvert damage are as follows:

Obstruction of Culvert

Obstruction of culvert with silt, natural debris or other material causes ponding of water upstream and overflow of water over the road surface, resulting in erosion/scour of slopes.

Insufficient Capacity of Culvert

Same effect as above.

Scour

Where no or improper outlet facilities are provided, water runs directly on a slope causing erosion of the slope.

13) Seawall Damage (SW-D)

Seawall damages are caused by the following:

- Insufficient strength of seawall against seawave and backwash actions
- Insufficient height of seawall

11.2 CURRENT RESTORATION MEASURES

Restoration measures currently being taken are mostly temporary measures resulting in recurrence of disaster. Major restoration measures are summarized in this Chapter by type of disaster. Appendix 11-2 presents the drawings for the restoration works recently implemented.

1) Cut Slope Failure (C-F)

Restoration measures for cut slope failure are, in most cases, limited to removing fallen soil mass from the road surface by pushing it to the valley side with a bulldozer. Drainage facilities, slope protection and other permanent measures are hardly adopted.

2) Embankment Slope Failure (E-F)

In most cases, either gravity type stone masonry or grouted riprap is applied for restoring a failed embankment slope, as found in the selected spots in this Study as follows:

Spot	Applied Measures
Bt - 20	Stone Masonry
Bt - 24	Stone Masonry
Bt - 25	Stone Masonry
Bt - 38	Stone Masonry
Bt - 54	Grouted Riprap
Bs - 28	Stone Masonry
L - 45	Grouted Riprap

In general, there are some technical mistakes in constructing these structures, which are pointed out as follows:

- Mortar is not properly placed.
- No berms is provided in grouted riprap over 10 meters high.
- Concentration of road surface water on shoulder is not corrected.
- No consideration is given to groundwater drainage.
- Back-fill materials are not compacted well.
- Foundation is not embedded enough.
- Foot protection is not provided even where necessary, for example, in case of embankment along a river.
- Surface drainage facilities are not incorporated enough.

These restoration works are, sometimes, not implemented immediately because it takes time for funds to be released.

3) Rock Fall/Debris Fall (FALL)

Restoration measures for rock fall/debris fall are mostly removal of rocks and debris which fall on the road surface. When the fallen rocks are very large, dynamite is used to break the rocks into small pieces. Usually, no protection work is done on the slope.

4) Landslide (L-SL)

Usually, overlay is made on the road surface when it sinks caused by landslide, which generally has an adverse effect to accelerate the landslide. Removal of soil is common measures when the road is located near the foot of sliding plane and covered by soil.

There is a case where stone masonry retaining wall is constructed against landslide.

5) Debris Flow (D-FL)

Restoration measures are usually removal of earth and rocks which have flowed onto the road surface.

There is a case where a bridge is constructed crossing the debris flow channel.

6) Scour/Washout of Roadbed (Rd-D)

Stone masonry and grouted riprap are common restoration measures for scour/washout of roadbed.

7) Flooded/Muddy Road Surface (FM-Rd)

Restoration measures commonly taken are construction of side ditches and raise of road elevation by embankment, as found at Spot L-23 where embankment about 2 meters high was constructed with slope protection by grouted riprap.

8) Permanent/Temporary Bridge Washout (PBr-W, TBr-W)

Reconstruction of the bridge, whether temporary or permanent, is only measures if taken. In some cases, only foot bridge is constructed or no measures are taken, thus motorized access is left to be cut.

9) Permanent/Temporary Bridge Approach Washout (PBr-A, TBr-A)

Refilling with slope protection by stone masonry, or extension of the bridge is common measures depending on degree of damage.

10) Permanent/Temporary Bridge Other Damage (PBr-D, TBr-D)

In most cases, no measures are taken against scour at pier/abutment/revetment resulting in critical damage like collapse/washout.

11) Spillway Damage (SPW-D)

Reconstruction of the spillway is common measures. Where approach portion is washed out due to riverbed widening caused by erosion of the bank, embankment is constructed with sand, gravel and stones, as seen at Spots L-19 and L-90.

12) Culvert Damage (CLV-D)

Damaged portion of culvert is replaced with new one and sometimes an additional piece is spliced where necessary. Embankment slope failure caused by defects in culvert is restored by stone masonry or grouted riprap, as seen at Spots Bt-7 and L-13. In most cases, outlet portion of the culvert is left unimproved.

13) Seawall Damage (SW-D)

Reconstruction is common measures. In some cases, temporary retaining work like wooden fence is carried out as seen in Spot Bs-51.

11.3 COMMENTS ON CURRENT RESTORATION MEASURES

Presented in this Chapter are the comments on the current restoration measures focusing on grouted riprap, stone masonry and pipe culvert which are often used as restoration measures.

11.3.1 Grouted Riprap

Commonly observed problems in design and construction of grouted riprap are as follows:

Application

Grouted riprap is used sometimes for slope protection, sometimes as retaining wall. Slope protection is mainly purposed to protect a slope from erosion by runoff of surface water, wherein the slope is stable by itself without any structural support. Retaining wall, in the other hand, has to support and retain a slope sustaining earth pressure exerted on it. Strength of grouted riprap to sustain earth pressure is so small that its application is limited to the use for slope protection or sustainer of small earth pressure. However, grouted riprap is sometimes applied improperly, resulting in its collapse on the occasion of slight increase in earth pressure.

Weep Holes and Filter Layer

Weep holes play an important role to eliminate water pressure which is usually much higher than earth pressure. Weep holes must be installed properly in size, number, location and inclination together with pervious and durable sack close as well as filter layer of good permeability. Some defects such as improper installation of weep holes, absence of or use of improper material for filter layer, etc. are sometimes observed in the existing grouted riprap, causing its early failure.

Grouting

All voids between stones must be completely filled with cement mortar. In some cases, grout is plastered only on the completed surface.

11.3.2 Stone Masonry as Gravity Type Retaining Wall

Stability

When stone masonry is constructed as gravity type retaining wall, its stability must be assured. However, the existing structures are sometimes not deemed to be stable enough, especially they are constructed on slopes.

Weep Holes and Filter Layer

The same problems as in grouted riprap are found.

Compaction of Backfill Material

Compaction of backfill material is apt to be neglected.

11.3.3 Pipe Culvert

Location

Location of pipe culverts must be carefully selected in consideration of not only perennial stream but also occasional stream during heavy rain. Pipe culverts are sometimes not located along major stream during heavy rain causing erosion of road surface and slope.

Cover Layer Thickness

A pipe culvert, in case of being covered by insufficient thickness of earth, undergoes excessive load resulting in its damage. Such cases are sometimes observed in the existing culverts.

Debris Problem

Accumulation of debris at a culvert inlet results in the culvert not performing as designed, causing spillover of incoming water. This situation is caused by improper design of inlet and/or lack of maintenance. Debris clogging is sometimes observed in the existing culverts.

Outlet Protection

Many pipe culverts are not equipped with apron at their outlets. Discharged water rapidly scoures the slope beneath the culvert causing a slope failure.

CHAPTER 12
TYPE OF RESTORATION MEASURES

A restoration is generally classified into the following two types:

- Urgent Restoration

  This is a measure which is taken immediately after occurence of disaster with the main objective of reopening the road which has been closed to traffic caused by the disaster.

- Permanent Restoration

  This is a measure which is taken after the urgent restoration to restore the road completely and to prevent the recurrence of disaster.

12.1 TYPE OF URGENT RESTORATION MEASURES

The purposes of urgent restoration are generally as follows:

- To secure urgently and temporarily at least one lane traffic by removing obstacles or by refilling eroded portion.
- To remove materials suspended to endanger traffic like unstable rocks on a slope.
- To check the progress of damage until permanent measures are taken.

The requirements for urgent restoration measures are as follows:

- To be able to be implemented immediately after occurrence of disaster and completed in a short period.
- To require no special equipment, material and expertise.
- To be low-cost.

Urgent restoration measures selected in view of the above and included in the Manual are as follows:

U1:	Earth Work	U1-1:	Removal of Deposit Materials
		U1-2:	Removal of Unstable Materials
		U1-3:	Removal of Head
		U1-4:	Refilling/Embankment
		U1-5:	Selected Material Fill

U2:	Surface Drainage	U2-1:	Temporary Slope Ditch
		U2-2:	Temporary Side Ditch
		U2-3:	Sand Bag Setting
U3:	Slope Protection	U3-1:	Sheet Covering
		U3-2:	Sand Bag Covering
U4:	Retaining Work	U4-1:	Sand Bag Wall
		U4-2:	Gabion Wall
		U4-3:	Wooden Fence
U5:	Foot Protection	U5-1:	Gabion Foot Protection
U6:	Bridge	U6-1:	Wooden Pile Bent
		U6-2:	H-Pile Bent
		U6-3:	Bailey Bridge
U7:	Pavement Work	U7-1:	Gravel Surfacing

Urgent restoration measures are summarized in Table 12.1-1 (1) to (4).

TABLE 12.1-1 (1) TYPE OF URGENT RESTORATION MEASURES

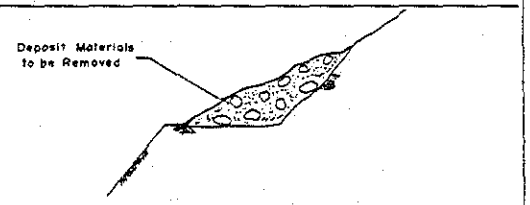
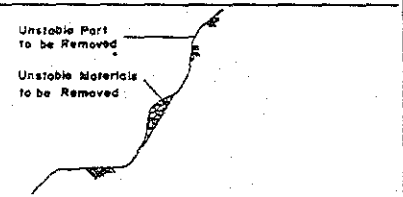
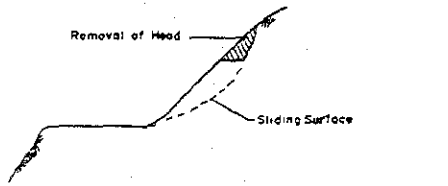
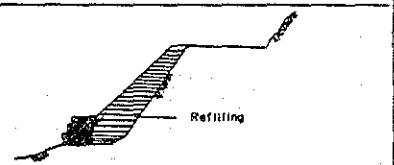
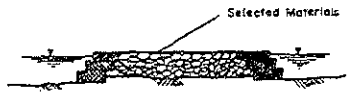
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
U1: Earth Work	U1-1: Removal of Deposit Materials	To open road for traffic by removing failed or moved materials deposited on the road.	C-F FALL L-SL D-FL	
	U1-2: Removal of Unstable Materials	To ensure traffic safety by removing unstable parts or materials on the slope	C-F FALL	
	U1-3: Removal of Head	To reduce motivating force by removing head portion of cut slope failure or landslide	C-F L-S Usually applied to landslide (L-S)	
	U1-4: Refilling/ Embankment	To open road for traffic by filling failure portions of the road with soil etc.	E-F PBr-A TBr-A CLV-D SW-D Usually applied with slope protection work or retaining work.	
	U1-5: Selected Material Fill	To fill portions influenced by water with selected materials such as sand and gravel, cobbles, etc.	E-F PBr-A TBr-A SPW-D CLV-D SW-D	

TABLE 12.1-1 (2) TYPE OF URGENT RESTORATION MEASURES

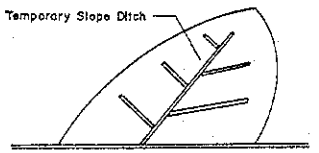
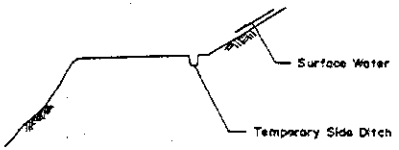
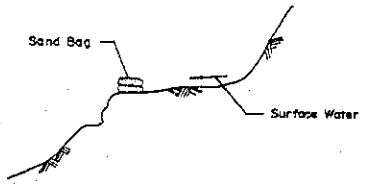
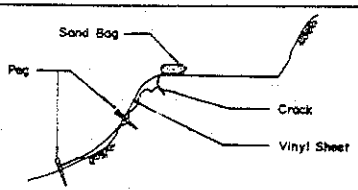
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
U2: Surface Drainage	U2-1: Temporary Slope Ditch	To collect and drain surface water on slope by providing slope ditch for preventing slope surface from erosion/scour.	C-F FALL	
	U2-2: Temporary Side Ditch	To drain surface water on the road for preventing water from flowing onto embankment slope.	E-F	
	U2-3: Sand Bag Setting	To prevent the surface water from flowing onto the collapsed slope by setting sand bags.	E-F Instead of sand bags, there is a case in which small bank is constructed.	
U3: Slope Protection	U3-1: Sheet Covering	To protect slope from erosion and scour by covering the slope surface with vinyl sheets, etc.	C-F E-F Usually applied to small area of the slope.	
	U3-2: Sand Bag Covering	To protect slope from erosion and scour by covering the slope with sand bags.	E-F Can be applied to fairly steep slope (up to 0.5:1)	

TABLE 12.1-1 (3) TYPE OF URGENT RESTORATION MEASURES

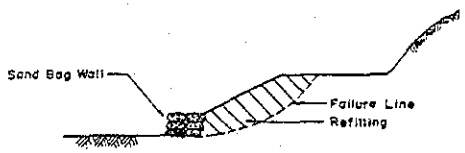
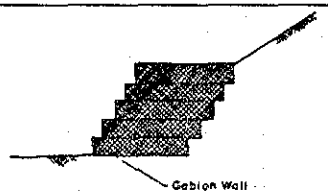
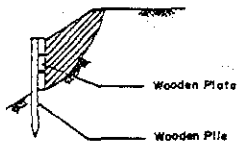
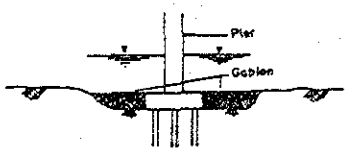
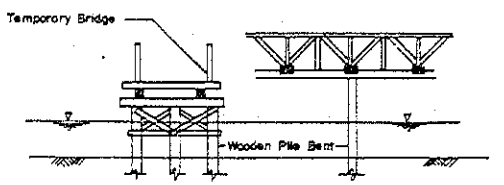
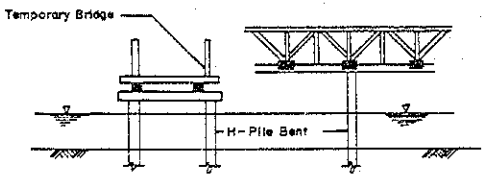
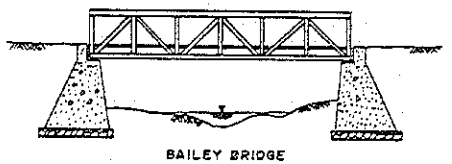
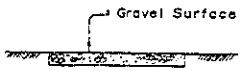
CLASSIFICTION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
U4: Retaining Work	U4-1: Sand Bag Wall	To resist earth pressure by stacking sand bags.	C-F E-F L-S	
	U4-2: Gabion Wall	To resist earth pressure by stacking gabions.	C-F E-F L-S PBr-A TBr-A SW-D Effective for slope with water seepage.	
	U4-3: Wooden Fence	To resist earth pressure by wooden fence.	E-F SW-D Mainly applied to embankment slope failure (E-F).	
U5: Foot Protection	U5-1: Gabion Foot Protection	To protect foot of revetment, retaining wall, pier, etc. from scour by placing gabion.	E-F PBr-A PBr-D TBr-A TBr-D CLV-D	

TABLE 12.1-1 (4) TYPE OF URGENT RESTORATION MEASURES

CLASSIFICTION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
U6: Bridge	U6-1: Wooden Pile Bent	To support a temporary bridge.	PBr-W PBr-A TBr-W TBr-A	
	U6-2: H-Pile Bent	To support a temporary bridge.	PBr-W PBr-A TBr-W TBr-A	
	U6-3: Bailey Bridge	To provide a temporary bridge.	PBr-W PBr-A TBr-W TBr-A	
U7: Pavement Work	U7-1: Gravel Surfacing	To restore deteriorated road surface.	Applied to all types of disaster except the following: PBr-W PBr-D TBr-W TBr-D	

12.2 TYPE OF PERMANENT RESTORATION MEASURES

Permanent restoration measures are usually taken after urgent measures for the following purposes:

- To restore the road completely to its original condition or upgrade it when necessary.
- To prevent the recurrence of disaster.

Major considerations in selecting permanent restoration measures are as follows:

- To be technically and practically applicable in the Philippines using available equipment, materials and expertise.
- To introduce new or uncommon techniques in the Philippine as far as practically acceptable.
- To be harmonized with natural environment.

Permanent restoration measures selected in view of the above and included in the Manual are as follows:

P1:	Earthwork	P1-1:	Recutting
		P1-2:	Removal of Head
		P1-3:	Refilling/Embankment
		P1-4:	Counterweight Fill
		P1-5:	Selected Material Fill
P2:	Surface Drainage	P2-1:	Slope Ditch
		P2-2:	Side Ditch
		P2-3:	Water Channel
		P2-4:	Culvert
		P2-5:	Catch Basin
P3:	Subsurface Drainage	P3-1:	Subsurface Drainer
		P3-2:	Horizontal Drain Hole
		P3-3:	Deep Well
		P3-4:	Drain Tunnel
P4:	Slope Protection by Vegetation	P4-1:	Hand Seeding
		P4-2:	Hand Seeding With Mat
		P4-3:	Sodding
		P4-4:	Strip Sodding
		P4-5:	Seed Spraying
		P4-6:	Pick Hole Seeding
		P4-7:	Seed Packet
		P4-8:	Wattling

P5:	Slope Protection by Structure	P5-1: Mortar Spraying P5-2: Concrete Spraying P5-3: Stone Pitching P5-4: Concrete Pitching P5-5: Gabion Pitching P5-6: Concrete Block Crib P5-7: Cast-in-place Concrete Crib P5-8: Sprayed Concrete Crib
P6:	Retaining Wall	P6-1: Riprap P6-2: Grouted Riprap P6-3: Concrete Block Wall P6-4: Gravity Type Stone Masonry Wall P6-5: Gravity Type Concrete Wall P6-6: Supported Type Concrete Wall P6-7: Cantilever Type Concrete Wall P6-8: Buttressed Type Concrete Wall P6-9: Gabion Wall P6-10: Sheet Pile Wall
P7:	Anchoring	P7-1: Rock Bolt P7-2: PC-Anchor
P8:	Catch Work	P8-1: Catch Fill and Ditch P8-2: Catch Gabion Wall P8-3: Catch Concrete Wall P8-4: Catch Fence P8-5: Catch Wire Net
P9:	Supporting Work	P9-1: Concrete Supporting
P10:	Rock Shed	P10-1: Concrete Rock Shed
P11:	Prevention Pile	P11-1: Steel Prevention Pile
P12:	Slope Breasting	P12-1: Stone Breasting P12-2: Gabion Breasting
P13:	Sabo Dam	P13-1: Concrete Sabo Dam P13-2: Gabion Sabo Dam P13-3: Steel Sabo Dam
P14:	Consolidation	P14-1: Concrete Consolidation P14-2: Gabion Consolidation
P15:	Bridge	P15-1: Concrete Bridge P15-2: Steel Bridge
P16:	Foot Protection including Apron	P16-1: Concrete Foot Protection P16-2: Gabion Foot Protection P16-3: Grouted Riprap Apron
P17:	Spurdike	P17-1: Stone Spurdike P17-2: Gabion Spurdike

P18:	Spillway	P18-1:	Concrete Spillway
P19:	Pavement Work	P19-1:	Gravel Surfacing
		P19-2:	Bituminous Pavement
		P19-3:	Concrete Pavement
P20:	Reinforced Earth	P20-1:	Reinforced Earth Wall
		P20-2:	Inserting of Reinforcing Bar

Permanent restoration works are summarized in Table 12.2-1 (1) to (16).

TABLE 12.2-1 (1) TYPE OF PERMANENT RESTORATION MEASURES

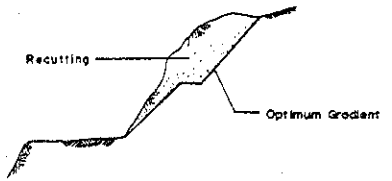
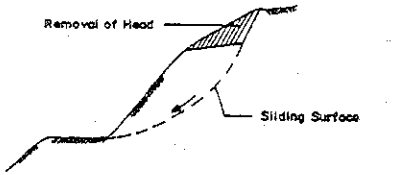
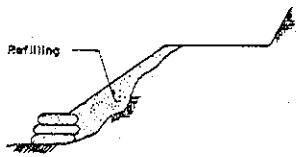
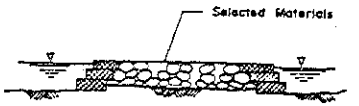
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P1: Earth Work	P1-1: Recutting	To stabilize slope by cutting it to optimum gradient.	C-F FALL Usually applied with drainage work and slope protection work.	
	P1-2: Removal of Head	To reduce sliding force by removing head portion of slope.	C-F L-SL Usually applied to landslide. (L-SL).	
	P1:3: Refilling/ Embankment	To recover failed portion of road by refilling with soil.	E-F PBr-A TBr-A CLV-D Usually applied with drainage work, slope protection work or retaining wall.	
	P1-4: Counterweight Fill	To resist sliding force by filling at foot portion of slope.	C-F E-F L-SL Usually applied to landslide (L-SL).	
	P1-5: Selected Material Fill	To fill portions influenced by water with selected materials such as sand and gravel, cobbles, etc.	E-F PBr-A TBr-A SPW-D CLV-D SW-D	

TABLE 12.2-1 (2) TYPE OF PERMANENT RESTORATION MEASURES

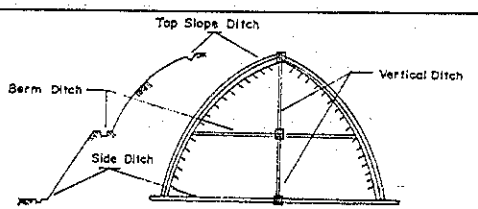
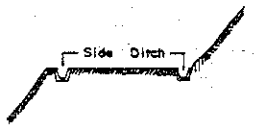
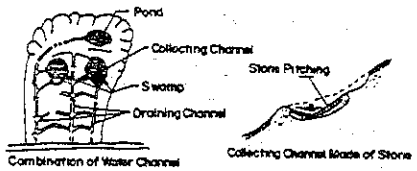
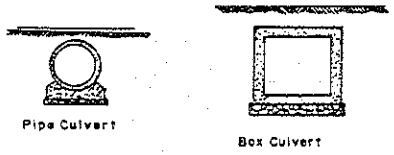
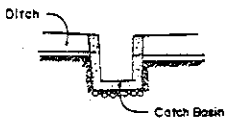
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P2: Surface Drainage	P2-1: Slope Ditch	To prevent erosion and scour of slope surface by collecting surface water running down on slope surface.	C-F FALL	
	P2-2: Side Ditch	To prevent erosion and scour of road and embankment surface by collecting surface water on road surface.	E-F PBr-A TBr-A	
	P2-3: Water Channel	To reduce sliding force by collecting and draining surface water in landslide area.	L-SL	
	P2-4: Culvert	To collect and drain water crossing road.	E-F SPW-D CLV-D	
	P2-5: Catch Basin	To connect different types of drainage facilities, reducing energy of flowing water.	Applied with other drainage works.	

TABLE 12.2-1 (3) TYPE OF PERMANENT RESTORATION MEASURES

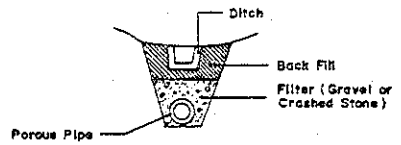
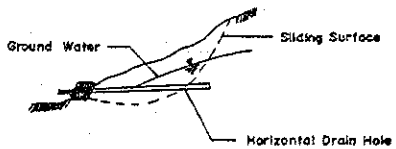
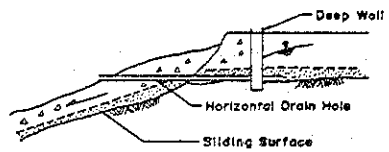
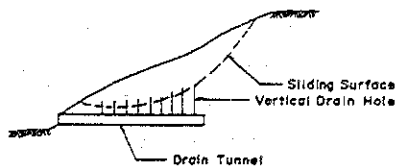
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P3: Subsurface Drainage	P3-1: Subsurface Drainer	To drain shallow groundwater and thus stabilize slope.	C-F L-SL Usually used in combination with surface drainage.	
	P3-2: Horizontal Drain Hole	To stabilize landslide-prone slope by draining groundwater in deep portion.	L-SL	
	P3-3: Deep Well	To stabilize landslide-prone slope by draining groundwater in deep portion.	L-SL Applied when horizontal drain hole is too long or crowdedly placed.	
	P3-4: Drain Tunnel	To stabilize landslide-prone slope by draining groundwater in deep portion.	L-SL Usually applied to large-scaled landslide with rich groundwater.	

TABLE 12.2-1 (4) TYPE OF PERMANENT RESTORATION MEASURES

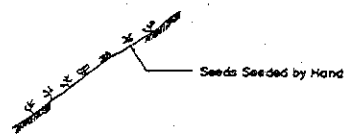
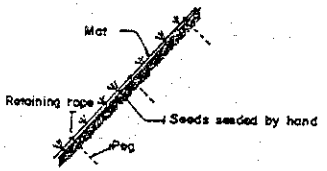
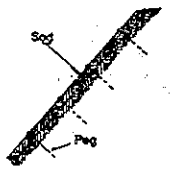
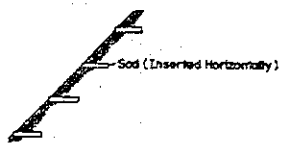
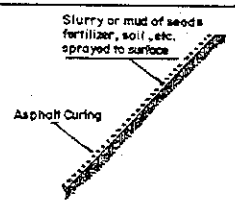
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P4: Slope Protection by Vegetation	P4-1: Hand Seeding	To prevent erosion, scour and weathering of slope by covering it with vegetation. Seeds are susceptible to be washed out by rain.	C-F E-F FALL L-SL Mainly applied to slope of soil or strongly weathered rock. Slope with gradient of greather than 0.8:1 is not applicable.	
	P4-2: Hand Seeding with Mat	To prevent erosion, scour and weathering of slope by covering it with vegetation. Slope is covered with mat after seeding to prevent washing out of seeds.	C-F E-F FALL L-SL	
	P4-3: Sodding	To prevent erosion, scour and weathering of slope by covering it with vegetation. Certain size of sod is directly laid on slope. Protection effect is immediately expected.	C-F E-F Usually applied to small area of slope.	
	P4-4: Strip Sodding	To prevent erosion, scour and weathering of slope by covering it with vegetation. Strip shaped sod is inserted on slope at some intervals.	E-F Only applied to embankment slope.	
	P4-5: Seed Spraying	To prevent erosion, scour and weathering of slope by covering it with vegetation. Mixed slurry or mud composed of seeds, water, fertilizer, soil, etc, are sprayed by pump or spray gun. Slope is covered with asphalt emulsion for curing after spraying.	C-F E-F FALL L-SL Applied to large area of slope.	

TABLE 12.2-1 (5) TYPE OF PERMANENT RESTORATION MEASURES

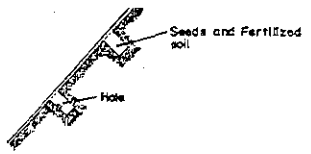
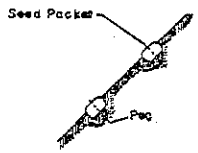
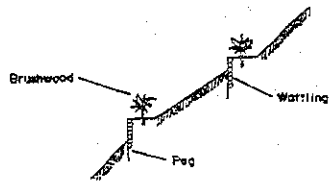
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P4: Slope Protection by Vegetation (Continued)	P4-6: Pick Hole Seeding	To prevent erosion, scour and weathering of slope by covering it with vegetation. Seeds and fertilized soil are filled into holes dug on slope.	C-F FALL Applied to slope relatively unsuitable to grow grass.	
	P4-7: Seed Packet	To prevent erosion, scour and weathering of slope by covering it with vegetation. Bags filled with seeds and fertilized soil are set on slope.	C-F FALL Applied to slope relatively unsuitable to grow grass.	
	P4-8: Wattling	To prevent erosion, scour and weathering of slope by covering it with vegetation. Interwoven fences of brushwood are made in shallow trenches on slope.	C-F FALL Mainly applied to eroded natural slope.	

TABLE 12.2-1 (6) TYPE OF PERMANENT RESTORATION MEASURES

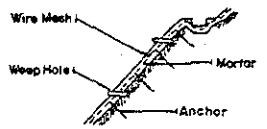
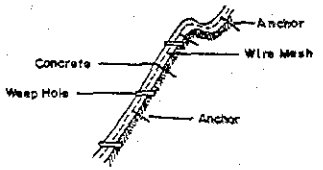
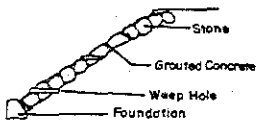
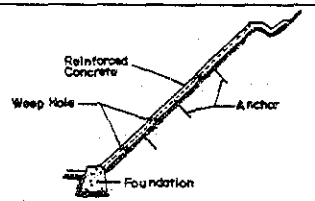
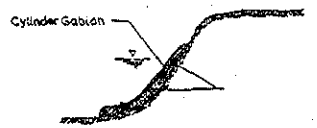
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P5: Slope Protection by Structure	P5-1: Mortar Spraying	To protect slope by covering it with sprayed mortar.	C-F FALL Applied to slope of weathered rock unsuitable to grow grass. Not applicable to slope with rich seepage water.	
	P5-2: Concrete Spraying	To protect slope by covering it with sprayed concrete.	C-F FALL Applied to slope of weathered rock unsuitable to grow grass. Not applicable to slope with rich seepage water.	
	P5-3: Stone Pitching	To protect slope by covering it with slope.	C-F E-F FALL Usually applied to slope gentler than 45°.	
	P5-4: Concrete Pitching	To protect slope by covering it with cast-in-place concrete.	C-F FALL Usually applied to slope gentler than 45°.	
	P5-5: Gabion Pitching	To protect slope by covering it with gabion.	C-F E-F PBr-A TBr-A CLV-D Usually applied to slope with seepage water or revetment of dike.	

TABLE 12.2-1 (7) TYPE OF PERMANENT RESTORATION MEASURES

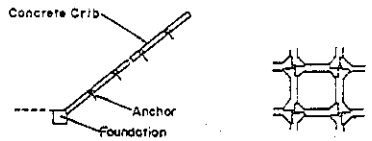
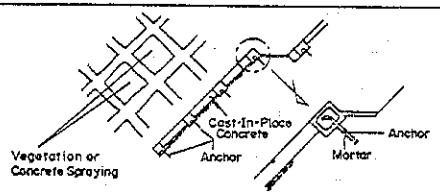
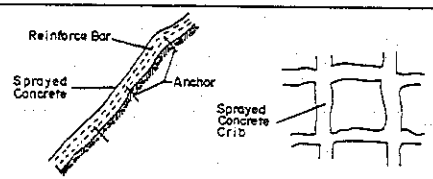
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P5: Slope Protection by Structure (Continued)	P5-6: Concrete Block Crib	To protect slope by covering it with precast concrete block crib.	C-F E-F FALL Usually applied to slope gentler than 45°.	
	P5-7: Cast-in-Place Concrete Crib	To protect slope by covering it with cast-in-place concrete crib. Resisting force against earth pressure may be expected when large size is applied.	C-F E-F FALL PBr-A TBr-A Applicable to slope steeper than 45°.	
	P5-8: Sprayed Concrete Crib	To protect slope by covering it with crib made by spraying concrete through gun. Resisting force against earth pressure may be expected when large size is applied.	C-F FALL Applicable to slope steeper than 45°. Irregularity of slope surface is not necessary to correct.	

TABLE 12.2-1 (8) TYPE OF PERMANENT RESTORATION MEASURES

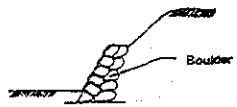
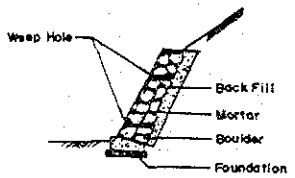
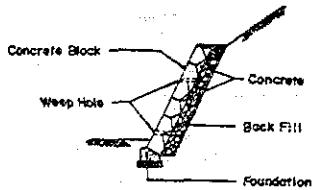
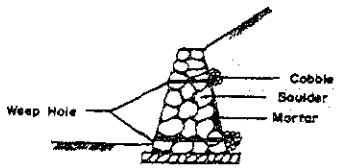
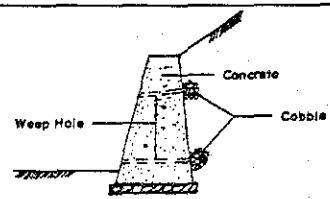
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P6: Retaining Wall	P6-1: Riprap	To protect slope from failure, resisting earth pressure. Resistant force is very small.	C-F E-F FALL Applicable to wall less than 3 m high.	
	P6-2: Grouted Riprap	To protect slope from failure, resisting earth pressure. Resistant force is small.	C-F E-F FALL PBr-A TBr-A CLV-D Applicable to wall less than 5 m high.	
	P6-3: Concrete Block Wall	To protect slope from failure, resisting earth pressure. Resistant force is small.	C-F E-F FALL PBr-A TBr-A CLV-D Applicable to wall less than 5 m high.	
	P6-4: Gravity Type Stone Masonry Wall	To protect slope from failure, resisting earth pressure.	C-F E-F FALL PBr-A TBr-A CLV-D Applicable to wall less than 5 m high.	
	P6-5: Gravity Type Concrete Wall	To protect slope from failure, resisting earth pressure.	C-F E-F FALL PBr-A TBr-A CLV-D Applicable to wall less than 5 m high.	

TABLE 12.2-1 (9) TYPE OF PERMANENT RESTORATION MEASURES

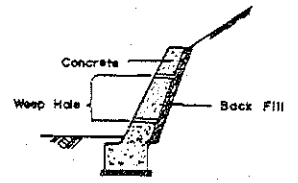
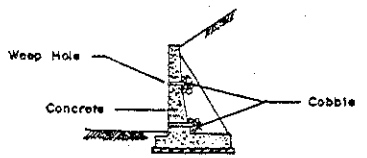
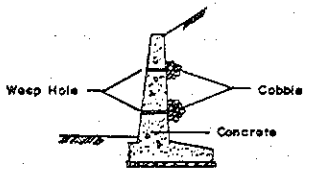
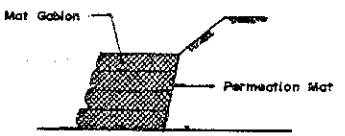
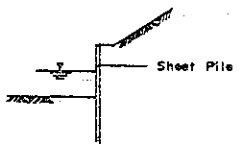
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P6: Retaining Wall (Continued)	P6-6: Supported Type Concrete Wall	To protect slope from failure, resisting earth pressure.	C-F FALL Mainly applied to cut slope. Applicable to wall less than 10 m high.	
	P6-7: Cantilever Type Concrete Wall	To protect slope from failure, resisting earth pressure.	E-F TBr-A PBr-A Usually applied to wall 3 to 10 m high.	
	P6-8: Buttressed Type Concrete Wall	To protect slope from failure, resisting earth pressure.	E-F TBr-A PBr-A Usually applied to wall more than 6 m high.	
	P6-9: Gabion Wall	To protect slope from failure, resisting earth pressure.	E-F TBr-A PBr-A Mainly applied to embankment slope with seepage water.	
	P6-10: Sheet Pile Wall	To protect slope from failure, resisting earth pressure.	E-F TBr-A PBr-A Mainly applied to bridge approach and revetment of dike.	

TABLE 12.2-1 (10) TYPE OF PERMANENT RESTORATION MEASURES

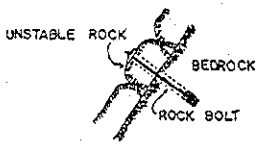
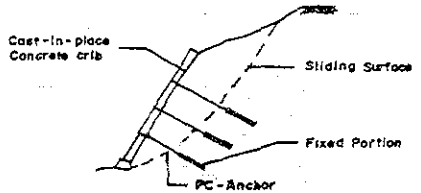
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P7: Anchoring	P7-1: Rock Bolt	To prevent unstable rocks on slope surface from falling down, by tying them to bedrock with rock bolt.	C-F FALL Usable also as supplemental measure of concrete crib.	
	P7-2: PC-Anchor	To prevent collapse and separation of bedrock by directly tightening the unstable bedrock with PC-anchor.	C-F FALL Usable also as supplemental measure of other protection works such as concrete crib, concrete pitching and retaining wall.	

TABLE 12.2-1 (11) TYPE OF PERMANENT RESTORATION MEASURES

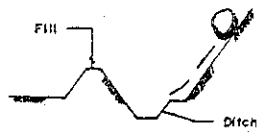
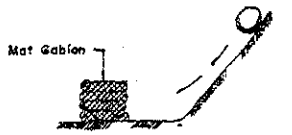
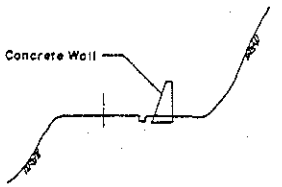
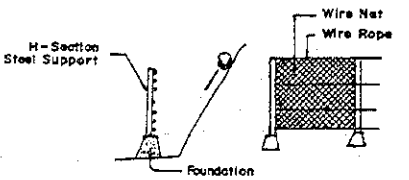
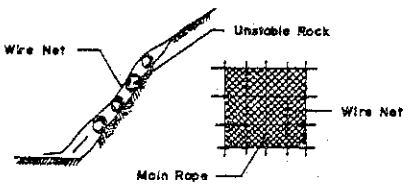
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P8: Catch Work	P8-1: Catch Fill and Ditch	To prevent falling rocks from extending to road by providing fill and ditch.	C-F D-FL FALL Wide space for deposit is required between road edge and toe of slope Applicable where wide space is available on roadside to provide space for deposite.	
	P8-2: Catch Gabion Wall	To prevent falling rocks from extending to road by providing catch gabion wall.	C-F D-FL FALL Applicable where enough space for deposit is available on roadside.	
	P8-3: Catch Concrete Wall	To prevent falling rocks from extending to road by providing catch concrete wall.	C-F D-FL FALL Applicable where enough space for deposit is available on roadside.	
	P8-4: Catch Fence	To prevent falling rocks from extending to road by providing catch fence.	FALL Applicable where enough space for deposit is available on roadside.	
	P8-5: Catch Wire Net	To prevent falling rocks from extending road by providing catch wire net.	FALL Applied where no space on roadside Unsuitable to slope of easily weathered materials.	

TABLE 12.2-1 (12) TYPE OF PERMANENT RESTORATION MEASURES

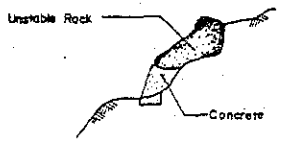
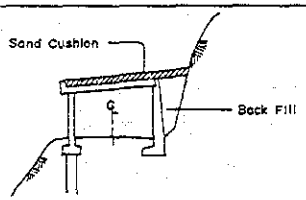
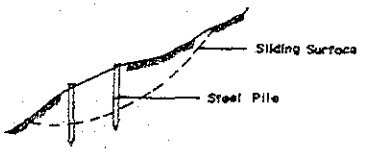
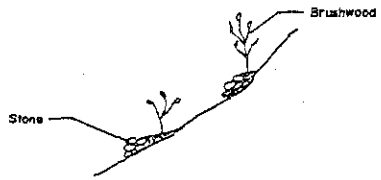
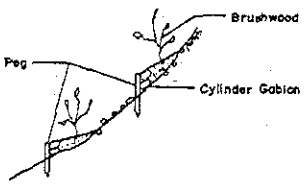
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P9: Supporting Work	P9-1: Concrete Supporting	To prevent unstable rock from falling down by supporting it with concrete.	FALL Mainly applied to supportless rocks which are big and difficult to remove.	
P10: Rock Shed	P10-1: Concrete Rock Shed	To avoid rock fall damage by covering road with shed.	C-F FALL Mainly applied to large-scaled fall.	
P11: Prevention Pile	P11-1: Steel Prevention Pile	To resist movement force of landslide by bending strength and shearing strength of pile.	L-SL Usually applied to landslide where sliding plane is deep.	
P12: Slope Breasting	P12-1: Stone Breasting	To stabilize cut slope with rocky deposit by providing riprap wall.	C-F FALL	
	P12-2: Gabion Breasting	To stabilize cut slope with rocky deposit by providing gabion wall.	C-F FALL	

TABLE 12.2-1 (13) TYPE OF PERMANENT RESTORATION MEASURES

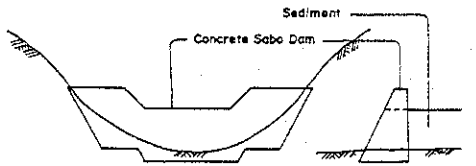
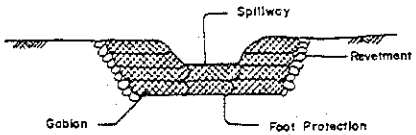
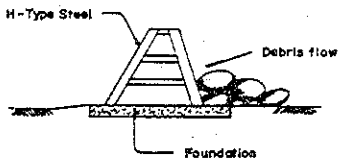
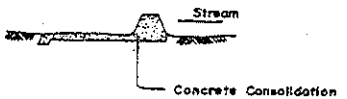
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P13: Sabo Dam	P13-1: Concrete Sabo Dam	To prevent debris flow by constructing concrete sabo dam.	D-FL Mainly applied to large-scaled debris flow.	
	P13-2: Gabion Sabo Dam	To prevent debris flow by constructing gabion sabo dam.	D-FL Mainly applied to large-scaled debris flow.	
	P13-3: Steel Sabo Dam	To prevent big rocks or trees from flowing down by providing steel sabo dam. Small-sized debris can pass through dam.	D-FL Mainly applied to large-scaled debris flow.	
P14: Consolidation	P14-1: Concrete Consolidation	To prevent scour of river bed by providing concrete consolidation like small-scaled sabo dam.	D-FL P8r-D	
	P14-2: Gabion Consolidation	To prevent scour of river bed by providing gabion consolidation like small-scaled sabo dam.	D-FL P8r-D	

TABLE 12.2-1 (14) TYPE OF PERMANENT RESTORATION MEASURES

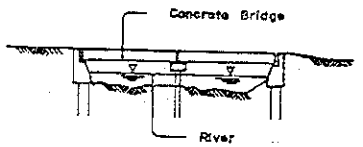
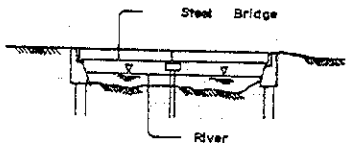
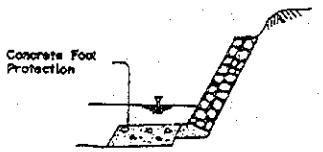
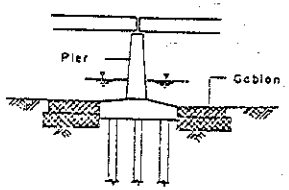
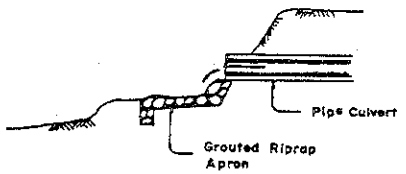
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P15: Bridge	P15-1: Concrete Bridge	To provide stream crossing facility.	D-FL PBr-W PBr-A TBr-W TBr-A SPW-D Applied to bridge and/or bridge approach washout. Applied sometimes to debris flow to avoid damage when other counter measures are difficult and costly.	
	P15-2: Steel Bridge	To provide stream crossing facility	D-FL PBr-W PBr-A TBr-W TBr-A SPW-D Applied to bridge and/or bridge approach washout. Applied sometimes to debris flow to avoid damage when other counter measures are difficult and costly.	
P16: Foot Protection including Apron	P16-1: Concrete Foot Protection	To prevent foot portion of structure from being scoured by stream of water by placing concrete.	E-F TBr-D PBr-A CLV-D PBr-D TBr-A	
	P16-2: Gabion Foot Protection	To protect foot portion of structure from being scoured by stream of water by placing gabion.	E-F TBr-D PBr-A CLV-D PBr-D TBr-A	
	P16-3: Grouted Riprap Apron	To protect foot portion of structure and/or frontage ground from being scoured by dropping water by placing grouted riprap apron.	CLV-D	

TABLE 12.2-1 (15) TYPE OF PERMANENT RESTORATION MEASURES

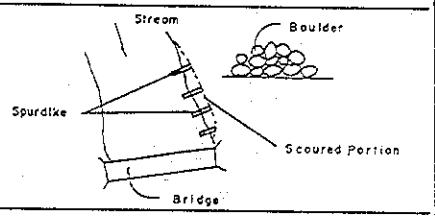
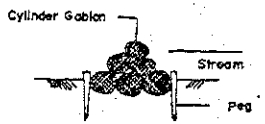
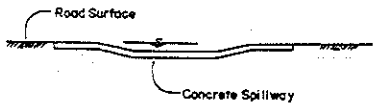
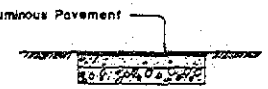
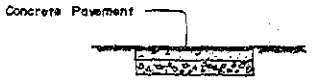
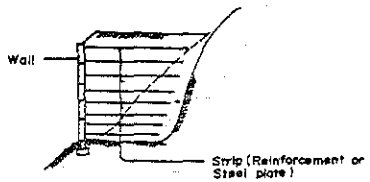
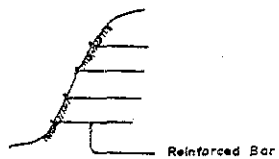
CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P17: Spurdike	P17-1: Stone Spurdike	To protect river bank and bridge approach by changing direction of stream with spurdike made of stone	E-F TBr-A PBr-A	
	P17-2: Gabion Spurdike	To protect river bank and bridge approach by changing direction of stream with spurdike made of gabion.	E-F TBr-A PBr-A	
P18: Spillway	P18-1: Concrete Spillway	To cross small stream by placing concrete spillway insted of culvert.	C-F D-FL E-F Applied only to small stream on mountainside.	

TABLE 12.2-1 (16) TYPE OF PERMANENT RESTORATION MEASURES

CLASSIFICATION	TYPE OF WORK	DESCRIPTION	APPLICATION (Type of Disaster)	ILLUSTRATION
P19: Pavement Work	P19-1: Gravel Surfacing	To reconstruct washed-out or deteriorated gravel surface.	Applied to various types of disaster of gravel surfaced road.	
	P19-2: Bituminous Pavement	To reconstruct washed-out or deteriorated bituminous pavement.	Applied to various types of disaster of bituminous pavement road.	
	P19-3: Concrete Pavement	To reconstruct washed-out or deteriorated concrete pavement.	Applied to various types of concrete pavement road.	
P20: Reinforced Earth	P20-1: Reinforced Earth Wall	To construct stable earth structure by placing reinforcing materials therein.	E-F Applied to embankment which requires perpendicular slope because of limitation of construction condition.	
	P20-2: Inserting of Reinforcing Bar	To stabilize steep slope by strengthening it with inserted reinforcing bar.	C-F	

CHAPTER 13
SELECTION OF RESTORATION MEASURES

13.1 SELECTION OF URGENT RESTORATION MEASURES

Main purposes of urgent restoration are:

- To reopen the road to traffic,
- To remove materials endangering traffic, and
- To check the progress of damage

Therefore, urgent restoration measures should be selected depending on necessity of answering respective purpose.

The basic flow for the selection of the urgent restoration measures is shown in Figure 13.1-1.

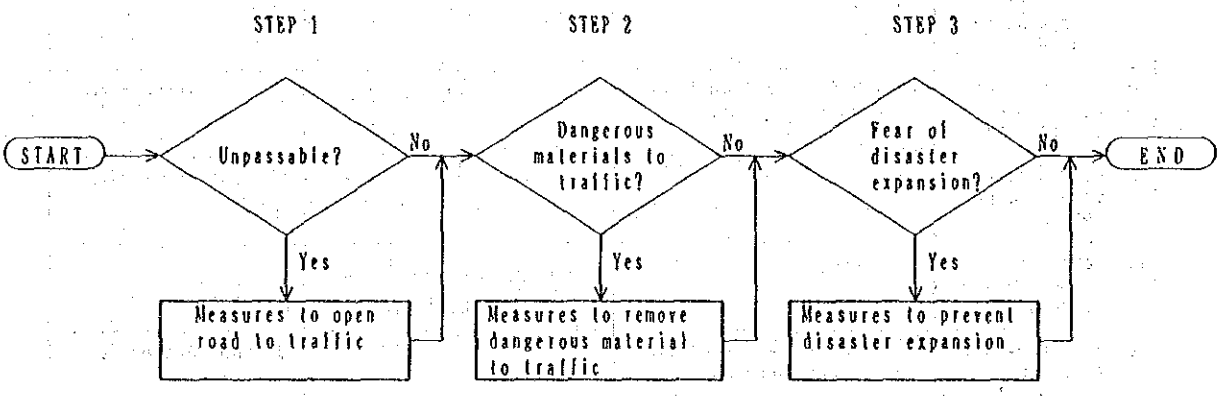


FIGURE 13-1.1 FLOW CHART FOR SELECTION OF URGENT RESTORATION MEASURES

The most important item to be achieved by the urgent restoration is to reopen the road to traffic. Therefore, in some cases, measures are selected from only step 1 neglecting step 2 and step 3.

Applicable measures corresponding to the purposes of the urgent restoration for each type of disaster are summarized in Table 13.1-1.

TABLE 13.1-1 APPLICATION OF URGENT RESTORATION MEASURES

Type of Disaster	Purposes		
	To Open Road to Traffic	To Remove Dangerous Material to Traffic	To Prevent Disaster Expansion
1. Cut Slope Failure (C-F)	U1-1 Removal of Deposit Materials	U1-2 Removal of Unstable Materials	U2 Surface Drainage U3 Slope Protection U4 Retaining Work
2. Embankment Slope Failure (E-F)	U1-4 Refilling/Embankment U4 Retaining Work	-	U2 Surface Drainage U3 Slope Protection
3. Rock Fall/ Debris Fall (FALL)	U1-1 Removal of Deposit Materials	U1-2 Removal of Unstable Materials	U2 Surface Drainage U3 Slope Protection U4 Retaining Work
4. Landslide (L-SL)	U1-1 Removal of Deposit Materials	U1-3 Removal of Head	U2 Surface Drainage U4 Retaining Work
5. Debris Flow (D-FL)	U1-1 Removal of Deposit Materials	-	-
6. Scour/Washout of Roadbed (Rd-D)	U1-4 Refilling/Embankment U4 Retaining Work	-	U2 Surface Drainage
7. Flooded/Muddy Road Surface (FM-Rd)	U1-4 Refilling/Embankment U4 Retaining Work	-	U2 Surface Drainage
8. Permanent Bridge Washout (PBr-W)	U6 Bridge	-	-
9. Permanent Br. Approach Wash-out (PBr-A)	U1-4 Refilling/Embankment U4 Retaining Work	-	U5 Foot Protection
10. Permanent Br. Other Damage (PBr-D)	-	-	U5 Foot Protection
11. Temporary Bridge Washout (TBr-W)	U6 Bridge	-	-
12. Temporary Br. Approach Washout (TBr-A)	U1-4 Refilling/Embankment U4 Retaining Work	-	U5 Foot Protection
13. Temporary Br. Other Damage (TBr-D)	-	-	U5 Foot Protection
14. Spillway Damage (SPW-D)	U1-5 Selected Material Fill U4 Retaining Work		U5 Foot Protection
15. Culvert Damage (CLV-D)	U1-4 Refilling/Embankment U4 Retaining Work		U3 Slope Protection
16. Seawall Damage (SW-D)	U1-4 Refilling/Embankment U4 Retaining Work	-	U2 Surface Drainage

13.2 SELECTION OF PERMANENT RESTORATION MEASURES

13.2.1 Factors to be Considered in Selection of Permanent Restoration Measures

Factors to be considered in the selection of the permanent restoration measures are as follows:

- Restoration level
- Work conditions
- Application of new techniques
- Environment impact

1) Restoration Level

To select proper restoration measures according to importance of road, different levels of measures have to be examined on their economic feasibility. In general, restoration measures are broadly divided into the following three levels including urgent measures:

- Urgent Measure:

  Urgent measure should be taken immediately after occurrence of disaster in any case irrespectively of importance of road as far as the road is on service.

- Standard Permanent Measure:

  Standard permanent measure is ordinary measure which is stable and durable with a little probability of recurrence of disaster.

- High Class Permanent Measure:

  High class permanent measure is more stable and durable than standard measure, usually lasting for more than 20 years. The construction cost is also higher than others.

To give a guideline to select proper level of restoration, economic feasibilities of different levels of measures were examined for the following types of disaster:

- Cut slope failure, embankment slope failure, rock fall/debris fall, permanent bridge approach washout and permanent bridge other damage, for which there are two options: standard permanent measure and high class permanent measure.

- Large-scale debris flow and temporary bridge washout, for which there is no proper standard permanent measure so that the choice will be whether high class permanent measure is taken or not (in either case, urgent measure is necessary).

Other types of disaster were not included in the analysis because there is no reasonable alternative measure other than standard permanent measure or the analysis results for the similar type are approximately applicable thereto.

The analysis was made in the following procedure:

(i) Selection of Case Study Spots and Restoration Measures

For each type of disaster, the typical spot was selected as the case study spot. Then, for each case study spot, restoration measures were selected as shown in Table 13.2-1. Figure 13.2-1 shows the preliminary design of the selected restoration measures.

(ii) Relationship between Benefit and Traffic Volume

Since a subject for discussion is permanent measure, whichever standard or high class, benefit is hereon defined as savable costs when the permanent measure is implemented as compared with the condition where only urgent measure but no permanent measure is taken.

Benefit increases according to the increase in traffic volume, if other conditions are constant.

Assuming that all other conditions than traffic volume are constant, the relationship between benefit and traffic volume was calculated, where benefit and traffic volume are defined as follows:

Benefit = total discounted benefit during 20 years analysis period as calculated in accordance with the methodology described in Chapter 15.2.

No difference is assumed between benefit of standard permanent measure and that of high class permanent measure.

Traffic Volume = AADT excluding tricycle and motorcycle in the first analysis year.

(iii) Examination of Economic Feasibility

By comparing the cost[1)] with the benefit vs. traffic volume relationship, the range of traffic volume in which the implementation of the measure is economically feasible was determined.

The analysis results are graphically shown in Figure 13.2-2, which are interpreted as shown in Table 13.2-2.

Based on the above analysis, the following guideline is given:

Standard permanent measures can be widely applied except in case that there is no proper standard measure, for example, large- scale debris flow and bridge washout. High class permanent measures are applicable to the road with enough traffic demand to justify the economic feasibility. Roughly speaking, the borderline traffic is 100 vehicles per day, except for application of permanent bridge instead of bailey bridge as a measure for bridge washout, wherein the borderline traffic is 400 vehicles per day.

Note: 1)

90% of the construction cost is counted in the economic analysis assuming 15% tax to be substructed and 5% design and construction supervision cost to be added.

TABLE 13.2-1 RESTORATION MEASURES SELECTED FOR CASE STUDY SPOTS

Type of Disaster	Case Study Spot	Urgent Measure	Standard Permanent Measure	High Class Permanent Measure
Cut Slope Failure (C-F)	L-84	Removal of deposit materials	Recutting/slope protection by vegetation/grouted riprap	Slope protection by concrete crib/ grouted riprap
Embankment Slope Failure (E-F)	Bt-54	Refilling/ Wooden fence	Gabion retaining wall	Concrete retaining wall
Rockfall/ Debris Fall (FALL)	L-65	Removal of deposite/ unstable materials	Recutting/grouted riprap	Concrete catch wall
Permanent Bridge Approach Washout (PBr-A)	Bt-55	Sand bag wall	Grouted ripra/gabion foot protection	Concrete bridge
Permanent Bridge Other Damage (PBr-D)	Bs-6	-	Concrete foot protection (partial)/ gabion consolidation	Option-1 Concrete and gabion foot protection (full width) Option-2 Concrete foot protection with steel sheet pile
Large-Scale* Debris Flow (D-FL)	Bt-70	Removal of deposit materials	-	Concrete bridge
Temporary Bridge Washout (TBr-W)	L-6	Bailey bridge	-	Concrete bridge

* in case debris flow preventive measures are very costly

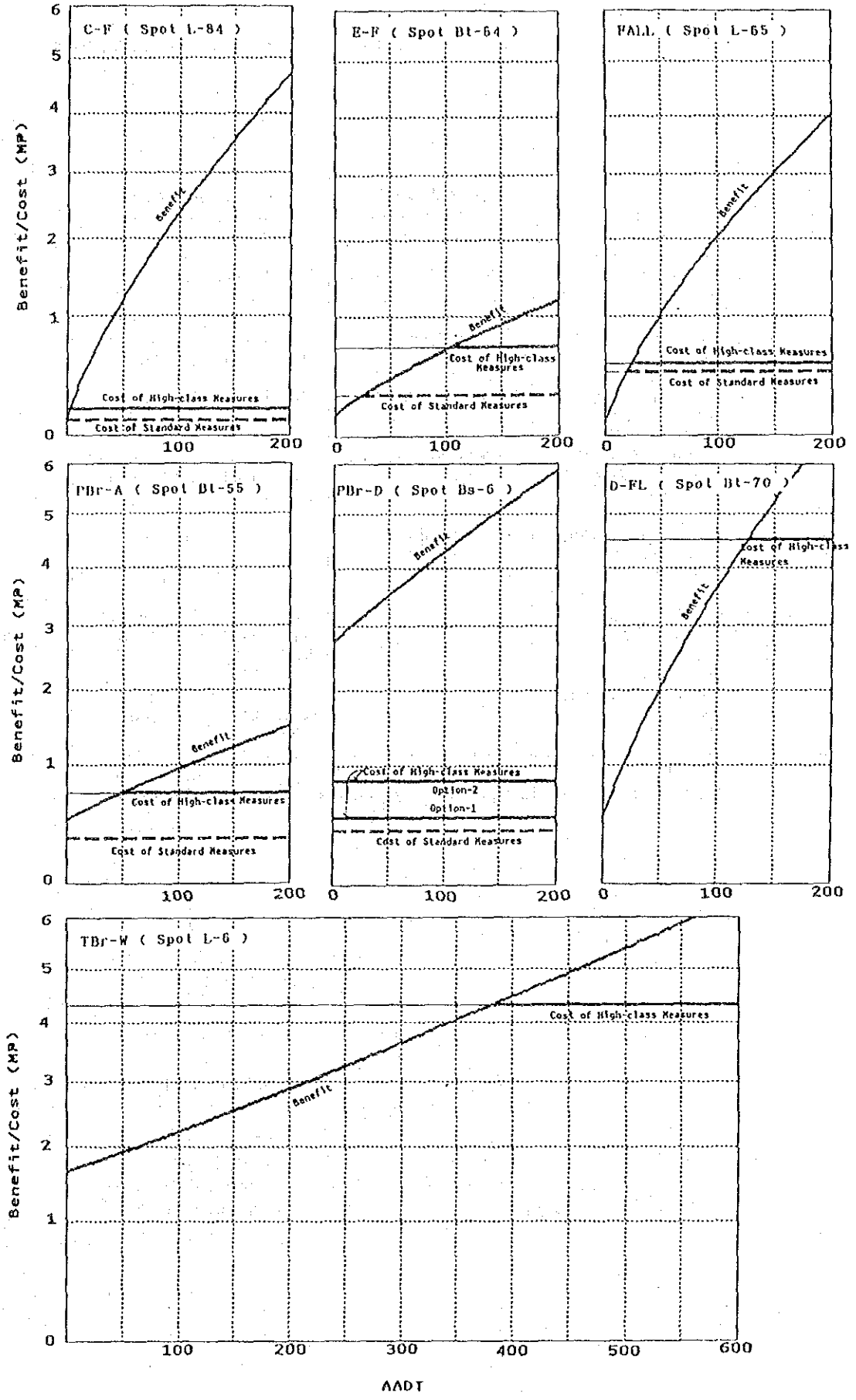


FIGURE 13.2-2 ANALYSIS RESULT OF RESTORATION LEVEL

TABLE 13.2-2 APPLICABILITY OF STANDARD AND HIGH CLASS MEASURES

Type of Disaster	Applicabilty of Standard Permanent Measure	Applicability of High Class Permanent Measures
Cut Slope Failure (C-F)	Widely applicable	Widely applicable
Embankment Slope Failure (E-F)	Widely applicable	Applicable to the road with AADT more than 100
Rock Fall/Debris Fall (FALL)	Widely applicable	Widely applicable
Permanent Bridge Approach Washout (PBr-A)	Widely applicable	Applicable to the road with AADT more than 50
Permanent Bridge Other Damage (PBr-D)	Widely applicable	Widely applicable
Large-Scale* Debris Flow (D-FL)	-	Applicable to the road with AADT more than 100 - 500
Temporary Bridge Washout (TBr-W)	-	Applicable to the road with AADT more than 400

* in case debris flow preventive measures are very costly

2) Work Conditions

Availability of the equipment, materials and expertise required for the restoration measures to be selected is one of the major factors to be considered in the selection of measures.

Most of the restoration measures listed in the previous chapter can be constructed by common equipment locally available such as bulldozer, wheel loader, dump truck, compaction roller, drop hammer, crawler crane, concrete mixer, etc.

Likewise, materials for most restoration measures are locally available, except for gabions which are presently not so widely used that may not easily be procured.

Special expertise is not required in most cases.

Thus, most restoration measures are applicable.

In addition, such measures as need more manpower than equipment or enable manpower to supersede equipment are preferable in line with the government policy of employment generation.

3) Application of New Techniques

Some restoration measures are rarely used in the Philippines although they are widely used in other countries because of their aptitude for restoration work, such as subsurface drainage work, slope vegetation work, gabion work, crib work, foot protection work, reinforced earth work, etc.

These new techniques, in the sense of being rarely used in the Philippines, are recommended to be positively introduced as far as they are effective, economical and constructable with available equipment and materials. This will promote the technologic development of the country.

4) Environmental Impact

Restoration measures well harmonizing with natural environment should be positvely selected, while measures or construction methods having negative effect on environment should be avoided.

The following are examples of environmental considerations:

- Slope protection works are broadly classified into two types: slope protection by vegetation and slope protection by structure. The slope protection by vegetation is to grow plants directly on the slope to firmly bind the soil. This does not only protect the slope from erosion but also improve natural environment along the road by greening the slope. Therefore, when the soil condition of the slope allows it, the slope protection by vegetation is preferable to the slope protection by structure.

- Soil and rocks falling from mountain onto road are often removed in a manner of pushing them down directly to the valley side of the road with bulldozer, giving negative effect on environment. In such a case, soil and rocks should be loaded on dump trucks and transported to proper dumping area.

13.2.2 Selection of Permanent Restoration Measures

1) Cut Slope Failure (C-F)

Main measures which are generally applied to cut slope failure are:

- P1-1 Recutting
- P2 Surface Drainage
- P3 Subsurface Drainage
- P4 Slope Protection by Vegetation
- P5 Slope Protection by Structure
- P6 Retaining Wall

Figure 13.2-3 shows the general flow for the selection of restoration measures for cut slope failure.

Main points to be considered in the selection are as follows:

- Where the collapsed slope is still unstable, (P1-1) recutting until the appropriate slope gradient is recommended as the most reliable and cheap measure to stabilize the slope.

- In case that the recutting is long and high, (P6) retaining wall shall be planned at the toe of the slope in order to shorten the slope length. (P6-2) grouted riprap is recommended as a retaining wall placed at the toe of the cut slope.

- Whenever soil condition allows it, (P4) slope protection by vegetation shall be apllied to the recut slope. This is not only to prevent the slope from erosion but also to improve the surrounding environment by greening it. Slope protection by vegetation which requires no special equipment and materials such as (P4-1) hand seeding, (P4-2) hand seeding with mat, (P4-6) pick hole seeding and (P4-8) wattling are recommended, depending on topographic and soil conditions of the slope.

- For slope protection by structure to be applied to the recut slope, (P5-3) stone pitching, (P5-7) cast in- place concrete crib or (P5-5) gabion pitching is recommended because they require no special equipment and materials. Among them, (P5-5) gabion pitching is very effective to the slope with rich surface and subsurface water.

- For the slope with rich groundwater, (P3-1) subsurface drainer shall be planned at points where seepage water is concentrated.

- For a wide area of cut slope, (P2-1) slope ditch shall be planned to collect and rain surface water flowing down on the slope. Especially where surface water in surrounding area is expected to flow into the slope, top slope ditch shall be planned. As the slope ditch, grouted riprap ditch is commonly applied in Philippines.

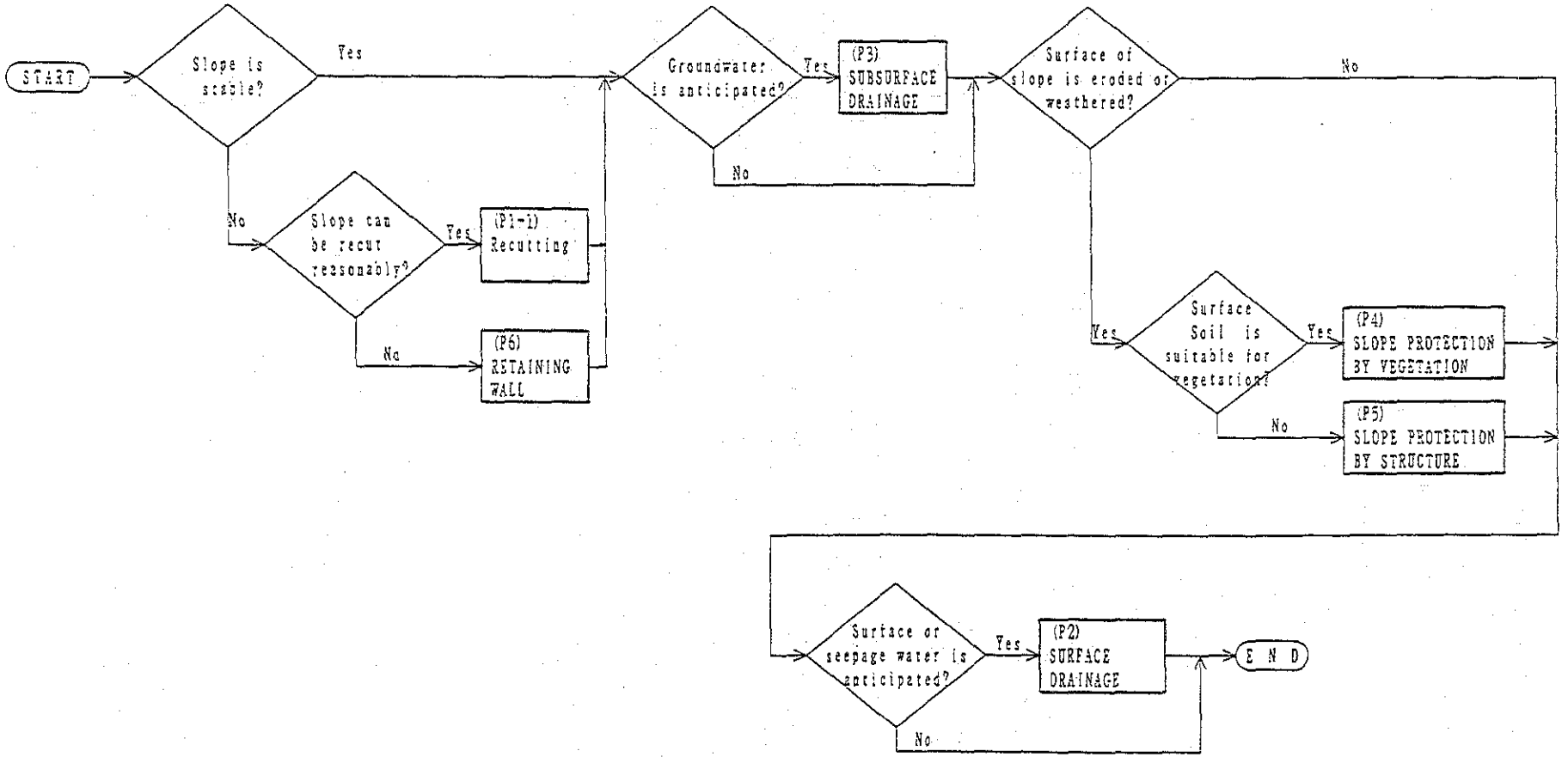


FIGURE 13.2-3 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR CUT SLOPE FAILURE (C-F)

2) Embankment Slope Failure (E-F)

Main measures which are generally applied to embankment slope failure are:

- P1-3 Refilling/Embankment
- P2 Surface drainage
- P3 Subsurface drainage
- P4 Slope protection by vegetation
- P5 Slope protection by structure
- P6 Retaining wall
- P20 Reinforced earth

Figure 13.2-4 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When the groundwater is acknowledged in the failed spot and its surrounding, (P3-1) subsurface drainer is needed to release the groundwater pressure harmful to stability of embankment before taking major measures.

- Wherever possible, (P1-3) refilling/embankment is the most appropriate measure for embankment slope failure from the view points of construction speed and cost.

- When the refilled surface is susceptible to erosion, slope protection work is required. In case of the refilled slope is relatively gentle and stable by itself, (P4) slope protection by vegetation is recommendable. On the other hand, when the refilled slope is steep, (P5-3) stone pitching, (P5-5) gabion pitching, (P5-6) concrete block crib or (P5-7) cast-in-place concrete crib is suitable. Especially, (P5-5) gabion pitching is, due to its permeability, an effective measure for river or sea side embankment.

- When the refilled slope is not stable, (P6) retaining wall or (P20-1) reinforced earth wall is necessary.

- (P2-1) slope ditch is necessary to be provided on the slope surface which is of large scale and has surface or seepage water.

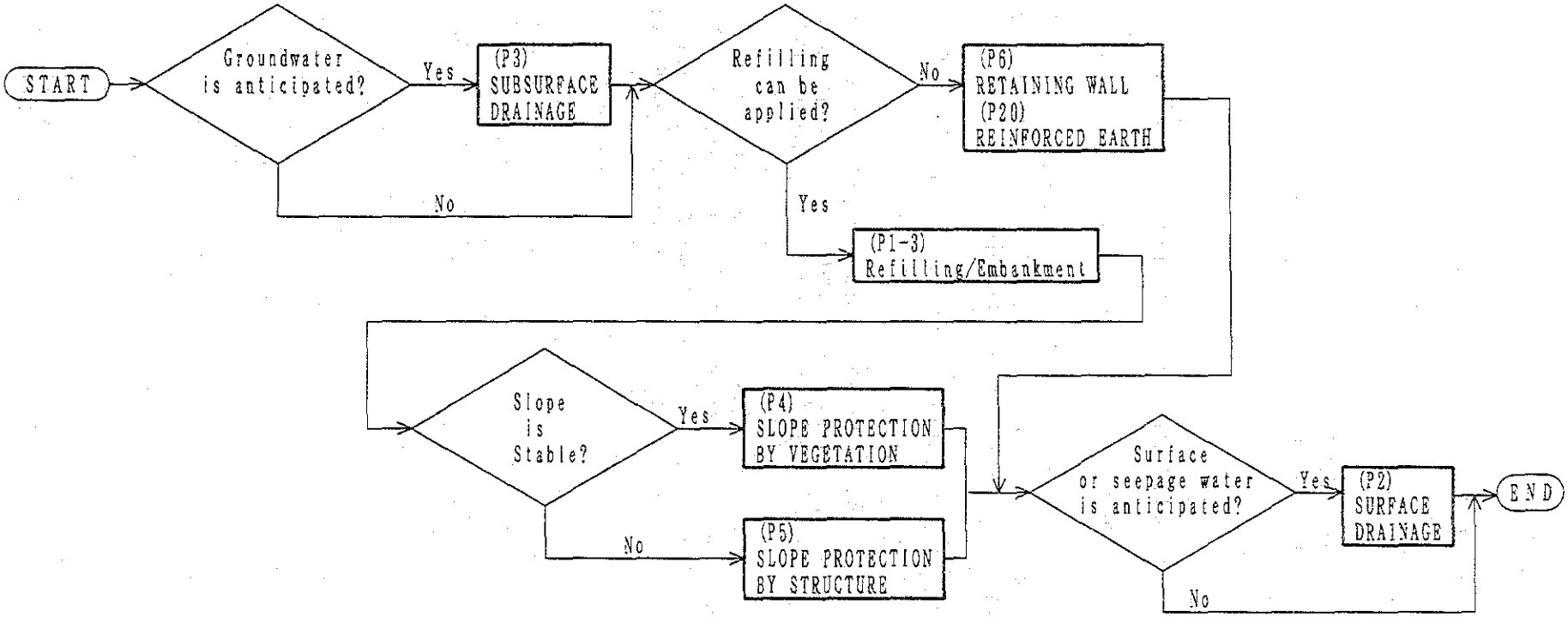


FIGURE 13.2-4 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR EMBANKMENT SLOPE FAILURE (E-F)

3) Rock Fall/Debris Fall (FALL)

Main measures which are generally applied to rock fall/debris fall are:

- P1-1 Recutting
- P1-2 Removal of Head
- P2 Surface drainage
- P4 Slope protection by vegetation
- P5 Slope protection by structure
- P8 Catch work
- P9 Supporting work
- P10 Rock shed

Figure 13.2-5 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When the slope is stable and detached rocks or supportless stones still exist thereon, the prevention work against fall such as (P8-5) catch wire net, (P9) supporting work or (P1-2) removal of head is necessary.

- On the other hand, when the slope is unstable, (P1-1) recutting is selected if reasonably applicable.

- After construction of above-mentioned restoration measures, the surface of slope must be protected by slope protection works and surface drainage works. Selection procedure of these works is the same as that for cut slope failure (C-F).

- In case that recutting work is difficult to be applied, (P8) catch work or (P10) rock shed is required to protect the road from rock fall/debris fall. Among catch work, (P8-1) catch fill and ditch, (P8-2) catch gabion wall, (P8-3) catch concrete wall, and (P8-4) catch fence are applicable. The choice is made depending on the site condition.

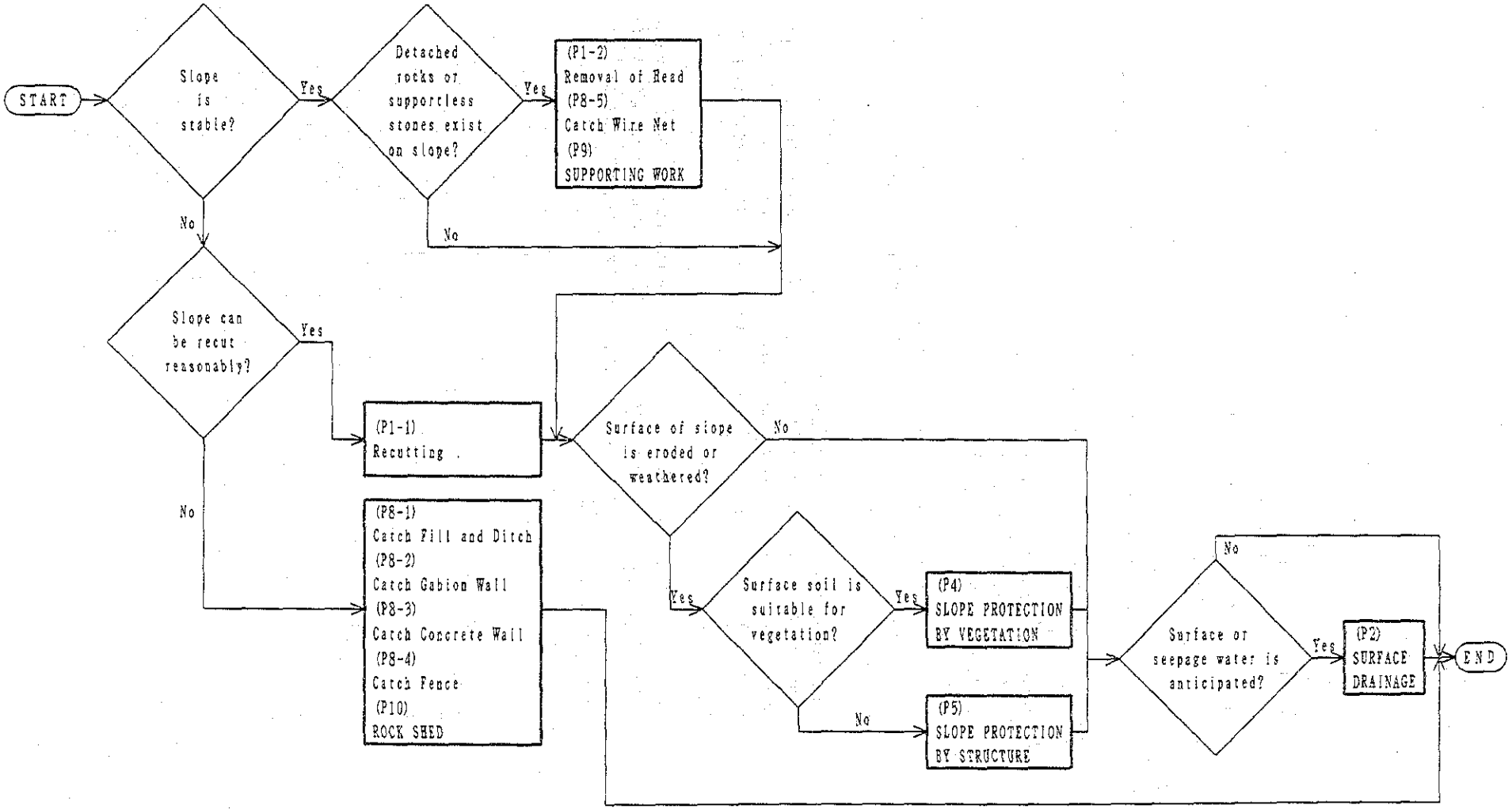


FIGURE 13.2-5 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR ROCK FALL/DEBRIS FALL (FALL)

4) Landslide (L-SL)

Main measures which are generally applied to landslide are:

- P1-2 Removal of head
- P1-4 Counterweight fill
- P2 Surface drainage
- P4 Slope protection by vegetation
- P6 Retaining wall
- P11 Prevention pile

Figure 13.2-6 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When earthwork is considered to be applicable and more suitable than other methods from engineering and economic points of view, (P1-2) removal of head and/or (P1-4) counterweight fill are applied.

- In case that the earthwork is unsuitable or impossible to be applied, (P6) retaining wall or (P11) prevention pile is an effective restoration measure to stop the landslide.

- One of main causes of landslide is the excess water existing in and on the slope. Therefore, (P2) surface drainage and (P3) subsurface drainage are necessary in any case. Especially when landslide is large-scale and groundwater level is high, (P3-2) horizontal drain hole or (P3-3) deep well is necessary to drain the excess water.

- In almost all cases of landslide, there exist bare areas after the failure occured. For such bare areas, (P4) slope protection by vegetation together with (P2-3) water channel is in general required to protect the bare areas of slope from erosion, scour and weathering.

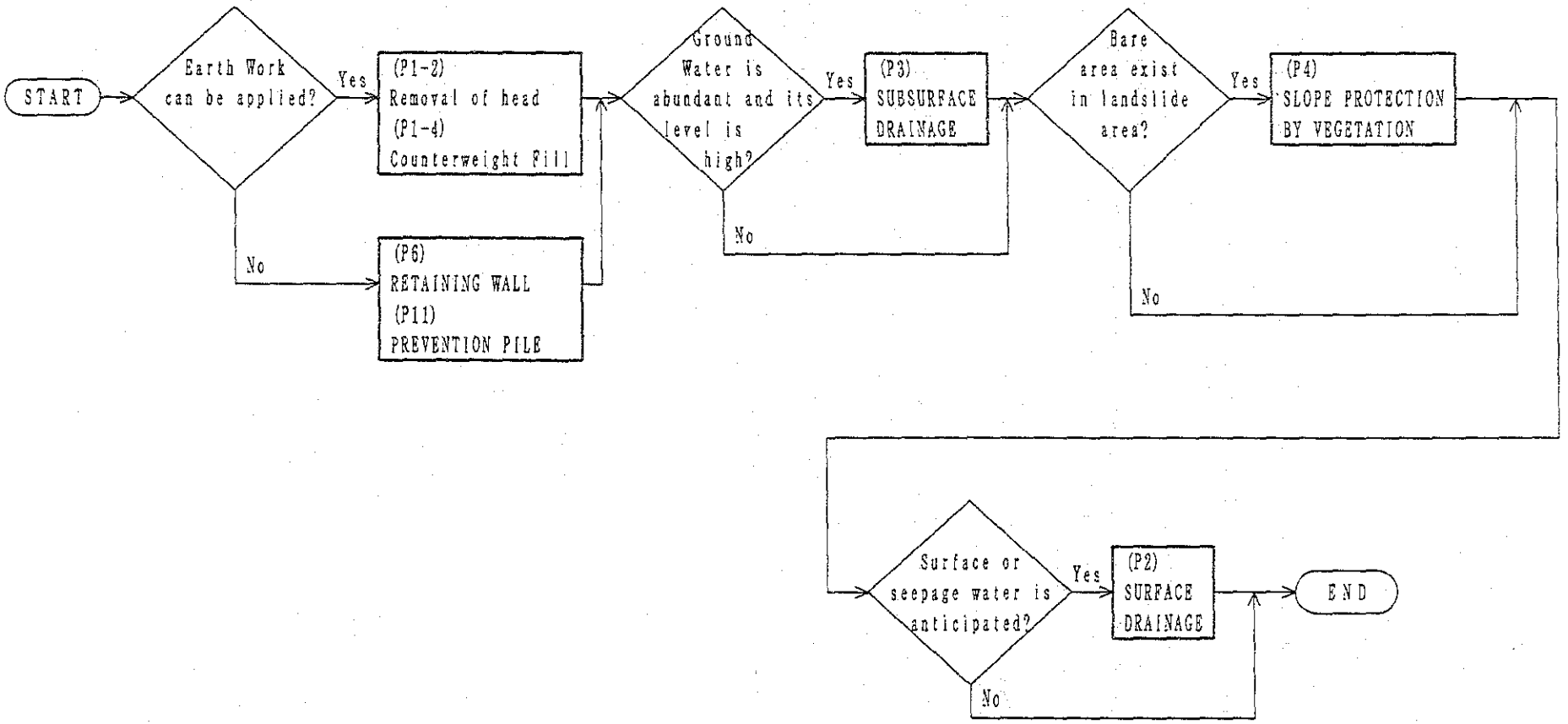


FIGURE 13.2-6 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR LANDSLIDE (L-SL)

5) Debris Flow (D-FL)

Main measures which are generally applied to debris flow are:

- P6 Retaining wall
- P13 Sabo dam
- P14 Consolidation
- P15 Bridge

Figure 13.2-7 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- Debris flow/mud flow generally affects a large extent of area extending over a long period. Therefore, restoration/prevention measures must be systematic. Systematic prevention works include training dike, sand deposit pond, mud reservoir, afforestation, etc. other than (P6) retaining wall, (P8) catch work, (P13) Sabo dam and (P14) consolidation.

- For debris flow on the gentle hillside. (P8-2) catch gabion wall is recommended as a simple and economical measure.

- For debris or mud flow on the river, which is usually a large- size disaster, a sabo system is necessary to be provided with (P13) Sabo dam, (P14) consolidation or a combination of the two.

- When these prevention works are judged to be inapplicable from the engineering and economic points of view, (P15) bridge is selected as a measure to avoid debris or mud flow directly attacking the road.

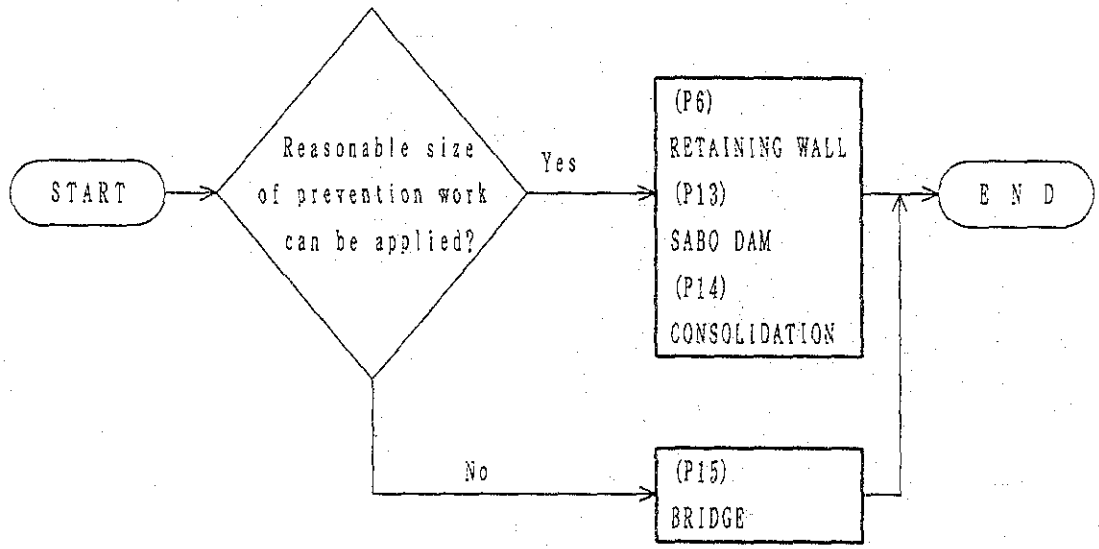


FIGURE 13.2-7 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR DEBRIS FLOW (D-FL)

6) Scour/Washout of Roadbed (Rd-D)

Main measures which are generally applied to scour/washout of roadbed are:

- P1-3 Refilling/embankment
- P4 Slope protection by vegetation
- P5 Slope protection by structure
- P6 Retaining wall
- P16 Foot protection including apron
- P17 Spurdike

Figure 13.2-8 shows the general flow for the selection of restoration measures.

Main points to be constructed in the selection are as follows:

- At first, possibility of application of refilling/embankment to the damaged spot is technically evaluated especially on stability of earth structure. When judged to be possible, (P1-3) refilling/embankment is selected to recover the damaged portion.

- In case that the refilled earth structure is expected to be washed out or scoured again, (P5) slope protection by structure and/or (P16) foot protection including apron are required to directly protect the slope. (P17) spurdike is also applied as one of the indirect measures as necessary. (P5) slope protection by structure is used mostly together with (P16) foot protection. In such case, same materials are advisable to be used. Among others, (P5-5) gabion pitching and (P16-2) gabion foot protection are recommended because gabion is excellently permeable quickly following the change of water level.

- Where the filled earth structure is free from scour, (P4) slope protection by vegetation is recommended.

- When refilling is judged to be unapplicable, (P6) retaining wall is the only possible measure. (P6-9) gabion wall is highly recommended from the same viewpoint as previously mentioned.

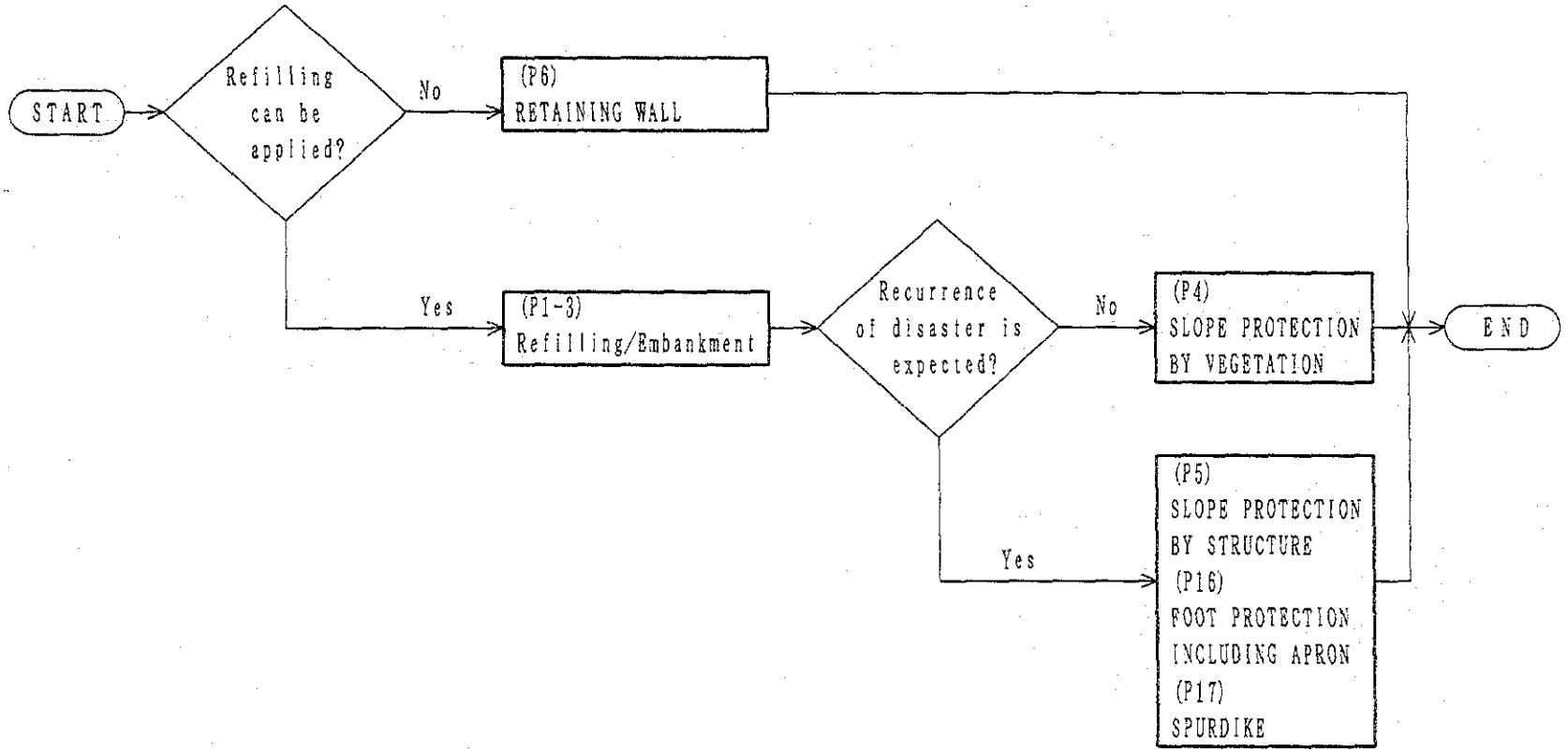


FIGURE 13.2-8 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR SCOUR/WASHOUT OF ROADBED (Rd-D)

7) Flooded/Muddy Road Surface (FM-Rd)

Main measures which are generally applied to flooded/muddy road surface are:

- 1-3 Refilling/embankment
- P2 Surface drainage
- P19 Pavement work

Figure 13.2-9 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When the road suffers from flood, (P1-3) refilling/embankment is constructed to avoid it.

- (P2) surface drainage, especially (P2-2) side ditch and (P2-4) culvert are required in most cases. They should be of enough capacity and installed at proper locations.

- (P19) pavement work is also required in most cases. Usually the same type as that in neighboring section of the road is selected.

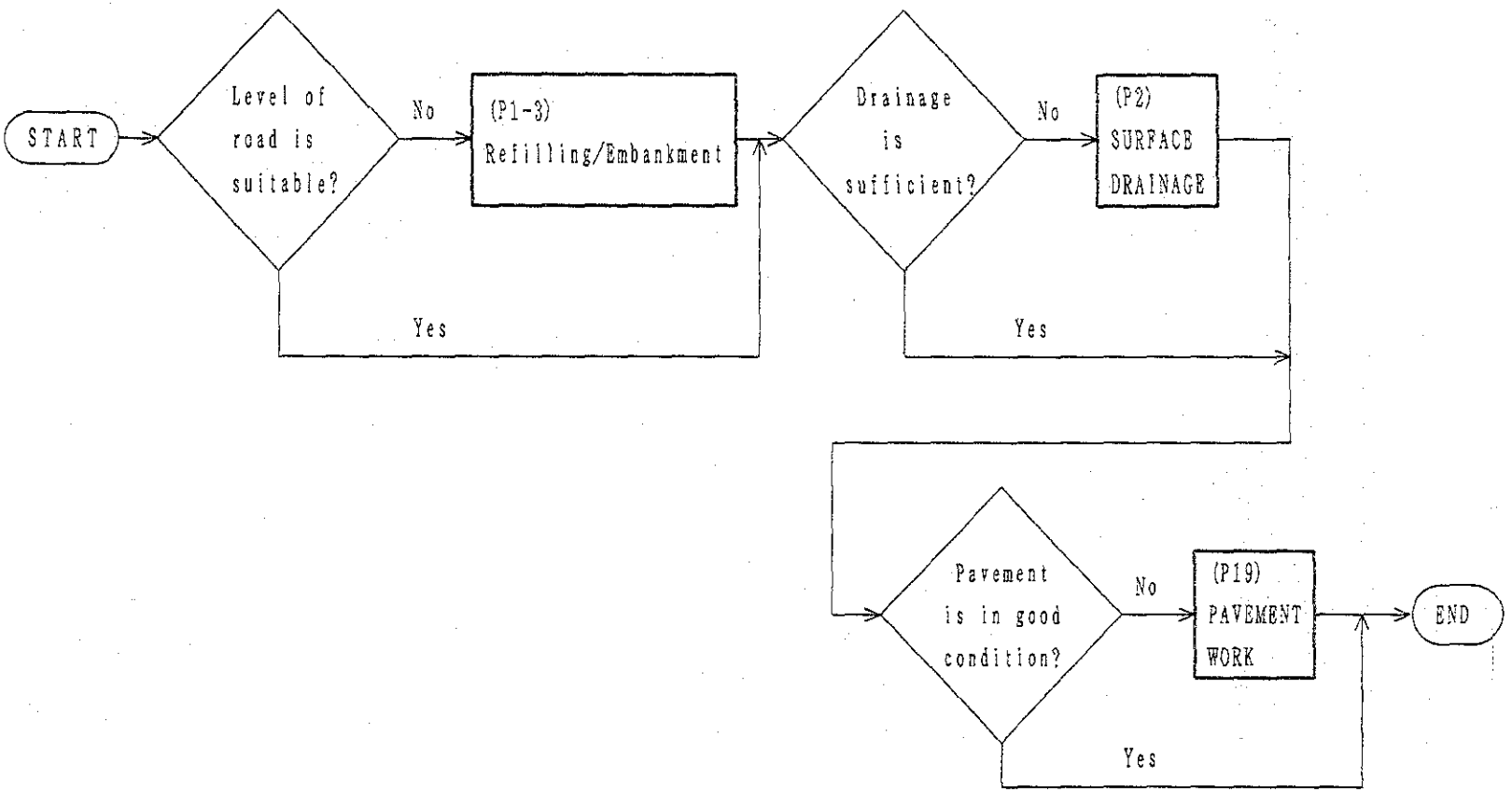


FIGURE 13.2-9 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR FLOODED/MUDDY ROAD SURFACE (FM-Rd)

8) Permanent Bridge Washout (PBr-W)

This section is applicable also to temporary bridge washout.

Figure 13.2-10 shows the general flow for the selection of restoration measures.

For bridge washout, temporary bridge should be constructed first as urgent measure to open the road to traffic urgently. The temporary bridge is replaced with (P15) bridge, if feasible judging from economic and other considerations.

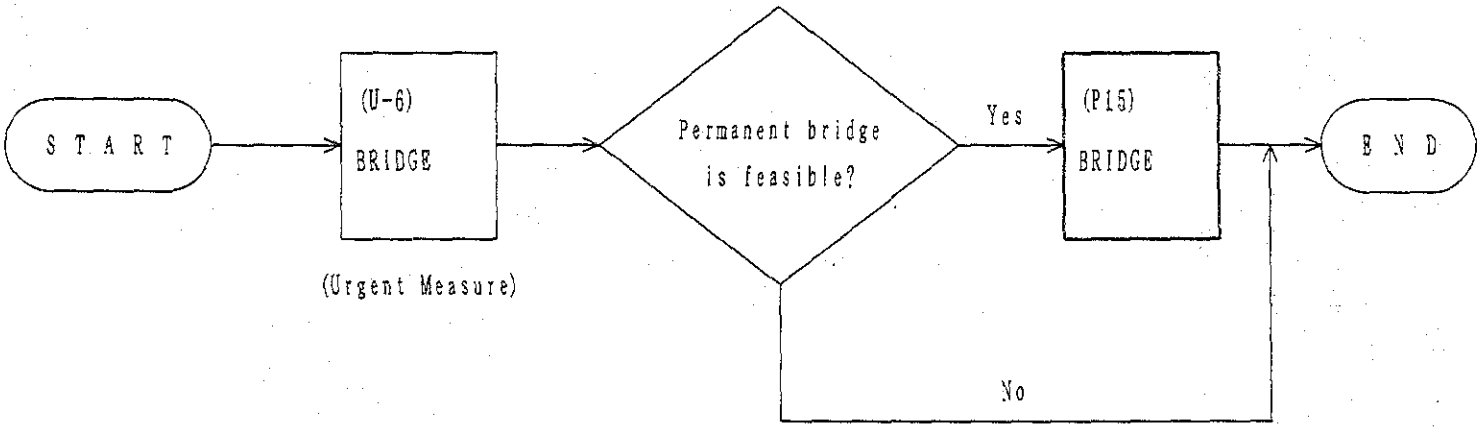


FIGURE 13.2-10 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR PERMANENT/TEMPORARY BRIDGE WASHOUT (PBr-W, TBr-W)

9) Permanent Bridge Approach Washout (PBr-A)

This section is applicable also to temporary bridge approach washout.

Figure 13.2-11 shows the general flow for the selection of restoration measures.

At first, it is judged technically whether the damaged approach can reasonably be restored with earth structure or not. If the approach has encroached or would encroach on the stream, the answer is no. In such case, the bridge should be expanded with (P15) bridge or (U6) bridge as the case may be.

If the damaged approach can reasonably be restored with earth structure, restoration measures are selected in the same way as scour/washout of roadbed. Refer to 6) of this chapter.

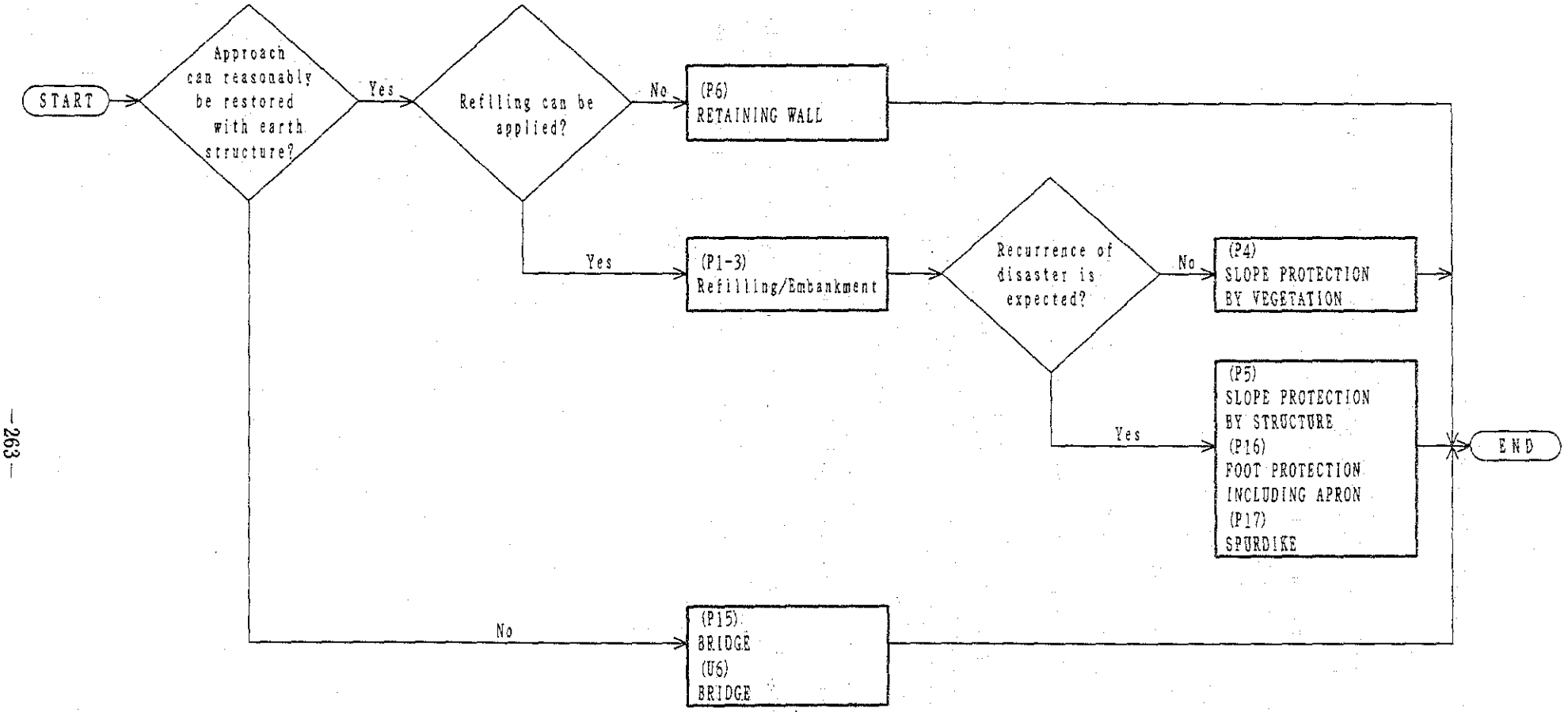


FIGURE 13.2-11 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR PERMANENT/TEMPORARY BRIDGE APPROACH WASHOUT (PBr-A, TBr-A)

10) Permanent Bridge Other Damage (PBr-D)

This section is applicable also to temporary bridge other damage.

Main measures which are generally applied to permanent/temporary bridge other damage are:

- P6 Retaining wall
- P13 Sabo dam
- P14 Consolidation
- P16-1 Concrete foot protection
- P16-2 Gabion foot protection
- P17 Spurdike

Figure 13.2-12 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When pier foundation is being scoured, it should be protected with (P16-1) concrete foot protection or (P16-2) gabion foot protection. Another solution is to construct downstream (P14) consolidation aiming at aggradation of riverbed, unless danger of collapse is imminent. Both measures are sometimes combined for more effect.

- When riverbed is aggrading, it should be controlled by proper means, for example, by constructing upstream (P13) sabo dam or (P14) consolidation.

- When abutment and/or river bank are being scoured, they should be protected with (P6) retaining wall or (P16) foot protection, or both. If the direction of stream must be controlled to prevent further erosion of bank, (P17) spurdike is required.

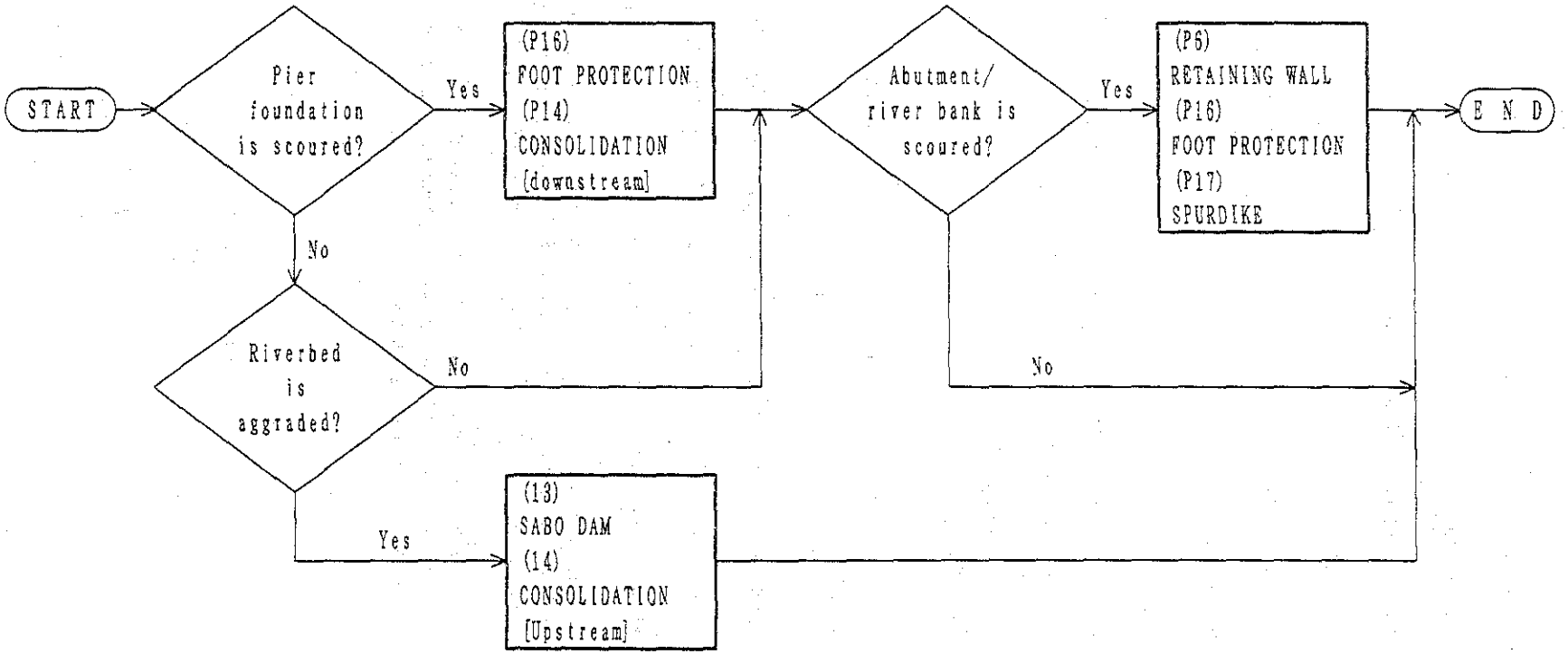


FIGURE 13.2-12 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR PERMANENT/TEMPORARY BRIDGE OTHER DAMAGE (PBr-D, TBr-D)

11) Temporary Bridge Washout (TBr-W)

Refer to 8) of this chapter.

12) Temporary Bridge Approach Washout (TBr-A)

Refer to 9) of this chapter.

13) Temporary Bridge Other Damage (TBr-D)

Refer to 10) of this chapter.

14) Spillway Damage (SPW-D)

Main measures which are generally applied to spillway damage are:

- P1-5 Selected material fill
- P2-4 Culvert
- P6 Retaining wall
- P13 Sabo dam
- P14 Consolidation

Figure 13.2-13 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- Spillway damage is classified into 2 types according to the cause as follows:
  - Body of spillway and/or its approach are scoured or washed out.
  - Culverts in the spillway are clogged with debris.
- In the first case, spillway should be reconstructed and or/extended. For this, the use of (P1-5) selected material fill protected by (P6) retaining wall such as (P6-6) supported type concrete wall or (P6-9) gabion wall is recommended.
- In the second case, removal of sediment is a solution. If recurrence of such sedimentation is anticipated, a fundamental preventive measure such as (P13) sabo dam or (P14) consolidation is needed.

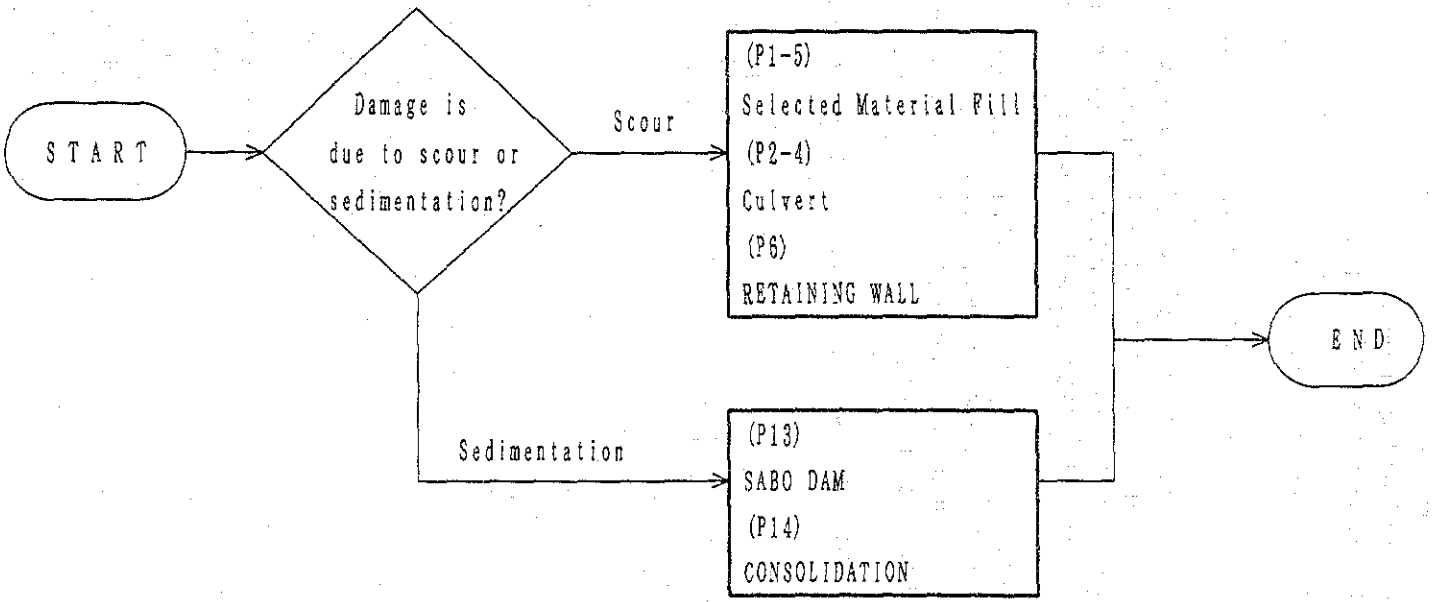


FIGURE 13.2-13 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR SPILLWAY DAMAGE (SPW-D)

15) Culvert Damage (CLV-D)

Main measures which are generally applied to culvert damage are:

- P2-4 Culvert
- P2-5 Catch basin
- P16-3 Grouted riprap apron
- Measures for embankment slope failure

Figure 13.2-14 shows the general flow for the selection of restoration measures.

Main points to be considered in the selection are as follows:

- When the existing culvert has a defect such as insufficient capacity, damage, and insufficient length, it should be corrected with proper-sized (P2-4) culvert: by replacement or addition against insufficient capacity, replacement against damage, and extension against insufficient length.

- When culvert inlet is clogged with debris, it should be removed. The installation of (P2-5) catch basin is sometimes effective for debris problem. When the portion near the culvert outlet is subjected to scour, proper protection such as (P16-3) grouted riprap apron is required.

- When embankment slope is damaged, it should be restored. See 2) of this chapter.

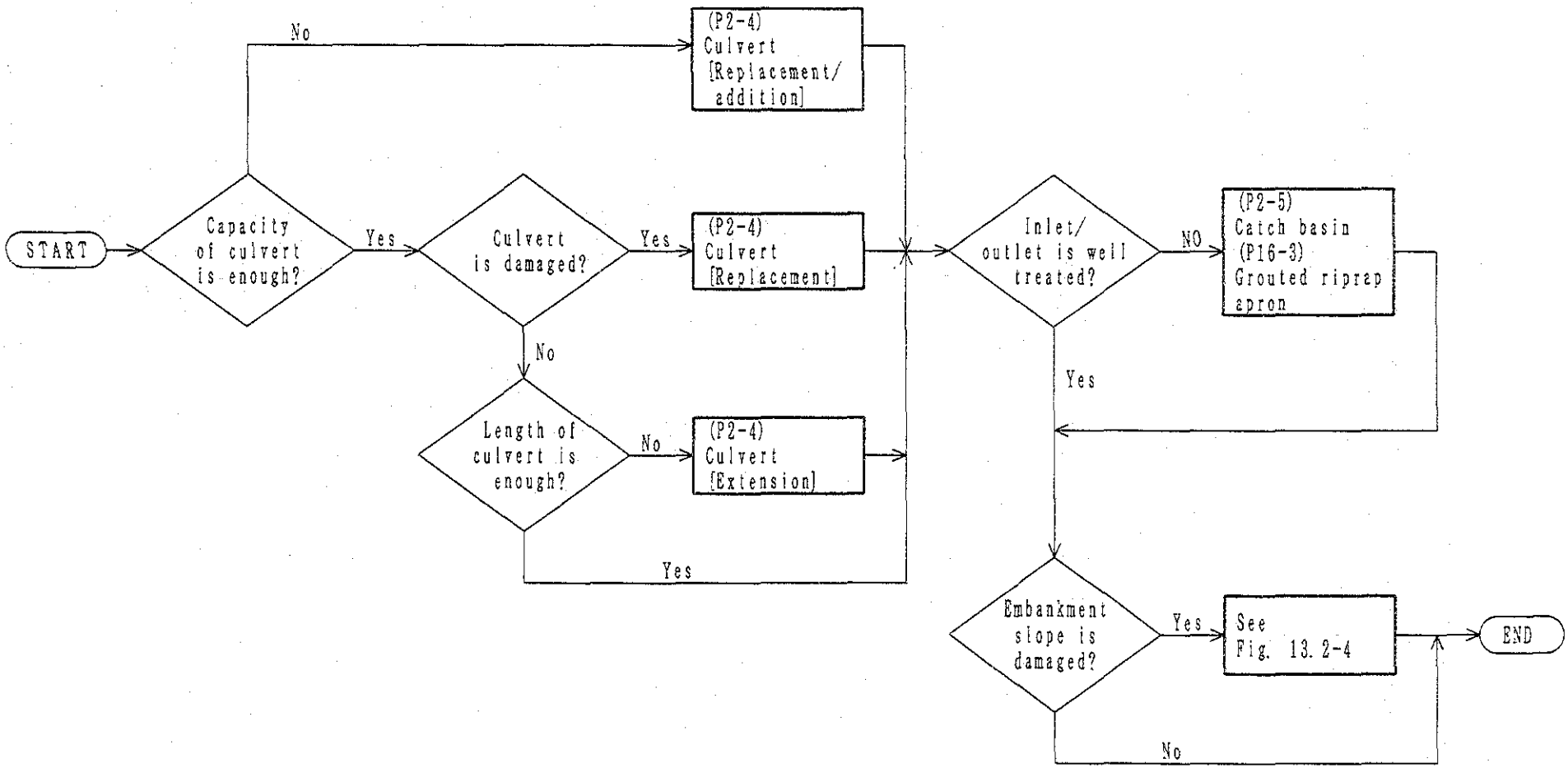


FIGURE 13.2-14 FLOW CHART FOR SELECTION OF RESTORATION MEASURES FOR CULVERT DAMAGE (CLV-D)

16) Seawall Damage (SW-D)

Permanent restoration measure for seawall damage is mainly (P6) retaining wall. Proper type of retaining wall should be selected in consideration of height, soil property, construction conditions, etc.

CHAPTER 14
PRELIMINARY DESIGN FOR THE SELECTED SPOTS

14.1 PRELIMINARY DESIGN FOR EXAMPLE SPOTS

Prelimnary design was carried out for all selected spots in the following procedures:

Engineering Survey

Site conditions were surveyed and causes of the disaster were assessed by the engineering survey as mentioned in Chapter 10.

Selection of Restoration Measures

Restoration measures, both urgent measures and permanent measures were selected out of various measures presented in Chapter 12 in accordance with the selection criteria shown in Chapter 13, including alternatives if any.

Preliminary Design of the Selected Restoration Measures

Restoration measures were designed in accordance with Volume V: Rural Road Restoration Manual.

Cost Estimate

The cost was estimated as shown later in this Chapter.

This Chapter shows the outline of the preliminary design for the selected example spots which are deemed to represent the respective types of disaster.

14.1.1 Cut Slope Failure

1) Spot L-84 (Leyte)

Location	:	7.6 km from Jct. Abuyog-Mahaplag Road
Road Name	:	Tadoc-Southern Leyte Road
Road Classification	:	Barangay Road
Geological Condition	:	Highly weathered hard clay
Water Condition	:	Water from hinterland

2) Description of Disaster

Top soil of the cut slope slid down 30 meters in length and 12 meters in height. The road was partially covered by the fallen soil.

3) Causes of Disaster

Steep gradient of cut slope and erosion of top soil are major causes of failure.

4) Proposed Restoration Measures

Urgent Restoration Measures

The proposed measures are as follows:

Proposed Measures		Purpose
U1-1	Removal of Deposit Materials	To remove traffic obstruction

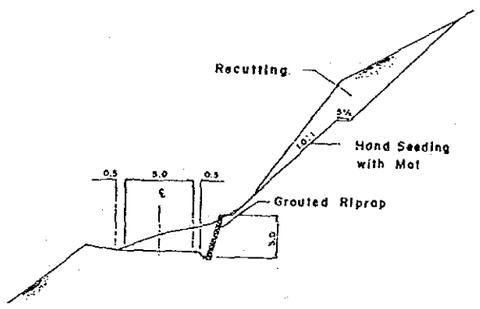
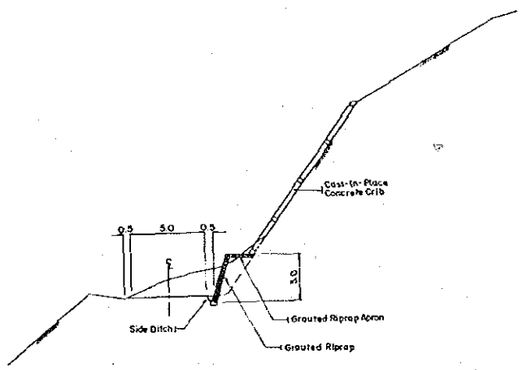
Permanent Restoration Measures

Two options were proposed; 1) grouted riprap with vegetation and 2) grouted riprap and concrete crib. They were compared as shown in Figure 14.1-1. From the economic and environmental aspects, the former was selected. The selected measures are as follows:

Proposed Measures		Purpose
P1-1	Recutting	To make the slope stable
P2-2	Side Ditch	To collect surface water coming from mountain side and thus prevent water from running directly on the surface of the road.
P4-2	Hand Seeding with Mat	To prevent the slope from erosion
P6-2	Grouted Riprap	To protect the slope toe

FIGURE 14.1-1 COMPARISON OF ALTERNATIVE RESTORATION MEASURES

TYPE OF DISASTER : CUT SLOPE FAILURE
PROVINCE AND SPOT NO: LEYTE, L-84

TYPE OF WORK AND ILLUSTRATION	ENGINEERING CHARACTERISTICS	CONSTRUCTION COST (₱1,000)	CONSTRUCTION CHARACTERISTICS	ENVIRONMENTAL ASPECTS	REMARKS
(1) Grouted Riprap and Vegetation 	· The slope is stabilized by cutting to stable gradient and protected by vegetation. · Maintenance is needed for vegetation growth.	Recutting 240 m^3 x 50 = 14 Grouted Riprap 34m^3 x 1,326 = 25 Hand Seeding w/ Mat 290 m^2 x 44 = 13 Side Ditch 19 m x 250 = 5 ₱57	· Special equipment and expertise are not necessary. · Construction period is about 1 month and 1 lane is passable during construction.	· The vegetation conserves natural environment.	· Recommendable from the economic and environmental aspects.
(2) Grouted Riprap and Concrete Crib 	· The slope is completely protected from erosion by concrete crib.	Concrete Crib 25m^3 x 2,238 = 78 Reinforcing Steel Bars 300 kg x 34 = 10 Grouted Riprap 19m^3 x 1,326 = 25 Grouted Riprap Apron 8 m^3 x 1,326 = 11 Side Ditch 19 x 250 = 5 ₱129	· Construction of cast-in-place on steep slope needs time and many labors but special equipment and expertise are not necessary. · Construction period is about 3 months and 1 lane is passable during construction	· Cast-in-place concrete harms natural view.	· Applicable.

14.1.2 Embankment Slope Failure

1) Spot Bt-54 (Benguet)

Location	:	23.4 km from Kibungan proper
Road Name	:	Kibungan-Kapangan Road
Road Classification	:	National Secondary Road
Geological Condition	:	Gravel bed
Water Condition	:	Surface water runs directly on the slope but not concentrates on particular portion

2) Description of Disaster

A river runs along the road embankment. The embankment slope with a gradient of 45 degrees and a height of 7 meters fell down 16 meters in length and 2.5 m in thickness on top. Debris was deposited on the riverbed. A triangular side ditch on the mountain side of the road was silted.

3) Causes of Disaster

Debris deposits on the riverbed narrowed river width at this point, resulting in rise of water level and high velocity of flow which caused erosion of embankment.

4) Proposed Restoration Measures

Urgent Restoration Measures

The proposed measures are as follows:

Proposed Measures		Purpose
U1-4	Refilling/Embankment	To fill scoured portion of slope
U4-3	Wooden Fence	To retain refilled slope temporarily

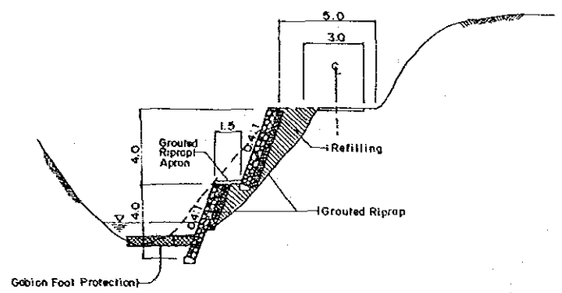
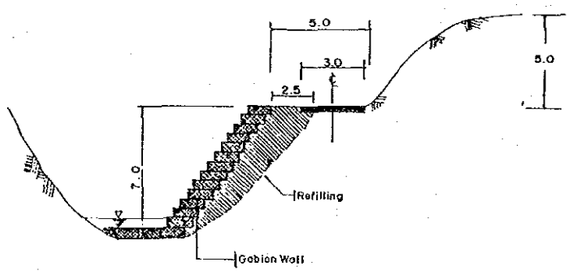
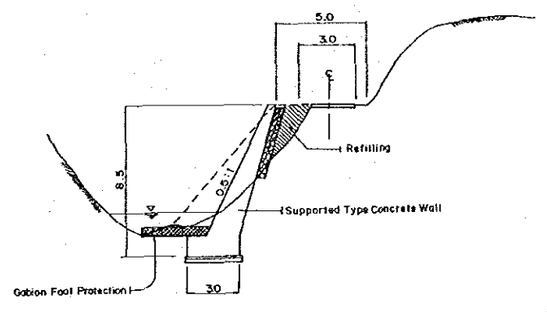
Permanent Measures

Three options were proposed; 1) grouted riprap, 2) gabion wall and 3) supported type concrete wall. They were compared as shown in Figure 14.1-2. From the engineering and economical aspects, the second option was selected, which is as follows:

Proposed Measures		Purpose
P1-3	Refilling/Embankment	To fill scoured portion of slope
P6-9	Gabion Wall	To retain refilled slope and protect it from scour

FIGURE 14.1-2 COMPARISON OF ALTERNATIVE RESTORATION MEASURES

TYPE OF DISASTER : EMBANKMENT SLOPE FAILURE
PROVINCE AND SPOT NO.: BENGUET, Bt-54

TYPE OF WORK AND ILLUSTRATION	ENGINEERING CHARACTERISTICS	CONSTRUCTION COST (₱1,000)	CONSTRUCTION CHARACTERISTICS	ENVIRONMENTAL ASPECTS	REMARKS
(1) Grouted Riprap 	· Grouted Riprap is weaker than Gabion Wall and Concrete Wall in strength of sustaining earth pressure. · The foundation of Grouted Riprap of upper row is in the embankment it is questionable.	Excavation 48 m^3 x 90 = 4 Grouted Riprap 72 m^3 x 1,326 = 95 Grouted Riprap Apron 5 m^3 x 1,326 = 7 Refilling 94 m^3 x 68 = 6 Gabion Foot Protection 29 m^3 x 1,425 = 41 ₱153	· Special equipment and expertise are not necessary. · Construction period is about 1 month.		· Not recommandable from the engineering aspect.
(2) Gabion Wall 	· Gabion is effective when there is seepage water from backfill. · River is maintained to its original width.	Refilling 310 m^3 x 68 = 21 Gabion Wall 154m^3 x 1,425 =219 Permeance Mat 100 m^2 x 34 = 3 ₱243	· Special equipment and expertise are not necessary. · Construction period is about 1.5 months.		· Recommendable from the engineering and economical aspects.
(3) Supported Type Concrete Wall 	· Durability and reliability is higher than the others.	Excavation 192 m^3 x 90 = 17 Concrete Wall 230m^3 x 2,942 =677 Refilling 43 m^3 x 68 = 3 Gabion Foot Protection 29m^3 x 1,425 = 41 ₱738	· Special equipment and expertise are not necessary. · Construction period is about 2 months.		· Applicable.

14.1.3 Rock Fall/Debris Fall

1) Spot L-65 (Leyte)

Location	:	3.3 km from Albuera Jct. - Baybay Road
Road Name	:	Albuera - Burauen Road
Road Classification	:	National Secondary Road
Geological Condition	:	Bedrock is tuff breccia but surface is highly weathered.
Water Condition	:	Surface water from hinterland

2) Description of Disaster

Rock fall occured last November 12, 1990 during typhoon "Ruping". Damaged section was about 34.0 m long and 25.0 m high. The cut slope is perpendicular or overhung.

3) Causes of Disaster

Weathered rocks on the surface of overhung slope were detached from bedrock due to seepage of water during heavy rain.

4) Proposed Restoration Measures

Urgent Restoration Measures

Proposed Measures		Purpose
U1-1	Removal of Deposite Materials	To remove traffic obstruction
U1-2	Removal of Unstable Materials	To prevent temporarily recurrence of rock fall

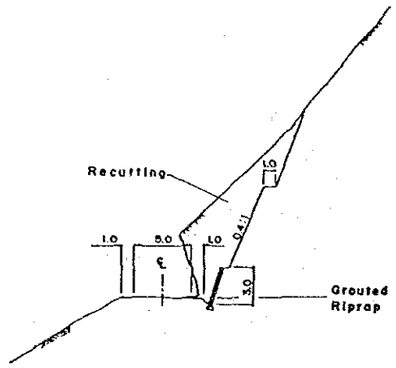
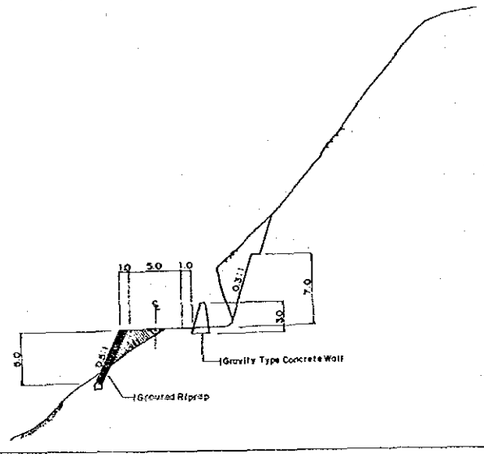
Permanent Restoration Measures

The two options were proposed: 1) recutting and grouted riprap and 2) realignment and catch wall. The two were compared as shown in Figure 14.1-3 and the first option was selected mainly for economical reason. The selected measures are as follows:

Proposed Measures		Purpose
P1-1	Recutting	To stabilize the slope
P2-2	Side Ditch	To prevent surface water from running on road surface
P6-2	Grouted Riprap	To protect the slope toe

FIGURE 14.1-3 COMPARISON OF ALTERNATIVE RESTORATION MEASURES

TYPE OF DISASTER: FALL
PROVINCE AND SPOT NO.: LEYTE, L-65

TYPE OF WORK AND ILLUSTRATION	ENGINEERING CHARACTERISTICS	CONSTRUCTION COST (₱1,000)	CONSTRUCTION CHARACTERISTICS	ENVIRONMENTAL ASPECTS	R E M A R K S
(1) Recutting and Grouted Riprap 	· The slope is stabilized to a degree of little possibility of recurrence of disaster.	Recutting 1,440m³ x 359 =409 Side Ditch 34 m x 250 = 9 Grouted Riprap 34 m x 1,326 = 45 ₱463	· Special equipment and expertise are not necessary. · Construction period is about 3 months. · During the recutting work (dynamite blasting), road is temporarily closed to traffic.		· Recommendable to economical reason.
(2) Realignment and Catch Wall 	· There is a possibility of surface failure at the upper part of slope. However, fallen rocks will be checked by the catch wall. · Maintenance will be needed for removing the debris accumulating on the back of the catch wall.	Recutting 360 m³ x 359 =129 Concrete Wall 112 m³ x 2,240=251 Grouted Riprap 119 m³ x 1,326=158 Refilling 183 m³ x 68 = 12 Gravel Surfacing 24 m³ x 316 = 8 ₱558	· Special equipment and expertise are not necessary. · Construction period is about 4 months. · During the recutting work (dynamite blasting), road is temporarily closed to traffic, but in shorter period than the above scheme.		· Applicable.

14.1.4 Landslide

1) Spot L-47 (Leyte)

Location	:	0.9 km from Km. Post 993
Road Name	:	Baybay - Jct. Mahaplag Road
Road Classification	:	National Secondary Road
Geological Condition	:	Soft Clay
Water Condition	:	Surface and seepage water from hinterland

2) Description of Disaster

On mountain side of the road, the evidence of landslide was found in 0.5 - 1.0 m high scarps along the sliding surface extending over about 40 m in length and 10 m in height. The side ditch on mountain side was displaced, damaged and clogged with soil about 40 m in length.

3) Causes of Disaster

Potential cause is on hillside cutting in road construction, injuring a stability of the slope. Landslide was induced by decrease in shear strength of the earth due to rise of groundwater level during heavy rain.

4) Proposed Restoration Measures

Urgent Measures

The proposed measures are as follows:

Proposed Measures		Purpose
U1-1	Removal of Deposit Material	To remove traffic obstruction
U2-2	Temporary Side Ditch	To prevent rain water from running on the road surface

Permanent Measures

Measures for stabilizing the slope by means of partial removal of sliding mass, groundwater drainage and foot protection to resist the sliding force were proposed as permanent measures for this spot. No alternative measures were proposed. The proposed measures include the following works (See Figure 14.1-4):

Proposed Measures		Purpose
P1-1	Recutting	To remove partially sliding mass
P1-3	Refilling/Embankment	To repair shoulder along valley side
P2-2	Side Ditch	To prevent water from running on road surface
P3-2	Horizontal Drain Hole	To drain groundwater and thus lower its level
P4-2	Hand Seeding w/Mat	To protect slope from erosion
P16-2	Gabion Foot Protection	To increase resisting force against sliding movement

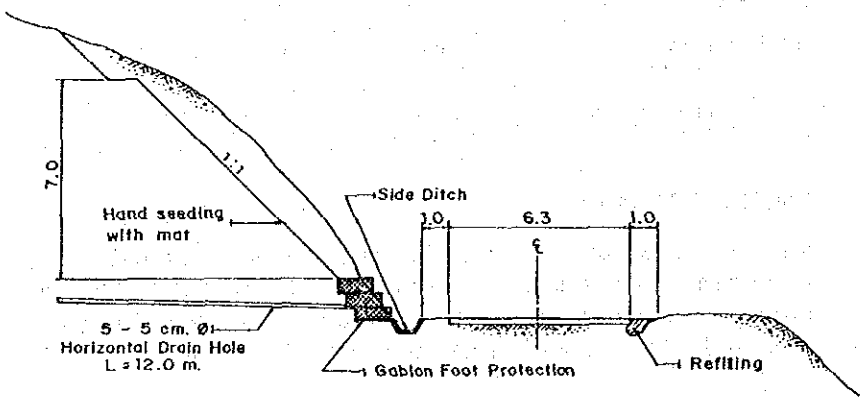


FIGURE 14.1-4 PERMANENT RESTORATION MEASURES FOR SPOT L-47

14.1.5 Debris Flow

1) Spot Bt-39 (Benguet)

Location	:	15.2 km from Kapangan Municipal Hall
Road Name	:	Kapangan-Acop Road
Road Classification	:	National Secondary Road
Geological Condition	:	Diorite
Water Condition	:	Concentrated water from mountain

2) Description of Disaster

Rocks carried by the flow of water from upstream accumulate on the bed of ravine about 40 meters in length and 16 meters in width at the roadside. The deposit rocks often flow over the road during heavy rain. The riprap protecting the slope on valley side of the road is eroded by the water directly running thereon.

3) Causes of Disaster

Debris flow was induced by the force of flow during heavy rain.

4) Proposed Restoration Measures

Urgent Restoration Measures

Proposed Measures		Purpose
U1-1	Removal of Deposit Materials	To remove traffic obstruction

Permanent Restoration Measures

Catch work against debris flow, drainage work for surface water and protection work for valley side slope were proposed for this spot. No alternative was proposed. The proposed restoration measures are as follows (See Figure 14.1-5):

Proposed Measures		Purpose
P6-2	Grouted Riprap	To protect the slope on valley side of the road
P8-2	Catch Gabion Wall	To catch debris and to control flow of debris
P16-3	Grouted Riprap Apron	To protect the foundation of grouted riprap from scour
P18-1	Concrete Spillway	To regulate the flow of surface water and to protect road surface

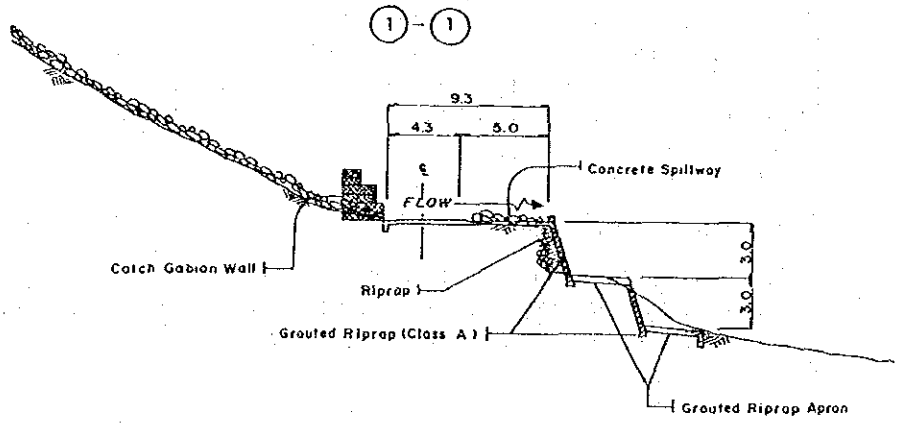


FIGURE 14.1-5 PERMANENT RESTORATION MEASURES FOR SPOT Bt-39

14.1.6 Scour/Washout of Roadbed

1) Spot Bt-2 (Benguet)

Location	:	0.3 km from Itogon
Road Name	:	Itogon - Balatok Road
Road Classification	:	National Secondary Road
Geological Condition	:	Dacite
Water Condition	:	Embankment is located along river, thus, subject to erosion.

2) Description of Disaster

The roadbed was totally washed out in the section with a total length of about 300 m caused by the July 1990 earthquake and succeeding floods due to typhoons. The road is totally cut and the flood plain is used as detour during dry season.

3) Causes of Disaster

Damage on slope due to earthquake and scouring action of flowing water are the causes of washout.

4) Proposed Restoration Measures

Urgent Measures

No urgent measures were proposed because of absence of proper measure to be completed in a short period.

Permanent Measures

Gabion wall was selected to support and retain the embankment taking advantage of its strength against erosion by water, availability of stores on the river bed, and lower cost than concrete wall. The proposed measures consist of the following (See Figure 14.1-6):

Proposed Measures		Purpose
P1-3	Refilling/Embankment	To fill washed-out section
P6-9	Gabion Wall	To retain embankment
P19-1	Gravel Surfacing	To surface the road

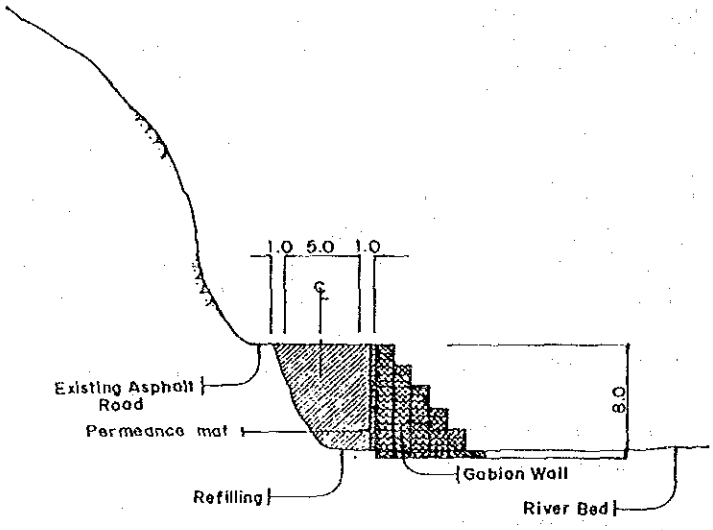


FIGURE 14.1-6 PERMANENT RESTORATION MEASURES FOR SPOT Bt-2

14.1.7 Flooded/Muddy Road Surface

1) Spot Bs-14 (Batangas)

Location	:	3.8 km from Mabini Jct. to Malimatok
Road Name	:	Mabini Jct. - Anilao - Solo Road
Road Classification	:	National Secondary Road
Geological Condition	:	Volcanic rocks, predominantly andesite
Water Condition	:	Surface water from hinterland

2) Description of Disaster

A pipe culvert of diameter 0.610 m is laid 42 m away from the lowest portion of the road. The entrance of the culvert is partly clogged with rocks and other debris resulting in insufficient capacity of discharging the rain water. No side ditch is provided. Due to surface water flowing directly on the road surface, the road is very muddy during rainy season.

3) Causes of Disaster

Improper drainage of surface water is the cause of the road surface to be muddy.

4) Proposed Restoration Measures

Urgent Measures

Proposed measures are as follows:

Proposed Measures		Purpose
U2-2	Temporary Side Ditch	To prevent water from running on road surface
U7-1	Gravel Surfacing	To improve road surface condition

Permanent Measures

Proposed measures consist of the following (See Figure 14.1-7):

Proposed Measures		Purpose
P2-2	Side Ditch	To prevent water from running on road surface
P2-5	Catch Basin	To prevent the entrance of culvert from clogging
P6-6	Supported Type Concrete Wall	To protect the existing riprap from erosion
P6-9	Gabion Wall	To protect outlet portion of culvert
P16-3	Grouted Riprap Apron	To protect outlet portion of culvert
P18-1	Concrete Spillway	To regulate the flow of surface water and to protect road surface

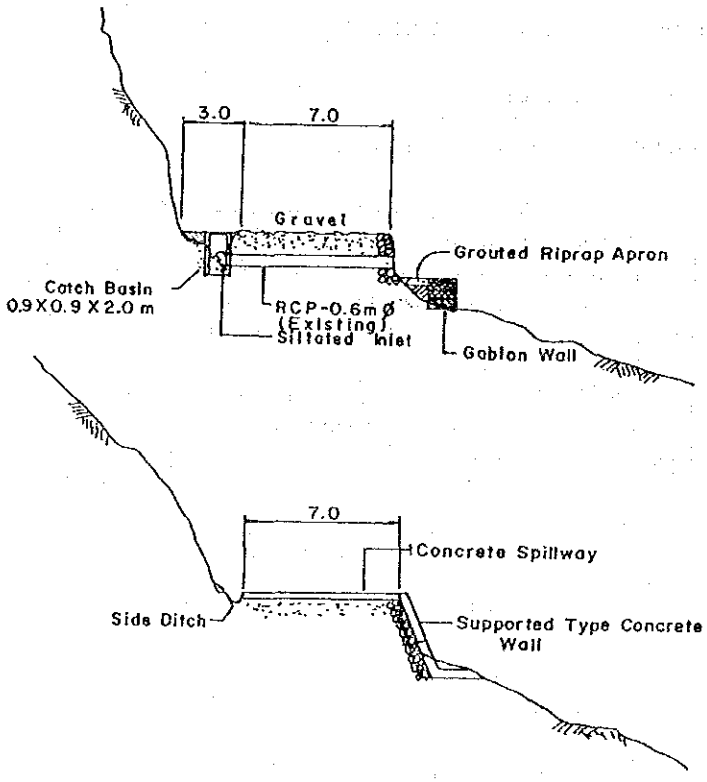


FIGURE 14.1-7 PERMANENT RESTORATION MEASURES FOR SPOT Bs-14

14.1.8 Permanent/Temporary Bridge Washout

1) Spot Bs-62 (Batangas)

Location	:	2.8 km from Tipas Jct. to Candelaria, Quezon
Road Name	:	Tipas Jct. - Pinagbayanan Road
Road Classification	:	Provincial Road
Geological Condition	:	Alluvial deposit on volcanic tuff and associated rocks particularly tuffaceous shale
Water Condition	:	Alluvial stream with unstable channel

2) Description of Disaster

The surrounding area of this spot is flat and low, and water from vast catchment area is drained through this area, submerging the area during heavy rain. Highest flood level reaches 1.50 m above the road surface. A bailey bridge 9.0 m long, together with Tipas side abutment, was washed out in 1990 by overflowing water. The riverbed was widened toward Tipas side both upstream and downstream of the bridge location. Thus, the approach portion is in danger of being washed-out.

3) Causes of Disaster

Overflow of the river submerging the bridge is the cause of this disaster.

4) Proposed Restoration Measures

Urgent Restoration Measures

For temporary bridge to be quickly constructed, bailey bridge with H-pile substructure was proposed.

Proposed Measures		Purpose
U6-1	H-Pile Bent	To serve as substructure of bridge
U6-2	Bailey Bridge	To serve as superstructure of bridge

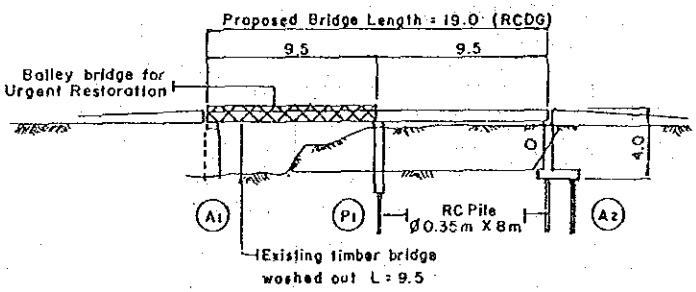
Permanent Restoration Measures

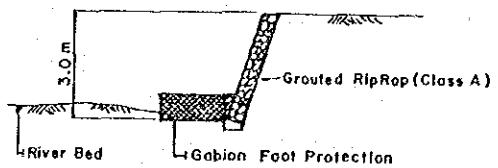
The following considerations were given in proposing permanent restoration measures:

- To raise bridge elevation to prevent the bridge from submergence.
- To add one more span not to encroach on the river stream, otherwise contracted river width may cause a rise of water level upstream and high velocity of flow bringing on severe erosion problem to approach portion.
- To protect river bank.

The permanent restoration measures were proposed as follows (See Figure 14.1-8):

Proposed Measures		Purpose
P1-3	Refilling/Embankment	To elevate approaches of the bridge
P6-2	Grouted Riprap	To protect river bank
P15-1	Concrete Bridge	To provide permanent river crossing structure
P16-2	Gabion Foot Protection	To protect foot of grouted riprap from scour
P19-1	Gravel Surfacing	To surface the approaches of the bridge





River Bank Protection

FIGURE 14.1-8 PERMANENT RESTORATION MEASURES FOR SPOT Bs-62

14.1.9 Permanent/Temporary Bridge Approach Washout

1) Spot Bs-33 (Batangas)

Location	:	18.5 km from Dagatan Jct. to Taysan
Road Name	:	Dagatan Jct. - Lobo Road
Road Classification	:	National Secondary Road
Geological Condition	:	Alluvial deposit, particularly sand fills the whole river.
Water Condition	:	Alluvial stream with unstable channel

2) Description of Disaster

Lobo bridge, 8-span RCDG bridge with a total length of 124 m, was constructed in 1984. Due to meandering of Lobo river, Malabrigo side bank started to be eroded in about 1986, and washed out about 160 m in width at the bridge location on the occasion of typhoon "Sisang" in Janauary 1988. The bridge itself is sound. A few vehicles cross the stream by fording during dry season.

3) Causes of Disaster

Shift of the main channel in meandering stream resulted in the disaster.

4) Proposed Restoration Measures

Urgent Restoration Measures

For temporary bridge to be quickly constructed, bailey bridge with H-pile substructure was proposed.

Proposed Measures		Purpose
U6-2	H-Pile Bent	To serve as substructure of bridge
U6-3	Bailey Bridge	To serve as superstructure of bridge

Permanent Restoration Measures

The river bank on Malagrigo side is in danger of being further eroded. Preventive measures against bank erosion must be incorporated with extension of bridge to cross the shifted main channel. Thus, the permanent restoration measures for this spot were proposed as follows (See Figure 14.1-9):

Proposed Measures		Purpose
P6-9	Gabion Wall	To protect bank from erosion
P15-1	Concrete Bridge	To cross the shifted main channel
P17-2	Gabion Spurdike	To control movement of stream

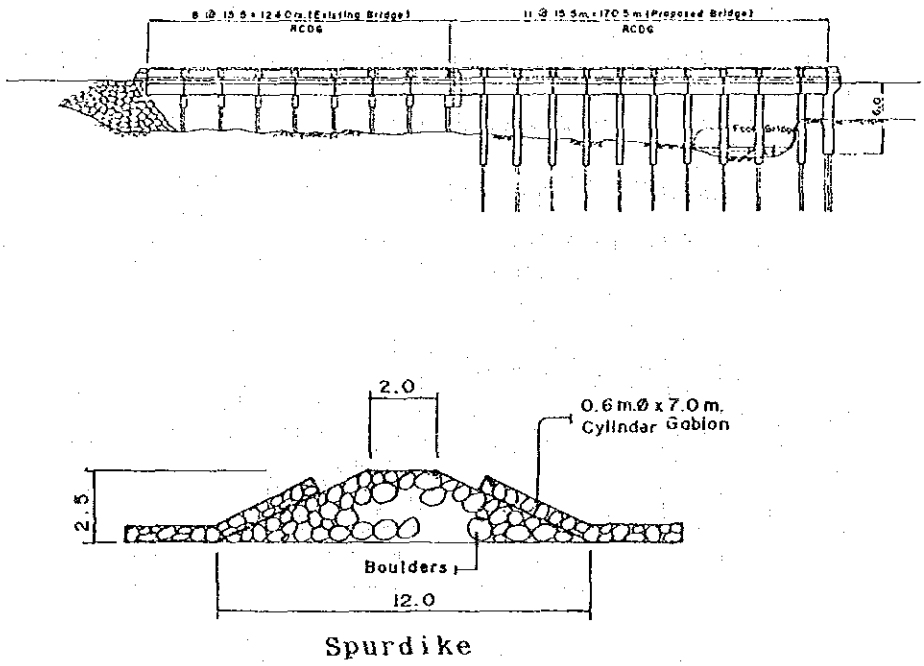


FIGURE 14.1-9 PERMANENT RESTORATION MEASURES FOR SPOT Bs-33

14.1.10 Permanent/Temporary Bridge Other Damage

1) Spot Bs-6 (Batangas)

Location	:	4.3 km from Jct. Calaca to Town Proper
Road Name	:	Calaca - Mahayahay Jct.
Road Classification	:	National Secondary Road
Geological Condition	:	Thick sand, consolidated tuff and conglomerate breccia
Water Condition	:	Flood plain 30 m wide, main channel 10 m wide

2) Description of Disaster

Sinisian Bridge, 3-span RCDG bridge with total length of 36 m, was constructed in 1983. Scour at the riverbed was noticed and reported in 1985. Presently, the riverbed is lower than the bottom of pier footings by 1.5 - 2.0 m, exposing piles as much. The abutment is protected by gabion wall but it sags due to riverbed lowering.

3) Causes of Disaster

Quarrying of sand and gravel at 100 m downstream may cause scour.

4) Proposed Restoration Measures

Urgent Restoration Measures

Since there is no interference to traffic for the present, no urgent measures were proposed except for preventive measures at abutment as follows:

Proposed Measures		Purpose
US-1	Gabion Foot Protection	To protect slope at the abutment from erosion

Permanent Restoration Measures

The following three options were proposed and compared as shown in Figure 14.1-10.

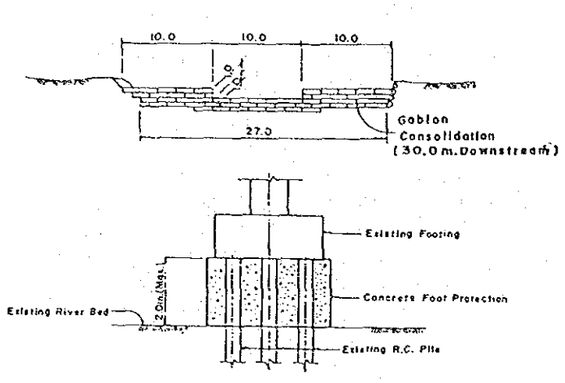
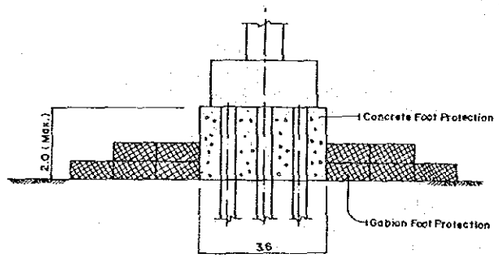
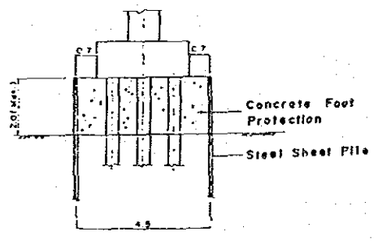
- Concrete foot protection and gabion consolidation at downstream
- Concrete foot protection surrounded by gabion foot protection
- Concrete foot protection surrounded by steel sheet pile

The first option was selected from the technical and economical points of view. The proposed measures are as follows:

Proposed Measures		Purpose
P14-2	Gabion Consolidation	To recover scoured river bed
P16-1	Concrete Foot Protection	To protect exposed piles

FIGURE 14.1-10 COMPARISON OF ALTERNATIVE RESTORATION MEASURES

TYPE OF DISASTER: PERMANENT BRIDGE OTHER DAMAGE
PROVINCE AND SPOT NO.: BATANGAS, Bs-6

TYPE OF WORK AND ILLUSTRATION	ENGINEERING CHARACTERISTICS	CONSTRUCTION COST (₱1,000)	CONSTRUCTION CHARACTERISTICS	ENVIRONMENTAL ASPECTS	REMARKS
(1) Concrete Foot Protection and Gabion Consolidation 	· Gabion consolidation is to place gabions on the present riverbed at down stream of the structure and to expect natural sediment up to the original level.	Gabion Consolidation 114m^3 x 1,425 =162 Concrete Foot Protection 65 m^3 x 2,942 =191 ₱353	· Special equipment and expertise are not necessary. · Construction period is about 2 months.		· Recommendable for economic reason.
(2) Concrete Foot Protection with Gabion 	· There is possibility of submerge of Gabion Foot Protection due to scouring of the river bed.	Conc. Foot Protection 65 m^3 x 2,942 =191 Gabion Foot Protection 206m^3 x 1,425 =294 ₱485	· Special equipment and expertise are not necessary. · Construction period is about 3 months.		· Applicable.
(3) Concrete Foot Protection with Steel Sheet Pile 	· Even if the riverbed is further scoured, the sheet pile affords stability.	Concrete Foot Protection 100m^3 x 2,942 =294 Steel Sheet Pile 18T x 34,200 =616 ₱910	· Sheet piles must be driven from above the bridge because of short height of the bridge, causing traffic disturbance. · Automatic pile hammer is necessary. · Construction period is about 6 months.		· Not recommandable because of high cost and difficulty in construction.

14.1.11 Spillway Damage

1) Spot L-90 (Leyte)

Location	:	1.5 km from Kananga proper
Road Name	:	Jct. Kananga - Tagaytay Road
Road Classification	:	Provincial Road
Geological Condition	:	Sand and gravel
Water Condition	:	Main channel 30 m wide, alluvial flow with instable channel

2) Description of Disaster

30 m long and 4 m wide spillway with 7 pieces of reinforced concrete pipe culverts crosses a meandering stream at about 20 m downstream of a bend. Approaches were washed out about 10-15 m in length on each side of the spillway during typhoon "Ruping" in November 1990. At that time, flood level reached about 1.0 m above the spillway. The spillway itself was still sound but traffic was totally interrupted.

3) Causes of Disaster

Erosion of bank by flood water is a cause of approach washout.

4) Proposed Restoration Measures

Urgent Restoration Measures

Proposed were the following measures, which would be utilized later as a part of permanent measures.

Proposed Measures		Purpose
U1-5	Selected Material Fill	To provide the stream crossing
U4-2	Gabion Wall	To protect the fill from erosion

Permanent Restoration Measures

Proposed permanent measures are to protect the approaches constructed as urgent measures, including the following works (See Figure 14.1-11):

Proposed Measures		Purpose
P2-4	Culvert R.C.P.C. 0.6 m	To provide the smooth water flow during the high flow
P6-6	Supported Type Concrete Wall	To provide permanent protection of the approach road constructed as urgent measures
P16-2	Gabion Foot Protection	To protect the upstream side river bank
P19-3	Concrete Pavement	To provide permanent surfacing

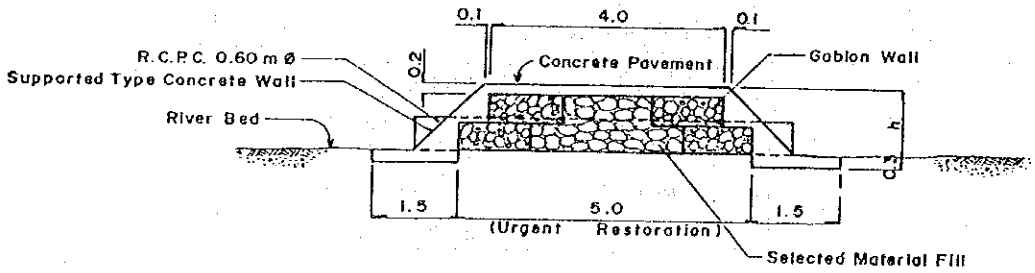


FIGURE 14.1-11 PERMANENT RESTORATION MEASURES FOR SPOT L-90

14.1.12 Culvert Damage

1) Spot L-13 (Leyte)

Location	:	8.8 km from Matag-ob Proper
Road Name	:	Matag-ob-Palompon Road
Road Classification	:	National Secondary Road
Geological Condition	:	Sandstone, gravelly soil
Water Condition	:	Concentrated water from hinterland

2) Description of Disaster

A pipe culvert of diameter 0.610 m was installed at curved portion of the road in mountainous terrain. Inlet was partially clogged with debris. Unprotected slope on valley side was eroded about 10 m in length and 2 m in width at top of slope.

3) Causes of Disaster

Insufficient capacity of culvert and accumulation of debris at inlet caused water to overflow on the road surface and run directly on bare slope surface resulting in slope failure.

4) Proposed Restoration Measures

Urgent Measures

The proposed measures consist of the following:

Proposed Measures		Purpose
U1-4	Refilling	To fill eroded portion of slope on valley side
U3-1	Sheet Covering	To prevent surface water from running directly on sand bag covering
U3-2	Sand Bag Covering	To protect fill surface
U4-3	Wooden Fence	To support temporarily fill material and sand bag

Permanent Restoration Measures

The following measures were proposed (See Figure 14.1-12):

Proposed Measures		P u r p o s e
P2-1	Slope Ditch	To provide waterway along mountain slope thus protect slope surface from erosion
P2-4	RCPC, 0.610 m in diameter	To extend the existing pipe culvert beyond the surface of slope
P2-5	Catch Basin	To connect slope ditch with pipe culvert reducing the energy of running water
P6-2	Grouted Riprap	To protect slope on valley side
P16-3	Grouted Riprap Apron	To protect foundation of grouted riprap from scour

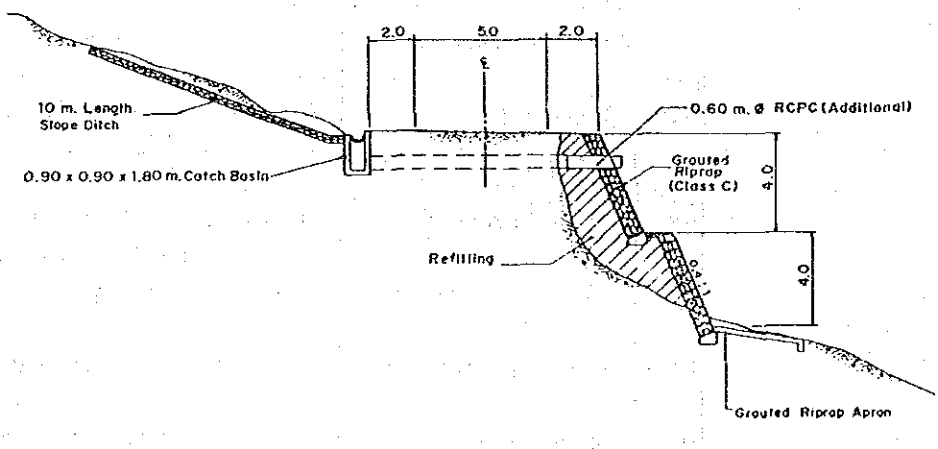


FIGURE 14.1-12 PERMANENT RESTORATION MEASURES FOR SPOT L-13

14.1.13 Seawall Damage

1) Spot Bs-51 (Batangas)

Location	:	0.65 km from Banoyo Jct. to Bagullaua
Road Name	:	Banoyo Jct. - San Luis Jct.
Road Classification	:	Provincial Road
Geological Condition	:	Clay, silt, sand, gravel and limestone fragments
Water Condition	:	Within affected zone of seawave

2) Description of Disaster

A seawall of 200 m in length and 2.1 m in height was initially constructed in the early 1970's and reconstructed in 1987 with grouted riprap. During the November 1988 typhoon, 42 m northern portion of the seawall was totally collapsed and 18 m southern portion was partially damaged.

3) Causes of Disaster

The damage was caused by seawave and backwash actions.

4) Proposed Restoration Measures

Urgent Restoration Measures

The following measures were proposed:

Proposed Measures		Purpose
U1-4	Refilling	To fill washed-out portion
U3-2	Sand Bag Covering	To protect fill surface
U4-3	Wooden Fence	To support temporarily fill material and sand bag

Permanent Restoration Measures

The following measures were proposed (See Figure 14.1-13):

Proposed Measures		Purpose
P6-5	Gravity Type Concrete Wall (With Ladder Foundation)	To retain embankment protecting it from erosion by seawave

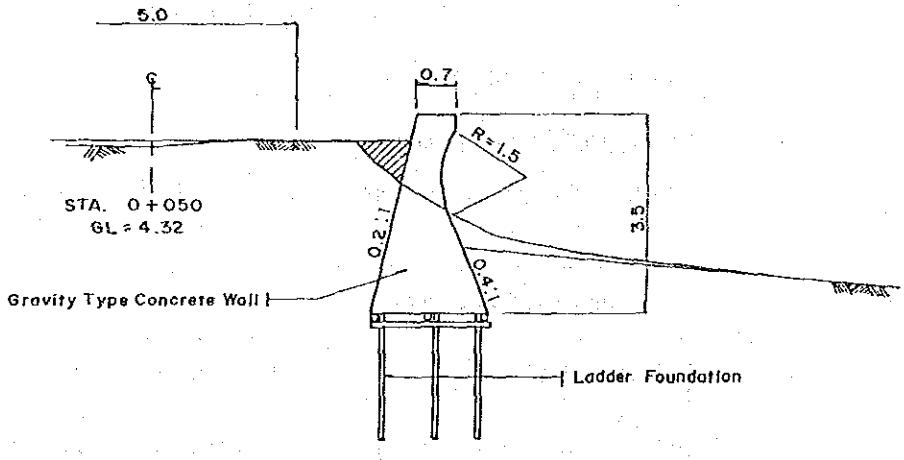


FIGURE 14.1-13 PERMANENT RESTORATION MEASURES FOR SPOT Bs-51

14.2 PRELIMINARY DESIGN FOR ALL SELECTED SPOTS

In the same manner as shown in Chapter 14.1, preliminary design was carried out for all selected spots.

Both urgent measures and permanent measures were prepared for each spot, except for the following spots:

- Spot: Bt-2 (Benguet), Disater Type: Rd-D (Scour/washout of Roadbed)

  The roadbed was totally washed out in 300 m long section. Presently, traffic is completely interrupted but a detour road is available. No urgent measures to be completed in a short time prior to permanent restoration measures are practical. In such case, immediate implementation of permanent measures is appropriate. In view of the above, no urgent measures were proposed.

- Spot: Bs-48 (Batangas), Disaster Type: PBr-D (Permanent Bridge Other Damage)

  Pile foundation of the bridge is exposed due to scour at the riverbed. The scour is considered still progressive. There is no interference to traffic for the moment. In this case, immediate implementation of permanent measures is recommended. Thus, no urgent measures were proposed.

- Spot: Bs-53 (Batangas), Disaster Type: FM-Rd (Flooded/Muddy Road Surface)

  This spot is often flooded and always muddy during rainy season. The main cause is on the elevation of the road which is lower than abutting area. For this spot, there is no other proper solution than raising of road elevation, which is already permanent measures. Thus, no urgent measures were proposed for this spot.

- Spot: L-4 (Leyte), Disaster Type: TBr-W (Temporary Bridge Washout)

  Construction of bailey bridge was proposed for this spot as urgent measures. By this, the original condition is to be completely recovered. Upgrading scheme by replacing temporary bridge with permanent bridge is also possible but it was not proposed in this spot because of economical unjustifiability. Thus, no permanent measures were proposed for this section.

- Spot L-6 (Leyte), Disaster Type: TBr-W (Temporary Bridge Washout)

  Same as Spot L-4.

Preliminary design for each spot is presented in Volume IV: Drawings. Table 14.2-1 shows the type of works applied to the design.

Major works by type of disaster is shown in Table 14.2-2.

TABLE 14.2-1 RESTORATION MEASURES APPLIED TO EACH SPOT

		TYPE OF DISASTER	C - F												E - F								
TYPE OF RESTORATION MEASURE		SPOT NUMBER	Bt-1	Bt-14	Bt-43	Bt-57	Bt-59	Bs-36	L-16	L-68	L-78	L-80	L-84	L-87	Bt-20	Bt-25	Bt-38	Bt-54	Bt-58	Bs-3	Bs-28	L-45	L-82
URGENT	U1-1	Removal of Deposit Materials	O	O	O	O	O	O	O	O	O	O	O	O									
	U1-2	Removal of Unstable Materials	O			O				O													
	U1-4	Refilling / Embankment													O			O		O	O	O	
	U1-5	Selected Material Fill																					
	U2-2	Temporary Side Ditch																				O	O
	U3-1	Sheet Covering		O												O	O		O				
	U3-2	Sand Bag Covering													O					O	O	O	
	U4-1	Sand Bag Wall																					
	U4-2	Gabion Wall																					
	U4-3	Wooden Fence													O			O			O	O	
	U5-1	Gabion Foot Protection																					
	U6-2	H - Pile Bent																					
	U6-3	Bailey Bridge																					
	U7-1	Gravel Surfacing																					
PERMANENT	P1-1	Recutting	O	O	O	O		O		O			O	O									
	P1-3	Refilling / Embankment												O		O	O	O		O	O	O	
	P1-4	Counterweight Fill																					
	P2-1	Slope Ditch																					
	P2-2	Side Ditch	O	O	O	O	O	O		O			O	O		O	O					O	
	P2-3	Water Channel																					
	P2-4	Culvert																			O		
	P2-5	Catch Basin																					
	P3-2	Horizontal Drain Hole																					
	P4-2	Hand Seeding with Mat		O									O	O			O					O	
	P4-6	Pick Hole Seeding			O					O		O											
	P4-8	Wattling	O			O	O	O			O												
	P5-3	Stone Pitching		O																			
	P6-2	Grouted Riprap	O	O	O	O	O			O			O		O	O	O		O	O	O		
	P6-4	Gravity Type Stone Masonry						O															
	P6-5	Gravity Type Concrete Wall																					
	P6-6	Supported Type Concrete Wall												O									
	P6-9	Gabion Wall	O															O			O		
	P6-10	Sheet Pile Wall																					
	P8-2	Catch Gabion Wall							O		O												
	P14-2	Gabion Consolidation																					
	P15-1	Concrete Bridge																					
	P16-1	Concrete Foot Protection														O							
	P16-2	Gabion Foot Protection																	O			O	
	P16-3	Grouted Riprap Apron													O				O	O	O		
	P17-2	Gabion Spurdike																					
	P18-1	Concrete Spillway																					
	P19-1	Gravel Surfacing																					
	P19-2	Bituminous Pavement																					
	P19-3	Concrete Pavement																					

		TYPE OF DISASTER	FALL					L-SL			D-FL					Rd-D		FM-Rd			
TYPE OF RESTORATION MEASURE		SPOT NUMBER	Bt-33	Bs-12	Bs-30	L-21	L-65	Bt-11	L-47	L-50	Bt-24	Bt-39	Bt-62	Bt-70	L-39	Bt-2	Bs-45	Bs-14	Bs-53	L-23	L-26
URGENT	U1-1	Removal of Deposit Materials	O	O	O	O	O		O	O	O	O	O	O	O						
	U1-2	Removal of Unstable Materials	O	O	O	O	O						O								
	U1-4	Refilling / Embankment															O				
	U1-5	Selected Material Fill																			
	U2-2	Temporary Side Ditch							O											O	
	U3-1	Sheet Covering																			
	U3-2	Sand Bag Covering													O		O				
	U4-1	Sand Bag Wall																			O
	U4-2	Gabion Wall																			
	U4-3	Wooden Fence																			
	U5-1	Gabion Foot Protection																			
	U6-2	H - Pile Bent																			
	U6-3	Bailey Bridge																			
	U7-1	Gravel Surfacing						O										O		O	
PERMANENT	P1-1	Recutting	O		O	O	O		O		O				O						
	P1-3	Refilling / Embankment							O					O		O			O		O
	P1-4	Counterweight Fill						O													
	P2-1	Slope Ditch						O											O		
	P2-2	Side Ditch	O			O	O		O	O	O							O		O	O
	P2-3	Water Channel																		O	
	P2-4	Culvert																		O	O
	P2-5	Catch Basin						O										O	O	O	
	P3-2	Horizontal Drain Hole						O	O	O											
	P4-2	Hand Seeding with Mat																			
	P4-6	Pick Hole Seeding	O						O												
	P4-8	Wattling			O																
	P5-3	Stone Pitching																			
	P6-2	Grouted Riprap	O			O	O					O	O				O				O
	P6-4	Gravity Type Stone Masonry																			
	P6-5	Gravity Type Concrete Wall																			
	P6-6	Supported Type Concrete Wall																O			
	P6-9	Gabion Wall						O								O		O			
	P6-10	Sheet Pile Wall																			
	P8-2	Catch Gabion Wall		O	O						O	O	O								
	P14-2	Gabion Consolidation																			
	P15-1	Concrete Bridge												O	O						
	P16-1	Concrete Foot Protection																			
	P16-2	Gabion Foot Protection							O	O											
	P16-3	Grouted Riprap Apron										O	O				O	O			
	P17-2	Gabion Spurdike																			
	P18-1	Concrete Spillway										O						O			O
	P19-1	Gravel Surfacing		O										O	O	O			O		
	P19-2	Bituminous Pavement						O													
	P19-3	Concrete Pavement																			

		TYPE OF DISASTER	PBr-W/ TBr-W			PBr-A/ TBr-A					PBr-D/ TBr-D			SPW-D			CLV-D						SW-D	
TYPE OF RESTORATION MEASURE		SPOT NUMBER	Bs-62	L-4	L-6	Bt-55	Bt-63	Bs-33	L-38	L-76	Bs-6	Bs-48	Bs-50	Bs-66	L-19	L-90	Bt-7	Bt-68	Bs-42	Bs-43	L-13	L-81	Bs-8	Bs-61
URGENT	U1-1	Removal of Deposit Materials															O							
	U1-2	Removal of Unstable Materials																						
	U1-4	Refilling / Embankment		O	O				O				O					O		O	O			O
	U1-5	Selected Material Fill												O	O	O								
	U2-2	Temporary Side Ditch																						
	U3-1	Sheet Covering															O	O			O	O		
	U3-2	Sand Bag Covering							O									O		O	O			
	U4-1	Sand Bag Wall				O												O	O			O	O	O
	U4-2	Gabion Wall											O	O	O	O								
	U4-3	Wooden Fence																			O		O	O
	U5-1	Gabion Foot Protection									O													
	U6-2	H - Pile Bent	O	O	O			O																
	U6-3	Bailey Bridge	O	O	O		O	O		O														
	U7-1	Gravel Surfacing		O	O																			
PERMANENT	P1-1	Recutting																						
	P1-3	Refilling / Embankment	O			O							O									O		
	P1-4	Counterweight Fill																						
	P2-1	Slope Ditch																			O			
	P2-2	Side Ditch																						
	P2-3	Water Channel																						
	P2-4	Culvert												O		O		O	O		O			
	P2-5	Catch Basin																O			O	O		
	P3-2	Horizontal Drain Hole																						
	P4-2	Hand Seeding with Mat																				O		
	P4-6	Pick Hole Seeding																						
	P4-8	Wattling																						
	P5-3	Stone Pitching																						
	P6-2	Grouted Riprap	O			O	O		O	O							O	O	O	O	O	O		
	P6-4	Gravity Type Stone Masonry																					O	
	P6-5	Gravity Type Concrete Wall																						O
	P6-6	Supported Type Concrete Wall												O	O	O								
	P6-9	Gabion Wall						O					O				O							
	P6-10	Sheet Pile Wall										O												
	P8-2	Catch Gabion Wall																						
	P14-2	Gabion Consolidation									O													
	P15-1	Concrete Bridge	O			O	O	O		O														
	P16-1	Concrete Foot Protection									O	O												
	P16-2	Gabion Foot Protection	O						O			O				O								
	P16-3	Grouted Riprap Apron															O	O	O	O	O	O		
	P17-2	Gabion Spurdike						O																
	P18-1	Concrete Spillway															O							
	P19-1	Gravel Surfacing	O																					
	P19-2	Bituminous Pavement																						
	P19-3	Concrete Pavement												O	O	O								

TABLE 14.2-2 RESTORATION MEASURES MAINLY APPLIED

Type of Disaster	Urgent Measures	Permanent Measures
C-F (Cut Slope Failure)	U1-1: Removal of Deposit Materials	P1-1: Recutting P4 : Slope Protection by Vegetation P6-2: Grouted Riprap
E-F (Embankment Slope Failure)	U1-4: Refilling/Embankment U3-1: Sheet Covering, or U3-2: Sand Bag Covering U4-3: Wooden Fence	P1-3: Refilling/Embankment P6-2: Grouted Riprap
FALL (Rock Fall/Debris Fall)	U1-1: Removal of Deposit Materials U1-2: Removal of Unstable Materials	P1-1: Recutting P6-2: Grouted Riprap, or P8-2: Catch Gabion Wall
L-SL (Landslide)	U1-1: Removal of Deposit Materials	P3-2: Horizontal Drain Hole P16-2: Gabion Foot Protection
D-FL (Debris Flow)	U1-1: Removal of Deposit Materials	P8-2: Catch Gabion Wall, or P15-1: Concrete Bridge
Rd-D (Scour/Washout of Roadbed)	U1-4: Refilling/Embankment U3-2: Sand Bag Covering	P6-2: Grouted Riprap
FM-Rd (Flooded/Muddy Road Surface)	U2-2: Temporary Side Ditch U7-1: Gravel Surfacing	P2 : Surface Drainage P19-1: Gravel Surfacing
PBr-W/TBr-W (Permanent/Temporary Bridge Washout)	U6-2: H-Pile Bent U6-3: Bailey Bridge	P15-1: Concrete Bridge, or None
PBr-A/TBr-A (Permanent/Temporary Bridge Approach Washout)	U6-3: Bailey Bridge	P6-2: Grouted Riprap P15-1: Concrete Bridge
PBr-D/TBr-D (Permanent/Temporary Bridge Other Damage)	None	P16-1: Concrete Foot Protection
SPW-D (Spillway Damage)	U1-5: Selected Material Fill U4-2: Gabion Wall	P6-6: Supported Type Concrete Wall P19-3: Concrete Pavement
CLV-D (Culvert Damage)	U1-4: Refilling/Embankment U3-1: Sheet Covering U3-2: Sand Bag Covering U4-1: Sand Bag Wall	P2 : Surface Drainage P6-2: Grouted Riprap
SW-D (Seawall Damage)	U4-3: Wooden Fence	U6-4: Gravity Type Stone Masonry, or U6-5: Gravity Type Concrete Wall

14.3 COST ESTIMATE

1) Equipment, Material and Labor Costs

Data on equipment, material and labor costs were obtained from the Associated Construction Equipment Lessors, Inc. (ACEL), the Price Monitoring Section of DPWH and market price survey conducted by the Study Team. Based on the data collected, unit prices at 1991 price level were established as shown in Tables 14.3-1, 14.3-2 and 14.3-3.

2) Unit Cost Analysis

Based on the equipment, material and labor costs, price analysis was conducted to develop the unit cost of each type of work, as summarized in Table 14.3-4. The unit cost analysis is presented in Appendix 14-1.

Note on the Cost of Bailey Bridge

Costs of H-pile bent (U6-2) and bailey bridge (U6-3) were estimated at the depreciation basis because they will be used only for a short period until permanent measures are completed and thereafter they may be re-used for other portions, except for spots L-4 and L-6 where no permanent measures were proposed and therefore, H-pile bents and bailey bridges will be used for a long term. The costs estimated based on full material costs were applied to spots L-4 and L-6.

3) Construction Cost

Construction costs of the proposed restoration measures were estimated for each spot as summarized in Table 14.3-5. The details are presented in Appendix 14-2.

TABLE 14.3-1 HOURLY COST OF CONSTRUCTION EQUIPMENT

Unit: Pesos at June 1991 Prices

Construction Equipment	Hourly Cost	Component (%)		
		F	L	T
Wheel Loader, 80 HP	452.70	67	20	13
Motorized Grader, 175 HP	445.60	67	20	13
Tractor Crawler with Dozer, 200 HP	1,075.10	67	20	13
Backhoe Crawler, 100 HP	702.10	67	19	14
Bulldozer, 200 HP	1,075.10	67	19	14
Dump Truck, 190 HP	506.90	60	20	20
Macadam Roller, 105 HP	460.40	67	19	14
Tandem Roller, 65 HP	414.95	67	19	14
Vibratory Roller, 175 HP	710.95	67	19	14
Pneumatic Roller, 106 HP	284.00	67	19	14
Transit Mixer, 190 HP	742.25	60	19	21
Concrete Vibrator for small works	40.80	65	20	15
Bar Bender	10.30	50	23	27
Bar Shear	35.40	50	23	27
Crushing Plant, 110 HP	1,359.90	60	18	22
Screening and Washing Plant, 24 HP	937.75	60	18	22
Air Compressor, 93 HP	308.73	67	19	14
Generator, 45 HP	256.50	67	19	14
Water Truck, 120 HP	333.70	65	20	15
Pile Hammer, 76 HP	569.30	67	20	13
Truck Mounted Crane	1,810.16	67	19	14
Rock Drill, 106 HP	58.30	60	23	17
Boring Machine	1,200.00	60	23	17
Cargo Truck	242.00	60	20	20
Stake Truck	305.00	60	20	20
Pick-up, 2 T	184.97	60	20	20

TABLE 14.3-2 COST OF MAIN MATERIALS

Unit: Pesos at June 1991 Price

Main Material	Unit	Unit Price	Component (%)		
			F	L	T
Portland Cement	Bags	120.00	55	30	15
Lumber, Yakal/Guijo	Bd.Ft.	22.00	25	60	15
Diesel Fuel	Liter	7.92	60	13	27
Regular Gasoline	Liter	15.00	60	13	27
Dynamite	Kg.	52.00	70	10	20
Blasting Caps and Fuse	Lb.	21.00	70	10	20
Safety Fuse	Kg.	18.00	70	20	20
Nails	Kg.	22.50	64	20	15
Wire Mesh (4 ft. x 12 ft.)	Roll	585.00	65	20	15
Vinyl Sheet (3 m x 5 m)	Each	1,560.00	55	30	15
Coco Lumber	Bd.Ft.	5.00	25	60	15
Peg	Bd.Ft.	22.00	25	60	15
Seed	M^2	5.00	25	60	15
Fertilizer	Bag	500.00	25	60	15
Cogon Mat	Bundle	5.00	-	100	-
Coarse Aggregate for Cement Concrete	M^3	179.00	66	19	15
Fine Aggregate for Cement Concrete	M^3	151.00	63	23	14
Crushed Aggregate for Base Course	M^3	215.00	66	19	15
Coarse Aggregate for Subbase Course	M^3	155.00	64	21	15
Asphalt Concrete Course	M^3	1,088.74	65	20	15
Emulsified Asphalt for Bituminous Tack Coat	M^3	8,061.49	65	20	15
Concrete Class A, delivered	M^3	1,988.00	60	25	15
Concrete Class B, delivered	M^3	1,889.00	60	25	15
Boulders	M^3	393.00	55	30	15
Reinforcing Steel Bars	Kg.	22.50	54	35	11
Reinforced Concrete Pipe Culvert 610 mm ϕ	LM	494.00	55	30	15
Reinforced Concrete Pipe Culvert 910 mm ϕ	LM	878.00	55	30	15
Reinforced Concrete Pipe Culvert 1,220 mm ϕ	LM	1,393.00	55	30	15
Cement Grout	M^3	2,170.00	55	30	15

TABLE 14.3-3 LABOR COST

Unit: Pesos at June 1991 Price

Labor Category	Hourly Rate	Daily Rate	Component (%)		
			F	L	T
Foreman	22.50	180.00	0	100	0
Assistant Foreman	19.00	152.00	0	100	0
Heavy Equipment Operator	17.00	136.00	0	100	0
Light Equipment Operator	16.00	128.00	0	100	0
Carpenter	16.00	128.00	0	100	0
Mason	16.00	128.00	0	100	0
Steelman	16.00	128.00	0	100	0
Driver	15.00	120.00	0	100	0
Skilled Laborer	16.00	128.00	0	100	0
Unskilled Laborer	14.00	112.00	0	100	0

TABLE 14.3-4 UNIT CONSTRUCTION COST (1/3)

Type of Work		Work Item		Unit	Unit Cost (Pesos)	Component (%)		
						F	L	T
U1-1	Removal of Deposit Materials	U1-1	Removal of Deposit Materials	P/m3	34.78	61	25	14
U1-2	Removal of Unstable Materials	U1-2	Removal of Unstable Materials	P/m3	72.15	62	24	14
U1-4	Refilling/Embankment	U1-4	Refilling/Embankment	P/m3	68.42	64	21	15
U1-5	Selected Material Fill	U1-5	Selected Material Fill	P/m3	368.94	60	25	15
U2-2	Temporary Side Ditch	U2-2	Temporary Side Ditch	P/lm.	10.99	5	93	2
U3-1	Sheet Covering	U3-1	Sheet Covering	P/m2	28.11	32	60	8
U3-2	Sand Bag Covering	U3-2	Sand Bag Covering	P/m2	112.17	50	37	13
U4-1	Sand Bag Wall	U4-1	Sand Bag Wall	P/m2	112.17	50	37	13
U4-2	Gabion Wall	U4-2	Gabion Wall	P/m3	1,424.71	47	40	13
U4-3	Wooden Fence	U4-3	Wooden Fence	P/lm.	185.17	21	67	12
U5-1	Gabion Foot Protection	U5-1	Gabion Foot Protection	P/m3	1,424.71	47	40	13
U6-2	H-Pile Bent (Depreciation)	U6-2	H-Pile Bent (Depreciation)	P/lm.	1,051.68	58	25	17
U6-3	Bailey Bridge (Depreciation)	U6-3	Bailey Bridge (Depreciation)	P/lm.	13,555.83	29	56	15
U7-1	Gravel Surfacing	U7-1	Gravel Surfacing	P/m3	315.50	60	26	14
P1-1	Recutting	P1-1(1)	Recutting (Common)	P/m3	58.30	61	25	14
		P1-1(2)	Recutting (Rock)	P/m3	358.53	65	19	16
P1-3	Refilling/Embankment	P1-3	Refilling/Embankment	P/m3	68.42	64	21	15
P1-4	Counterweight Fill	P1-4	Counterweight Fill	P/m3	68.42	64	21	15
P2-1	Slope Ditch	P2-1	Slope Ditch	P/lm.	318.76	46	41	13
P2-2	Side Ditch	P2-2(1)	Side Ditch Type A	P/lm.	250.30	46	41	13
		P2-2(2)	Side Ditch Type B	P/lm.	318.76	46	41	13
		P2-2(3)	Side Ditch Type C	P/lm.	500.60	46	41	13
P2-3	Water Channel	P2-3(1)	Structural Conc. Class A	P/m3	2,942.21	53	32	15
		P2-3(2)	Reinforcing Steel Bar	P/kg.	33.60	45	45	10

Note: U6-2 and U6-3: not applicable to Spots L-4 and L-6 (Leyte) where full material cost instead of depreciation cost are assumed.

TABLE 14.3-4 UNIT CONSTRUCTION COST (2/3)

Type of Work		Work Item		Unit	Unit Cost (Pesos)	Component (%)		
						F	L	T
P2-4	Culvert	P2-4(1)	Conc. Pipe Culvert 610 mm	P/lm.	1,410.17	58	27	15
		P2-4(2)	Conc. Pipe Culvert 910 mm	P/lm.	1,959.33	57	28	15
		P2-4(3)	Conc. Pipe Culvert 1220 mm	P/lm.	2,950.85	57	28	15
P2-5	Catch Basin	P2-5(1)	Catch Basin for 610 mm	P/ea.	5,751.17	54	32	14
		P2-5(2)	Catch Basin for 910 mm	P/ea.	7,531.23	54	32	14
		P2-5(3)	Catch Basin for 1070 mm	P/ea.	8,791.07	54	32	14
		P2-5(4)	Catch Basin for 1220 mm	P/ea.	11,200.73	54	32	14
P3-2	Horizontal Drain Hole	P3-2	Horizontal Drain Pipe	P/lm.	767.35	57	29	14
P4-2	Hand Seeding with Mat	P4-2	Hand Seeding with Mat	P/m2	44.01	12	82	6
P4-6	Pick Hole Seeding	P4-6	Pick Hole Seeding	P/m2	161.20	5	94	1
P4-8	Wattling	P4-8	Wattling	P/lm.	391.55	8	88	4
P5-3	Stone Pitching	P5-3	Stone Pitching	P/m3	1,326.00	51	35	14
P6-2	Grouted Riprap	P6-2	Grouted Riprap	P/m3	1,326.00	51	35	14
P6-4	Gravity Type Stone Masonry Wall	P6-4(1)	Structural Excavation	P/m3	89.79	52	36	12
		P6-4(2)	Structural Conc. Class A	P/m3	2,942.21	53	32	15
		P6-4(3)	Grouted Riprap	P/m3	1,326.00	51	35	14
P6-5	Gravity Type Conc. Wall	P6-5(1)	Recutting (Common)	P/m3	58.30	61	25	14
		P6-5(2)	Structural Conc. Class A	P/m3	2,942.21	53	32	15
		P6-5(3)	Ladder Foundation	P/m2	132.11	20	70	10
P6-6	Supported Type Conc. Wall	P6-6	Supported Type Conc. Wall	P/m3	2,942.21	53	32	15
P6-9	Gabion Wall	P6-9(1)	Gabion Wall	P/m3	1,424.71	47	40	13
		P6-9(2)	Permeance Mat	P/m2	34.11	20	68	12
P6-10	Sheet Pile Wall	P6-10	Steel Sheet Pile	P/lm.	2,987.24	75	15	10
P8-2	Catch Gabion Wall	P8-2	Catch Gabion Wall	P/m3	1,424.71	47	40	13
P14-2	Gabion Consolidation	P14-2	Gabion Consolidation	P/m3	1,424.71	47	40	13

TABLE 14.3-4 UNIT CONSTRUCTION COST (3/3)

Type of Work	Work Item		Unit	Unit Cost (Pesos)	Component (%)		
					F	L	T
P15-1 Concrete Bridge	P15-1(1)	Surplus Common Excavation	P/m3	58.30	61	25	14
	P15-1(2)	Structural Excavation	P/m3	89.79	52	36	12
	P15-1(3)	Concrete Railing	P/lm.	1,325.70	47	43	10
	P15-1(4)	Concrete Piling	P/lm.	2,157.86	64	20	16
	P15-1(5)	Reinforcing Steel Bar	P/kg.	33.60	45	45	10
	P15-1(6)	Struc. Conc. Class A for Bridge	P/m3	3,475.61	47	39	14
	P15-1(7)	Pre-Stressed Girder (L = 24 m)	P/ea.	245,109.53	57	28	15
	P15-1(8)	Pre-Stressed Girder (L = 38 m)	P/ea.	849,156.58	57	28	15
P16-1 Concrete Foot Protection	P16-1	Concrete Foot Protection	P/m3	2,942.21	53	32	15
P16-2 Gabion Foot Protection	P16-2	Gabion Foot Protection	P/m3	1,424.71	47	40	13
P16-3 Grouted Riprap Apron	P16-3	Grouted Riprap Apron	P/m3	1,326.00	51	35	14
P17-2 Gabion Spurdike	P17-2(1)	Selected Material Fill	P/m3	368.94	60	25	15
	P17-2(2)	Cylinder Gabion	P/m3	1,424.71	47	40	13
P18-1 Concrete Spillway	P18-1	Concrete Spillway	P/m3	2,942.21	53	32	15
P19-1 Gravel Surfacing	P19-1	Gravel Surfacing	P/m3	315.50	60	26	14
P19-2 Bituminous Pavement	P19-2(1)	Bituminous Tack Coat	P/ton	11,883.25	64	21	15
	P19-2(2)	Bituminous Conc. Surface Course	P/ton	2,015.75	64	21	15
P19-3 Concrete Pavement	P19-3	Concrete Pavement	P/m3	2,942.21	53	32	15

TABLE 14.3-5 CONSTRUCTION COST (1/2)

Unit Cost as of June 1991 Price

Type of Disaster	Spot	Urgent Measures Cost (₱)	Permanent Measures Cost (₱)
C-F (Cut Slope Failure)	Bt-1	43,612	530,799
	Bt-14	22,616	170,196
	Bt-43	6,956	153,849
	Bt-57	7,290	97,084
	Bt-59	6,956	222,881
	Bs-36	3,651	378,488
	L-16	3,130	273,544
	L-68	1,275	196,522
	L-78	3,130	861,144
	L-80	696	177,320
	L-84	2,782	56,705
	L-89	3,478	169,279
	Ave./Spot	8,798	273,984
E-F (Embankment Slope Failure)	Bt-20	15,469	49,062
	Bt-25	6,746	330,894
	Bt-38	8,995	86,776
	Bt-54	3,442	244,026
	Bt-58	4,216	149,018
	Bs-3	5,075	57,272
	Bs-28	11,237	261,099
	L-45	17,279	131,001
	L-82	6,475	52,612
	Ave./Spot	8,770	151,307
FALL (Rock Fall/Debris Fall)	Bt-33	2,691	132,510
	Bs-12	5,590	123,461
	Bs-30	7,677	266,562
	L-21	637	157,184
	L-65	1,800	462,318
	Ave./Spot	3,679	228,407
L-SL (Landslide)	Bt-11	8,485	491,817
	L-47	886	130,545
	L-50	3,826	167,756
	Ave./Spot	4,399	263,372
D-FL (Debris Flow)	Bt-25	6,746	330,894
	Bt-39	5,217	270,275
	Bt-62	6,995	122,413
	Bt-70	13,912	5,018,409
	L-39	5,913	1,829,342
	Ave./Spot	7,757	1,514,267
Rd-D (Scour/Washout of Roadbed)	Bt-2	-	11,257,375
	Bs-45	3,045	25,194
	Ave./Spot	3,045	5,641,285

TABLE 14.3-5 CONSTRUCTION COST (2/2)

Unit Cost as of June 1991 Price

Type of Disaster	Spot	Urgent Measures Cost (₱)	Permanent Measures Cost (₱)
FM-Rd (Flooded/Muddy Road Surface)	Bs-14	4,261	70,111
	Bs-53	-	301,341
	L-23	15,715	233,773
	L-26	6,730	800,126
	Ave./Spot	8,902	351,337
PBr-W (Permanent Bridge Washout)	Bs-62	224,304	1,054,498
	L-4	5,823,969	-
TBr-W (Temporary Bridge Washout)	L-6	2,126,951	-
	Ave./Spot	2,725,075	1,054,498
PBr-A (Permanent Bridge Approach Washout)	Bt-55	13,460	742,886
	Bt-63	122,002	1,395,914
	Bs-33	3,374,984	15,347,738
TBr-A (Temporary Bridge Approach Washout)	L-38	3,001	27,606
	L-76	406,674	2,934,653
	Ave./Spot	784,024	4,089,759
PBr-D (Permanent Bridge Other Damage)	Bs-6	5,698	353,659
	Bs-48	-	812,075
	Bs-50	172,656	179,629
TBr-D (Temporary Bridge Other Damage)	Ave./Spot	89,177	448,454
SPW-D (Spillway Damage)	Bs-66	125,822	267,392
	L-19	296,428	529,598
	L-90	50,539	158,044
	Ave./Spot	157,596	318,344
CLV-D (Culvert Damage)	Bt-7	4,479	124,994
	Bt-68	15,239	68,157
	Bt-42	1,121	25,827
	Bt-43	4,900	22,542
	L-13	20,532	101,242
	L-81	10,239	43,446
	Ave./Spot	9,418	64,368
SW-D (Seawall Damage)	Bs-8	1,228	8,425
	Bs-51	19,889	772,766
	Ave./Spot	10,559	390,596

CHAPTER 15
PROJECT EVALUATION

15.1 TECHNICAL EVALUATION

This chapter discusses the technical feasibility of the restoration measures proposed in Chapter 14. Requirements of restoration measures from the technical point of view are sure and quick constructability, stability and durability, maintainability and freedom from adverse effect on environment. Constructability is closely related to availability of materials, equipment and technique required for the proposed measures. Thus, the technical evaluation of the proposed restoration measures is conducted on the following items:

- Construction materials
- Construction equipment
- Construction technique
- Stability and durability
- Maintenance requirements
- Environmental impact

1) Construction Materials

Major materials used for the proposed restoration measures are shown in Table 15.1-1.

All material are locally available, except for the following:

- Gabions are presently not so widely used that they may not easily be procured.
- H-piles and bailey panels are not enough stockpiled for always meeting the needs.
- Seeds for vegetation are not stably supplied, since seed production may easily be affected by weather condition.

TABLE 15.1-1(1) MAJOR MATERIALS AND EQUIPMENT REQUIRED FOR THE PROPOSED RESTORATION MEASURES

Type of Restoration Measure			Major Materials	Major Equipment
URGENT	U1-1	Removal of Deposit Materials	-	Wheel Loader, Bulldozer
	U1-2	Removal of Unstable Materials	-	-
	U1-4	Refilling/Embankment	Soil, Boulder	Dump Truck, Bulldozer, Backhoe Crawler Compactor
	U1-5	Selected Material Fill	Sand, Gravel, Cobble, Stone	Dump Truck, Backhoe Crawler
	U2-2	Temporary Side Ditch	-	-
	U3-1	Sheet Covering	Vinyl Sheet	-
	U3-2	Sand Bag Covering	Sand Bag, Soil	-
	U4-1	Sand Bag Wall	Sand Bag, Soil	-
	U4-2	Gabion Wall	Gabion, Stone	Crane, Dump Truck
	U4-3	Wooden Fence	Wooden Pile, Wooden Plate	-
	U5-1	Gabion Foot Protection	Gabion, Stone	Crane, Cargo Truck
	U6-2	H-Pile Bent	H-Type Steel	Crane, Pile Hammer, Stake Truck
	U6-3	Bailey Bridge	Bailey Bridge	Crane, Winch, Cargo Truck
	U7-1	Gravel Surfacing	Gravel	Motorized Grader, Dump Truck
PERMANENT	P1-1	Recutting	-	Breaker, Air Compressor,Bulldozer
	P1-3	Refilling/Embankment	Soil, Boulder	Dump Truck, Bulldozer, Backhoe, Crawler, Compactor
	P1-4	Counterweight Fill	Soil, Boulder	Dump Truck, Bulldozer, Backhoe, Crawler, Compactor
	P2-1	Slope Ditch	Cobble, Concrete	Transit Mixer, Cargo Truck
	P2-2	Side Ditch	Cobble, Concrete	Transit Mixer, Cargo Truck
	P2-3	Water Channel	Cobble, Concrete	Transit Mixer, Cargo Truck
	P2-4	Culvert	R.C.P.C. Concrete, Reinforcing Bar	Transit Mixer, Backhoe Crawler, Crane, Cargo Truck
	P2-5	Catch Basin	Concrete	Transit Mixer, Backhoe Crawler, Cargo Truck

TABLE 15.1-1(2) MAJOR MATERIALS AND EQUIPMENT REQUIRED FOR THE PROPOSED RESTORATION MEASURES (CONTINUED)

Type of Restoration Measure			Major Materials	Major Equipment
PERMANENT	P3-2	Horizontal Drain Hole	Steel Pipe	Boring Machine, Cargo Truck
	P4-2	Hand Seeding with Mat	Seed, Fertilizer, Cogon Mat	-
	P4-6	Pick Hole Seeding	Seed, Fertilizer	-
	P4-8	Wattling	Peg, Cogon Mat, Brushwood	-
	P5-3	Stone Pitching	Stone, Concrete	Transit Mixer, Cargo Truck
	P6-2	Grouted Riprap	Cobble, Stone, Concrete	Transit Mixer, Cargo Truck
	P6-4	Gravity Type Stone Masonry	Cobble, Stone, Concrete	Transit Mixer, Cargo Truck
	P6-5	Gravity Type Concrete Wall	Concrete	Transit Mixer, Cargo Truck
	P6-6	Supported Type Concrete Wall	Concrete, Reinforcing Bar	Transit Mixer, Bar Bender, Bar Shear, Cargo Truck
	P6-9	Gabion Wall	Gabion, Stone	Crane, Dump Truck
	P6-10	Sheet Pile Wall	Steel Sheet Pile	Crane, Pile Hammer, Stake Truck
	P8-2	Catch Gabion Wall	Gabion, Stone	Crane, Dump Truck
	P14-2	Gabion Consolidation	Gabion, Stone	Crane, Dump Truck
	P15-1	Concrete Bridge	Concrete, Reinforcing Bar	Transit Mixer, Bar Bender, Bar Shear, Crane, Cargo Truck
	P16-1	Concrete Foot Protection	Concrete	Transit Mixer, Cargo Truck
	P16-2	Gabion Foot Protection	Gabion, Stone	Crane, Dump Truck
	P16-3	Grouted Riprap Apron	Cobble, Stone, Concrete	Transit Mixer, Cargo Truck
	P17-2	Gabion Spurdike	Gabion, Stone	Crane, Dump Truck
	P18-1	Concrete Spillway	Concrete	Transit Mixer, Cargo Truck
	P19-1	Gravel Surfacing	Gravel	Motorized Grader, Dump Truck
	P19-2	Bituminous Pavement	Bituminous Tack Coat, Bituminous Concrete Surface Course	Tandem Roller, Dump Truck, Motorized Grader, Cargo Truck
	P19-3	Concrete Pavement	Concrete,	Transit Mixer, Cargo Truck

2) Construction Equipment

Major equipment used for the proposed restoration measures is shown in Table 15.1-1.

All equipment is locally available. However, the following are noted:

- In some cases, procurement of heavy construction equipment may take time in remote areas.

- Vibro rammer or vibro plate compactor is required for compaction of fill material at narrow portion. This equipment is not commonly used for the road purpose.

3) Construction Technique

All the proposed restoration measures may be constructed in conventional way. Important is only to completely meet the construction requirements, especially for unconventional type of work such as gabion work and horizontal drain hole.

4) Stability and Durability

All the proposed permanent restoration measures are stable and durable enough as far as they are properly designed and constructed. Stability and durability depend largely on appropriateness in design and quality in construction.

5) Maintenance Requirements

The maintenance of restored portions will be covered by the ordinary maintenance work as parts of roads.

As far as the proposed restoration measures are concerned, the following are noted:

- Drainage system should be always well maintained keeping waterways free from accumulation of debris, otherwise it will not perform as designed.

- Vegetation needs maintenance to help it to grow as the case may be.

- Catch works need a removing work of deposit materials behind them before pocket areas are filled up therewith.

6) Environmental Impact

In view of the advantage of slope protection by vegetation giving a preferable impact on environment, this method was proposed as much as possible.

All other measures will give no remarkable effect on environment; never affect adversely at worst.

7) Conclusion

The restoration measures proposed in Chapter 14 are all technically feasible, with the following comments:

- Gabions, H-piles, bailey panels and seeds for vegetation may not always easily be procured. Proper steps for improving such situation are expected.
- Unconventional type of work such as gabion work and horizontal drain hole must be well understood on their construction requirements.
- Maintenance works especially for drainage system, vegetation and catch work need to be done in proper timing.

15.2 ECONOMIC EVALUATION

15.2.1 Basic Assumptions

1) Subject of Evaluation

In the cost-benefit analysis, benefit is generally defined as extra costs which will be needed if a project is not implemented (without case) and will be saved if a project is implemented (with case). The conditions in the without and with cases are assumed according to the kind of work subjected to the evaluation.

The restoration works are broadly divided into two types:

- Urgent measures for securing urgently or temporarily at least one lane traffic and checking the progress of damage until permanent measures are taken.
- Permanent measures for restoring the road completely to its original condition and preventing the recurrence of disaster

Usually, urgent measures are taken first when a disaster occurs and then permanent measures are taken when necessary fund is made available. The necessity and viability of the urgent measures are beyond question because if not, the road would stop its function. The viability of permanent measures are, therefore, examined in this Study by quantifying the cost and benefit accruing from the construction of permanent measures against the condition where only urgent measures are taken, except the following cases:

- In case of disaster occurrence pattern-4 or 5 (described later), permanent measures are evaluated against do-nothing condition.
- In case of temporary bridge washout, reconstruction of temporary bridge is an option, which falls under urgent measures in this Study. In this case, urgent measures are evaluated against do-nothing condition.

2) Disaster Occurrence Pattern and Definition of Without and With Cases

The conditions in the without and with cases are assumed depending on type, magnitude and frequency of disaster and timing of taking measures, which are classified into five (5) patterns. The definitions of the without and with cases are as follows (see Figure 15.2-1):

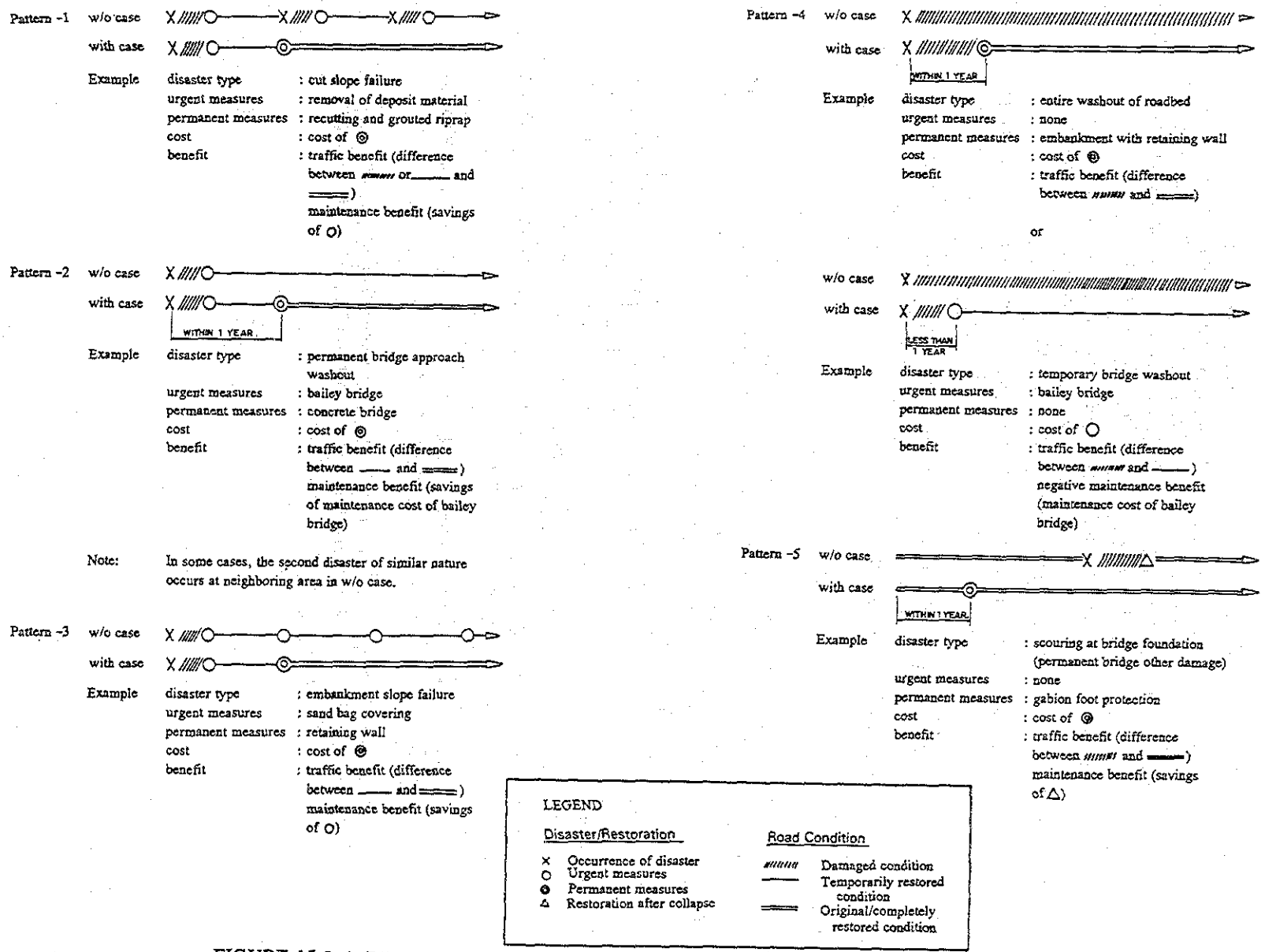


FIGURE 15.2-1 DISASTER OCCURRENCE PATTERN AND ASSUMED TIMING OF TAKING

Disaster Occurrence Pattern-1

Without Case: When a disaster occurs, urgent measures are taken only for securing at least one lane traffic urgently but no permanent measures are taken resulting in recurrence of disasters. Consequently, disaster occurs repeatedly (in most cases one or more times a year) and the urgent measures are taken every time.

With Case : After a disaster occurred, the same urgent measure as in without case are taken first and then permanent measures are implemented before next disaster occurs.

A typical example of this pattern is cut slope failure for which removal of deposit materials is carried out as urgent measures.

Benefits accruing from the implementation of the permanent measures are traffic cost savings and savings of costs for urgent measures to be needed in the second occurrence of disaster and thereafter.

Disaster Occurrence Pattern-2

Without Case : Urgent measures of long lasting quality are taken after disaster occurred and consequently no disaster recurs during the analysis period. The road section is maintained passable although substandard.

With Case : At first, the same urgent measures as in without case are taken and then permanent measures are implemented within one year after the occurrence of disaster. In some cases, the permanent measures are constructed as additional or improving work of the urgent measures utilizing them entirely or partly.

A typical example of this pattern is permanent bridge approach washout for which bailey bridge is constructed as urgent measures.

Traffic cost savings due to improvement of road condition from substandard to standard are considered as benefits in this pattern.

The case where the next disaster of similar nature is anticipated at neighboring area like bridge washout followed by approach washout and the permanent measures are preventive thereof is included in this pattern.

Disaster Occurrence Pattern-3

Without Case: After a disaster occured, urgent measures of relatively poor lasting quality are taken and thereafter the urgent measures are reconstructed repeatedly for preventing recurrence of disaster and maintaining the road section to be passable.

With Case : After taking the same urgent measures as in without case, permanent measures are implemented.

A typical example of this pattern is embankment slope failure for which sand bag covering is carried out as urgent measures.

Benefits accruing from the implementation of the permanent measures are traffic cost savings and savings of reconstruction costs of urgent measures.

Disaster Occurrence Pattern-4

Without Case : After a disaster occurred, the road section is left in damaged condition without taking any measures because of no proper urgent measures of low cost.

With Case : Without urgent measures, permanent measures are taken within the first year of the analysis period.

Typical example is entire washout of roadbed.

Traffic cost savings are main benefits in this pattern.

The case where urgent measures are subjected to the evaluation is included in this pattern substituting permanent measures with the urgent measures.

Disaster Occurrence Pattern-5

This pattern is found in case that presently there is no interference to traffic but progressive defect in road facilities is exposed to such extent that their collapse in near future is anticipated unless proper preventive measures are taken.

Without Case: No measures are taken resulting in the collapse of road facilities after a certain period from the beginning of the analysis period. The collapsed facilities are restored thereafter.

With Case: Permanent measures for preventing collapse are taken within the first year of the analysis period. In some cases, urgent measures are taken prior to permanent measures.

A typical example of this pattern is scouring at bridge foundation.

Traffic cost savings during the period from the occurrence of collapse of road facilities until the completion of their restoration and the restoration costs are considered as benefits in this pattern. In case that some urgent measures are taken prior to permanent measures in with case, the cost for the urgent measures is considered as a part of cost in the cost-benefit analysis.

3) Analysis Period

1992 is set as the first year of the analysis. Analysis period is 20 years from 1992 to 2011.

4) Quantified Cost

Cost for permanent restoration measures or urgent restoration measures whichever is the subject of evaluation is counted as cost in the cost-benefit analysis. The cost is assumed to be expended in the first analysis year.

5) Quantified Benefit

Benefits are divided into traffic benefit and maintenance benefit.

- Traffic Benefit : In without case, the road is in damaged condition or temporarily restored condition depending on before or after taking urgent measures, while in with case, the road is in original condition after completion of permanent measures. The difference in traffic costs between the without and with cases is counted as traffic benefit.
- Maintenance Benefit: In case of Disaster Occurrence Pattern-1 or 3, the costs for urgent measures needed in without case are savable in with case at and after the second time. In case of Pattern-5, the restoration costs of collapsed road facilities are savable. These cost savings are counted as maintenance benefit.