2.3.7 Benefit Assessment

The assessment of benefits of investment schemes helps our understanding of the relative value-for-money of competing projects. Road authorities never have sufficient funds to meet all the needs placed on them, and so an effective and independent way prioritizing projects helps use limited funds in a way that maximizes the positive impacts of spending.

The section provides a guide for calculating benefits for schemes designed to prevent natural disasters on roads.

The basic components of benefit from investment in disaster prevention measures are savings in time and distance which would otherwise occur if traffic had to re-route to avoid a road which had to be closed due to disaster. These are quantified as vehicle-hours and vehicle-kilometres, and ways of calculating these is shown in Section 2.3.3. These have to be converted into monetary values and then compared with the cost of disaster prevention measures.

The factors for converting the vehicle-hours and vehicle-kilometer into costs are set out in Table 2.3.13.

Table 2.3.13 Vehicle Operating Costs and Passenger Costs, Nicaragua 2002

Vehicle type	Operating Cost per 1000 km, US $	Passenger Costs per vehicle hour
Car	341.9	2.84
Utility	365.6	1.09
Average Bus	909.8	14.90
Light Goods	891.9	1.04
Medium Goods	1289.8	1.04
Heavy Goods	1509.8	0.75

Source : NIC2000 Transport Plan and year 2002 prices

In evaluation, constant prices are used because future rates of inflation are never known. So, all monetary values are expressed as the value at a common time. In the table above, the price base is the year 2002. Vehicle operating costs can then be assumed to remain constant in the future, if expressed as 2002 prices. Although the cash cost of fuel might increase, if it rises in line with overall inflation, then the constant price base will be accurate.

Passenger time values are expected to rise in real terms, that is, at a faster rate than inflation, because of forecast real GDP per capita growth.
This reflects increasing levels of income. Typically income levels grow at different rates for

different sectors of the population, and often in a fast growing economy it is higher wage earners who experience higher growth rates. However, there are no hard forecasts for this and hence average values for growth are used across the population as whole. These are set out in Table 2.3.14.

Table 2.3.14 Percentage Annual Growth Rates for Values of Time

Vehicle Passenger Type	2002 to 2010	2010 to 2002
Car	2.7	8.0
Camioneta	2.7	8.0
Bus	2.7	8.0
Light Goods	2.7	8.0
Medium Goods	2.7	8.0
Heavy Goods	2.7	8.0

Figure 2.3.13 shows how the information calculated in Table 2.3.4 is used to produce the benefits in monetary terms

	Traffic Volume	2002 Additional Daily		Traffic Growth	Traffic Volume	2010 Additional Daily	
	2002 AADT	Vehicle Km	Vehicle hours	2002 - 2010	2010 AADT	Vehicle Km	Vehicle hours
Cars	300	900	23	5.8	471	1413	36
Camionetas	400	1200	31	5.8	628	1884	48
Buses	100	300	8	3.3	130	389	10
Light Goods	100	300	8	6.5	165	496	13
Medium Goods	100	300	7	6.5	165	496	11
Heavy Goods	50	150	3	6.5	83	248	5
Total	1050	3150	79		1642	4927	123

	Cost per Veh-km 2002 (US$)	Cost per Veh-hr 2002 (US$)	Growth Rate %	Cost per Veh-hr 2010 (US$)
Cars	0.3419	2.84	2.7	3.5
Camionetas	0.3656	1.09	2.7	1.3
Buses	0.9098	14.9	2.7	18.4
Light Goods	0.8919	1.04	2.7	1.3
Medium Goods	1.2988	1.04	2.7	1.3
Heavy Goods	1.5098	0.75	2.7	0.9

Input Data

	Vehicle km 2002 (US$)	Vehicle-hr 2002 (US$)	Total Benefit 2002	Vehicle km 2010 (US$)	Vehicle-hr 2010 (US$)	Total Benefit 2010
Cars	308	65	373	483	127	610
Camionetas	439	33	472	689	65	754
Buses	273	114	387	354	183	537
Light Goods	268	8	276	443	16	459
Medium Goods	390	7	397	645	15	660
Heavy Goods	226	2	229	375	5	379
Total	1903	230	2133	2988	411	3399

Figure 2.3.13 Calculation Sheet for Monetary Benefits (per Day)

The benefits calculate above will occur if, as a result of investing in disaster prevention measures, a road link is safeguarded which would otherwise would have failed because of disaster. Unfortunately we never know when a slope will collapse, or rock falls occur, so we can never be absolutely sure these benefits will really occur as result of the investment.

However, we do know that there is a risk of failure or collapse. There is also the question of the severity of the risk, or scale of the impact. Hence potential disaster sites need to be rated in terms of severity or *score*, and likelihood of failure or *risk*. These are defined as follows:

> **Score** (maximum of 100) describes the potential severity of the disaster site in termsof impact on health and safety;
>
> **Risk** (measured in years) is the time period over which the site is bound to fail. The shorter the time period, the higher the risk.

Benefits can be calculated by score or risk, or both. When score is used the benefits are factored by the score divided by 100. When risk is used, the benefits only occur in the year after the site has deemed to have failed.

The monetary values of benefit can be compared to the cost of investing to prevent the disaster. Because benefits are a stream which continue to flow, and cost is usually a single capital item, economists use a process known as discounted cost-benefit analysis to be able to compare costs with benefits. In this process the benefits and costs in the future are discounted reflect the fact that benefits today are worth more than they will be in ten years time. A discount rate of 10% is used to factor down both costs and benefits each future year form today.

The discounted cost-benefit calculation is shown as an example spreadsheet in Figure 2.3.14. Costs are entered at each year they will be spent, at constant prices. Usually the capital costs for a scheme are paid for early in the first year or two of the evaluation. Subsequent maintenance costs should be entered if the works require it. Some temporary measures for disaster prevention do not need maintenance, but do need to be replaced after a time. If this is the case, then the replacement cost must be entered as a capital amount in the relevant year.

Benefits are entered for each year they are forecast to occur. Using the fact that we generally make forecasts for 2002, 2010, 2020 (and later every subsequent 10 years), benefits for intermediate years can be calculated by interpolation. If the benefit stream does not start until, say 2008, because of the risk factor, then all benefits from 2002 to 2007 must be set to zero.

Inputs to the discounted cost-benefit spreadsheet are:

- Capital costs
- Maintenance costs
- Monetary values of benefits
- Discount Rate

An example is shown as Figure 2.3.14, in which the benefit inputs are taken from figure 2.3.13.

Cost-Benefit Analysis

Site No	2	N001A280	A-Node	1109	B-Node	1102	
Site Name	NIC 1, 73.2			Link Length (km)		36.4	

IRR	
By Risk	11.3%
By Score	16.0%

Type of Disaster	Rock Fall		Permanent/Temporary (P/T)	P
Discount Rate (%)	10		Discount Period	17
Risk : Without Prevention Measures Road will fail in			6	years
Score	60		Benefit Factor	60

By Risk	B/C 2.55
By Score	B/C 2.3

	2002	2010	2020
Total Daily Benefits ($)	2133	3399	4500

Year	Capital Cost US$	Maintenance Cost (US$)	Total Cost (US $)	Total Dis-counted Cost	Total Benefits	Risk Profile	Discounted Benefits	Disocunted Benefits	Net Benefits	Net Benefits
							$ US M	$ US M	$ US M	$ US M
2002							*By Risk*	*By Score*	*By Risk*	*By Score*
2003	2000000		2000000	1800000	778545	0	0.0	0.0	-1.8	-1.8
2004	0	40000	40000	32400	844558	0	0.0	0.4	0.0	0.4
2005	0	40000	40000	29160	910571	0	0.0	0.4	0.0	0.4
2006	0	40000	40000	26244	976584	0	0.0	0.4	0.0	0.4
2007	0	40000	40000	23620	1042596	0	0.0	0.4	0.0	0.3
2008	0	40000	40000	21258	1108609	1	0.6	0.4	0.6	0.3
2009	0	40000	40000	19132	1174622	1	0.6	0.3	0.5	0.3
2010	0	40000	40000	17219	1240635	1	0.5	0.3	0.5	0.3
2011	0	40000	40000	15497	1280822	1	0.5	0.3	0.5	0.3
2012	0	40000	40000	13947	1321008	1	0.5	0.3	0.4	0.3
2013	0	40000	40000	12552	1361195	1	0.4	0.3	0.4	0.2
2014	0	40000	40000	11297	1401381	1	0.4	0.2	0.4	0.2
2015	0	40000	40000	10167	1441568	1	0.4	0.2	0.4	0.2
2016	0	40000	40000	9151	1481754	1	0.3	0.2	0.3	0.2
2017	0	40000	40000	8236	1521941	1	0.3	0.2	0.3	0.2
2018	0	40000	40000	7412	1562127	1	0.3	0.2	0.3	0.2
2019	0	40000	40000	6671	1602314	1	0.3	0.2	0.3	0.2
2020	0	40000	40000	6004	1642500	1	0.2	0.1	0.2	0.1
Total	2,000,000	680,000	2680000	2,069,966			**5.3**	4.7	**3.2**	**2.7**

Figure 2.3.14 Discounted Cost-Benefit Calculation Sheet

Two outputs from the sheet in Figure 2.3.14 are:

- Benefit to Cost Ratio (B/C); and
- Internal Rate of Return (IRR).

B/C is the ratio of the sum of discounted benefits to the sum of discounted costs, over the project life. If B/C > 1.0, then the benefits outweigh the costs and the project is worthwhile. B/C values for different projects can be compared to each other in order to assess which is the best value for money.

IRR is another measure of project efficiency. The internal rate of return is effectively the interest rate received for an investment consisting of the construction and maintenance costs (negative values) and income from benefits (positive values) that occur each year. Again, IRR's can be compared to find the higher values representing better value for money. Projects are not viable when the IRR falls below the discount rate. Typical IRR's for internationally funded projects should be at least of the range 16% to 22%.

2.3.8 Restoration Level

Since the calamity scale of rock collapse, a landslide, a debris flow, or collapse of the bridge by scouring etc. is large, when a calamity occurs, immense expense and immense time are needed for restoration.
Therefore, the Potential Spot where the serious calamity of a scale is expected is coped with by giving priority and it is important to prevent these collapses by the natural disaster in advance.
However, a priority can be lowered when the detour shown below can be secured.

i) There is a suitable detour.
ii) There is enough space where a temporary road can be build.

In addition, when taking a detour into consideration, it is necessary to grasp about the situation of a detour.

However, a priority can be lowered, if a suitable detour road can exist or the lot where a hypothetical management road can be built can be secured. In addition, when taking a detour into consideration, it is necessary to grasp also about the situation of a detour. Suitable detours are as follows.

i) The alignment conditions, width, plane alignment, vertical alignment through which urgent vehicles and restoration vehicles can pass are secured.
ii) The power-proof of a bridge is enough to passing of urgent vehicles

An example to take into consideration in comparison of restorative difficulty is shown below, and the example of evaluation is shown in the table 2.3.15.

- Calamity scale
- Restorative difficulty
- Expense and time for restoration construction
- Distance from Managua (Much time is required for send main equipments and engineers to calamity site in faraway area from Managua).
- Space for traffic management or calamity restoration
- Condition of detour road

Table 2.3.15 An Example of an Evaluating

<table>
<tr><th colspan="3">Evaluation Criteria</th><th>Point</th></tr>
<tr><td colspan="2" rowspan="4">Distance from Managua</td><td>≦100km</td><td>1</td></tr>
<tr><td>100 < L ≦150km</td><td>2</td></tr>
<tr><td>150 < L ≦200km</td><td>3</td></tr>
<tr><td>200km < L</td><td>4</td></tr>
<tr><td colspan="2" rowspan="3">Space for management or calamity restoration</td><td>There is a enough space</td><td>1</td></tr>
<tr><td>There is not a enough space</td><td>5</td></tr>
<tr><td>The above-mentioned middle</td><td>3</td></tr>
<tr><td colspan="2" rowspan="3">Condition of detour road</td><td>There is a detour.</td><td>1</td></tr>
<tr><td>There is no detour.</td><td>5</td></tr>
<tr><td>Much time is required for detour</td><td>5</td></tr>
<tr><td colspan="2" rowspan="5">Type of disaster</td><td>Rock Falling (R.F.)</td><td>2</td></tr>
<tr><td>Rock Collapsing (R.C.)</td><td>3</td></tr>
<tr><td>Slop slide (S.S.)</td><td>5</td></tr>
<tr><td>Debris Flow (D.F.)</td><td>5</td></tr>
<tr><td>Scoring of fundation (Bridge)</td><td>4</td></tr>
<tr><td rowspan="6">Length of slope and Bridge</td><td rowspan="3">Slope</td><td>≦100m</td><td>1</td></tr>
<tr><td>100< L ≦200m</td><td>3</td></tr>
<tr><td>200m < L</td><td>5</td></tr>
<tr><td rowspan="3">Bridge</td><td>≦20m</td><td>1</td></tr>
<tr><td>20< L ≦ 100m</td><td>3</td></tr>
<tr><td>100m < L</td><td>5</td></tr>
</table>

2.4 Methods of Establishment for Implementation Programe

2.4.1 General

The implementation programme should be based on an accurate plan. Each relevant division and direction should be aware of the contents of the plan so it can be smoothly executed based on a suitable connecting system. Necessary planning contents of the implementation programme are as follows.

- ◆ Contents of road disaster prevention plan,
- ◆ Financial or budget plans according to road disaster prevention plan, and
- ◆ Surrounding environmental impact assessment according to road disaster prevention plan.

2.4.2 Maintenance Plan

Emergency, routine and periodic inspections should be executed for road disaster prevention based on the Inspection Manual. All inspection and survey data should be arranged by the General Direction of Road as shown by Figure 2.4.1.

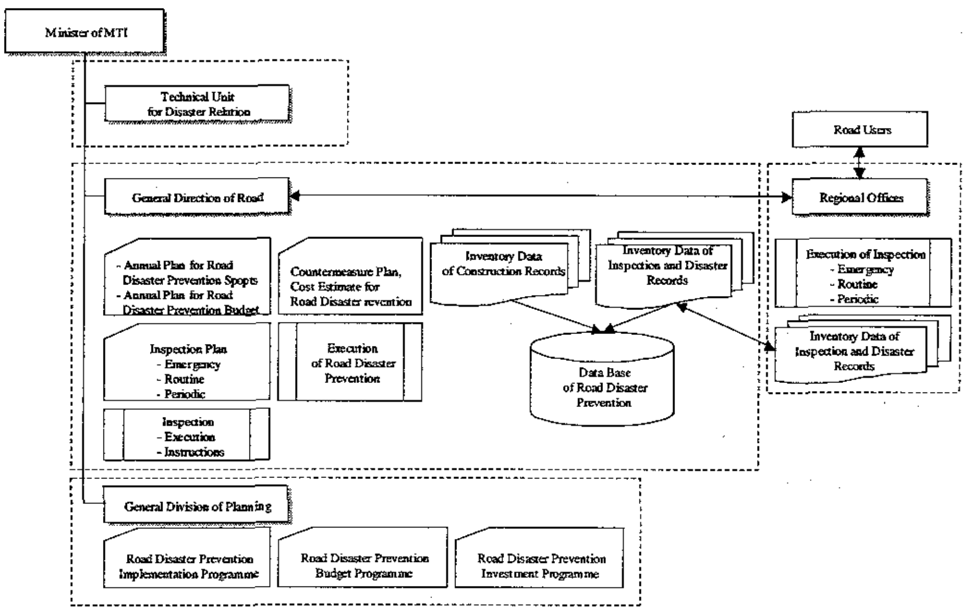


Figure 2.4.1 General Arrangements for Maintenance Planning

The responsibilities for maintenance and road disaster prevention planning are set out below.

<Technical Unit for Disaster Relation>

- To exchange Information with external organizations, e.g. INETER
- To review and make Design Standards and materials specifications regarding road disaster prevention, and
- To develop techniques regarding road disaster prevention.

<General Division of Planning>

- To plan implementation programme for road disaster prevention,
- To plan a financial and budget programme for road disaster prevention, and
- To plan an investment programme for road disaster prevention.

<General Direction of Road>

- To prepare a detailed annual plan for budget and disaster prevention spots,
- To prepare inspection plan for road disaster prevention (route No., frequency, etc.),
- To prepare a countermeasures plan and cost estimates for road disaster prevention,
- To receive and arrange the execution contents of road disaster prevention and the inventory data of inspection and disaster records to a central Database,
- To instruct the Inspectors in each regional office, and
- To execute road disaster prevention measures.

<Regional Offices>

- To conduct inspections (emergency, routine and periodic), and
- To arrange the contents of local road disaster prevention and the local inventory data of inspection and disaster records to a database, and to forward data to the GDR.

The Database for road disaster prevention should be prepared as shown in Figure 2.4.2 using this manual. As shown in Figure 2.4.2, road disaster prevention should be carried out based on each of the Manuals. Stable plans for road disaster prevention will be possible when all result are stored in the Database.

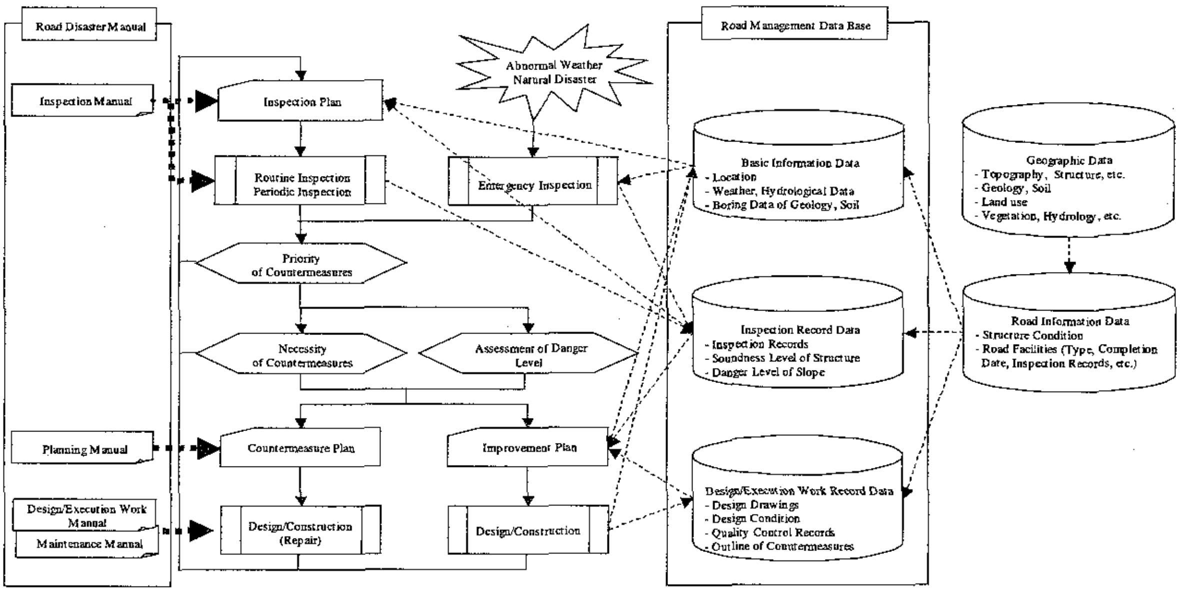


Figure 2.4.2 Organization of Database for Disaster Prevention

2.4.3 Budget Plan

The General Direction of Road should prepare estimates for an annual budget for road disaster prevention spots, using the results of inspections. This estimate should be sent to General Division of Planning. General Division of Planning will review the estimate and determine whether the projects are approved or not. The budget plan for road disaster prevention measures should be determined by careful road disaster prevention planning.

Roads and spots for road disaster prevention are always influenced by weather conditions each year. Therefore finance and budgets for road disaster prevention should be decided annually following a review of all the conditions and evaluation criteria.

2.4.4 Environmental Impact Assessment (EIA)

1) Method of EIA

EIA is carried out about the selected environment impact factor. And, these factors are evaluated about the validity of the environment consideration items in the project with EIA. On this occasion, as for the validity of the way of giving careful consideration to the environment, it is judged referring to "NIC 2000". Specially, the minimum responsibility that it faces in the legal environment in a stage of a construction contract must refer to the section 108 of NIC2000.

And, as for the item that evaluation is difficult at this stage, consideration items are suggested in every item.

2) The Point of View of the Evaluation of Every Factor

a) Inhabitant Transfer

It is evaluated about the avoidance of the inhabitant transfer and/or the expropriation of the land. In case that transfer and/or land expropriation are necessary, it is evaluated about whether it is the range that inhabitant's agreement can get, and whether the process of the transfer and/or land expropriation is followed the law of the Nicaraguan.

b) Economic Activity

It is evaluated about the impact on the place of the necessary economic activities to live. In case that it impact the place of the economic activities, it is estimated that whether the impact is an allowable range, and/or whether lost activities can change into the new economic activities. Furthermore, as for the possibility of the agreement with the active person as well, it is evaluated.

c) Facility for Life and Traffic

It is evaluated about the impact on the movement means (e.g. in such cases as the backing up the traffic jam, the change of the bus route), the hospital and school and so on, which are necessary for the inhabitant's life. This must be evaluated about the under construction and the after construction.

d) Area Severance

It is evaluated about severance of the community by the project. In case that the area severance results, the validity of the countermeasure of the severance avoidance by the crossing facilities and so on is evaluated.

e) Historical place/Cultural asset

It is evaluated about the avoidance of the Historical place and Cultural asset. In case that avoidance is difficult, it is estimated that whether the transfer of the historical place and cultural asset can be done, and/or whether it can be kept in other methods.

f) Water Right/ Common Right

It evaluated about a block of the water rights (fishery right) and the common right by the project. In case that there is a block of the right, it is evaluated that whether it is the range that the agreement of the right person can get, and/or whether covering of the new right is possibility.

g) Health/Hygiene

It is evaluated about the aggravation factor of health sanitation such as occurrence of the trash and the parasite. In case that there is an aggravation factor, the validity of that countermeasure is evaluated.

h) Waste

It is evaluated about the waste by the project from the following two points of view.

- Disposal Method

  Whether the construction waste is disposed in accordance with the standard by Ministry of Natural Resources and Environment and the Ministry of Health.

- Disposal Place

  Whether the position of the project and the kind of the waste are specified, and whether a disposal place is specified.

i) Disaster (Risk)

It is evaluated about the possibility that danger such as the ground collapse is induced by a project. In case that there is a new disaster occurrence factor, it is evaluated about the validity of that countermeasure.

j) Geography/Geology

It is evaluated about the avoidance of the precious geographical features and the geology. In case that avoidance is difficult, it is estimated that whether it can be kept in other methods.

k) Soil Erosion

It is evaluated about the validity of the prevention countermeasure of soil erosion by forest felling, and/or surface erosion of the slope. This evaluation must be enforced about the under construction and the after the construction. And, soil erosion must be careful of the water pollution as well because it has the possibility to make water pollution result.

l) Groundwater

It is evaluated about the exhaustion of the ground water by cutting of the ground water pulse and so on. Specially, an impact on the ground water (well) use in the neighborhood is evaluated. Then, in case that it has an impact, it is evaluated about the validity of that countermeasure.

m) Lake and River

An impact on existing flow of the lake and the river by the project is evaluated. Specially, the validity of the countermeasure that an impact is avoided is evaluated in case that there are economic activities and life activities, which a lake and a river were used for.

n) Coast/Sea area

An impact on existing flow of the coast and the sea area by the project is evaluated. Specially, the validity of the countermeasure that an impact is avoided is evaluated in case that there are economic activities and life activities, which a coast and a sea area were used for.

o) Fauna/Flora

It is evaluated about the impact of the territory of the animals and plants by the project. In case that it impact on a territory, it is evaluated that whether suitable mitigation measure shown in the Figure 2.4.4 is taken. On this occasion, in case that a plant is made to be restored directly on the cut slope, the slope grade shown in the Table 2.4.1 is careful whether it is adopted. as for the restoration of vegetation, it is careful whether latent natural vegetation is being considered. And, in case that an animal's movement is blocked, the plan to show it in the Figure 2.4.3 in consideration of the animal's movement is checked.

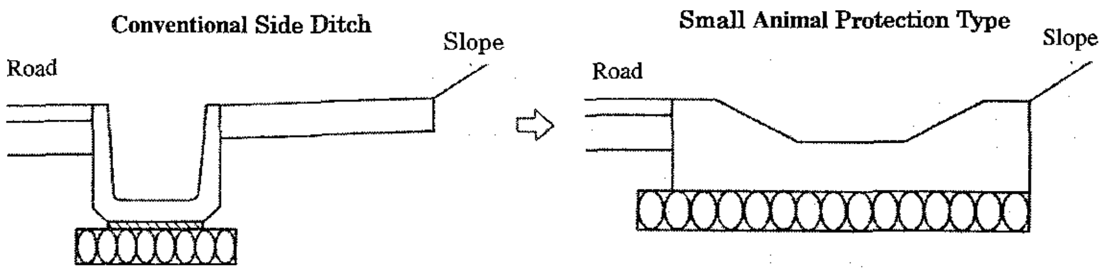


Figure.2.4.3 e.g. The Side Ditch in Consideration of the Small Animal's Movement

Table.2.4.1 The Standard of the Slope Grade for the Greening

Slope Grade	Greening Target
～30° (1:1.7)	The renaturation of the plant community which arboreal gives priority to
～45° (1:1.0)	The renaturation of the plant community which low arboreal and bush gives priority to
～60° (1:0.6)	The renaturation of the plant community which bush and grass plant gives priority to

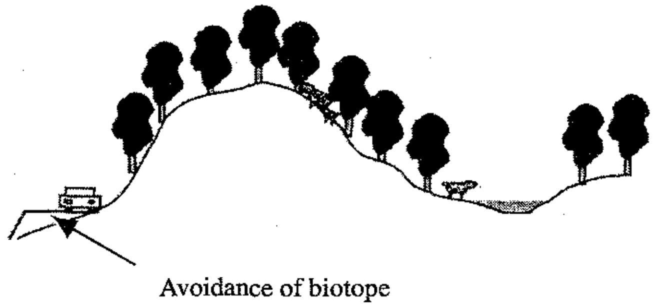
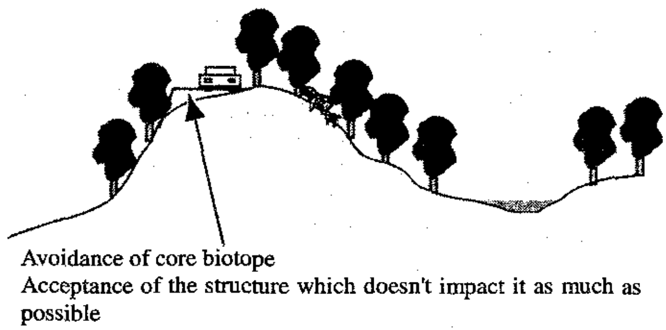
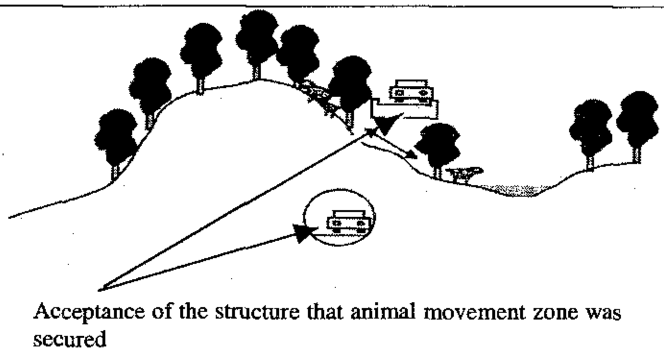
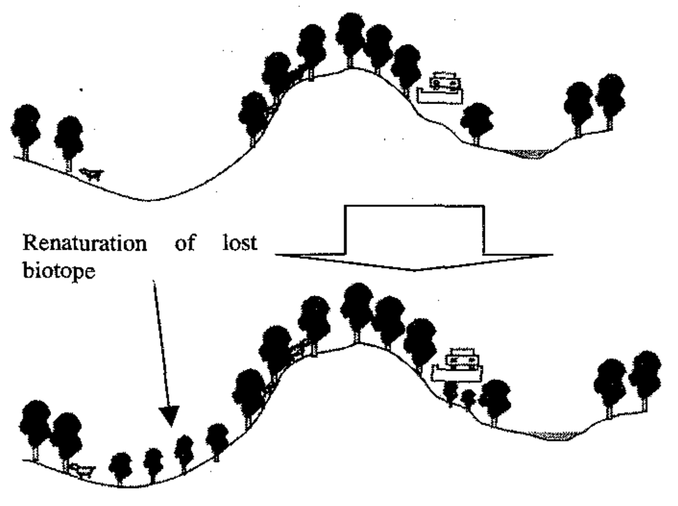
Echelon	Explanation	
Avoiding		Avoidance from biotope and movement zone.
Minimizing		Avoidance from core biotope. Minimization of *embankment and cut.*
Balancing		An impact is made to balance in the same point.
Restoration or Compensating		It alternates the impact in other places. An alternate site is secured in other places. The impact which can't be avoided is compensated for. *Four tree-planting duties for one felling by the guidance of MARENA are contained here.

Figure2.4.4 Method of Mitigation

p) Weather

It is evaluated about the impact on the weather (existing wind, temperature) of the area by the large-scale built facilities. In case that it has an influence, it is evaluated that whether suitable measure that an impact is avoided is taken, and/or whether it is examined about that future impact.

q) Landscape

It is evaluated about the change in the landscape from the national park, conservation area and/or the main viewpoint. In case that there is a change, it is evaluated about the validity of the countermeasure against the harmony with the landscape of the circumference.

r) Air pollution

This evaluation must be enforced about under construction and after construction. As for the under construction, it is evaluated that whether it is the plan that the environmental standards shown in NIC2000 are observed. On the other hand, as for the after construction, it is evaluated that whether suitable measure is taken against the long-term influence by causing of the new traffic and so on, and/or whether that impact is examined.

s) Water pollution

This evaluation must be enforced about under construction and after construction. As for the under construction, it is evaluated that whether it is the plan that the environmental standards shown in NIC2000 are observed. On the other hand, as for the after construction, the validity of the countermeasure for the factor (e.g. soil erosion), which makes water pollution occur, is evaluated.

And, the case of the countermeasure is shown in the Table 2.4.2.

Table2.4.2 e.g. Water Pollution Countermeasure of the Road Construction

A countermeasure under construction	A permanent countermeasure
- The installation of the temporary drainage A temporary drainage way is installed. Then, an earth and sand prevention fence and a prevention dam or earth and sand sedimentation tank is installed on its down stream side. - The prevention of slope It is covered in the seat, and the permeation of the rainwater is prevented in the early days. Furthermore, a nakedness ground period is shortened by the seed coating and so on. And, the drain of the earth and sand is prevented.	- The covering of road surface A road surface is covered by asphalt. - The suitable drainage facilities The installation of the drainage facilities which made flow speed low, and catch pit that mud pool was secured is done. - The prevention of slope Protection by the seed coating and so on is done in embankment. And, protection by concrete frame and so on is done in cut slope.

t) Soil pollution

It is evaluated about the possibility of the soil pollution by the project.

In case that soil pollution results, it is evaluated that whether suitable measure that an impact is avoided is taken, and/or whether it is examined about that future impact. Specially, in case that there is use of the heavy metals with a project, it must be evaluated about way of managing.

u) Noise, Vibration

This evaluation must be enforced about under construction and after construction. As for the under construction, it is evaluated that whether it is the plan that the environmental standards shown in NIC2000 are observed. On the other hand, as for the after construction, it is evaluated that whether suitable measure against the noise, vibration caused by the increase in the traffic and so on is taken, and/or whether that impact is examined. It must specially pay attention in the point, which calm such as a hospital and school should be necessary.

v) Ground Subsidence

It is evaluated about the occurrence of the ground subsidence caused by the decline of the ground water by cutting of the ground water pulse, digging of the temporary well under construction, and so on. In case that the occurrence of the ground subsidence is expected, it is evaluated whether suitable measure that an impact is avoided is taken, and/or whether it is examined about that future impact.

w) Afoul smell

This evaluation must be enforced about under construction and after construction. Because an afoul smell with the road construction is a thing due to the discharge of the exhaust gas by the construction equipments and so on, it is evaluated that whether it is the plan that the environmental standards shown in NIC2000 are observed. As for after the construction, it is evaluated that whether suitable measure is taken against the increase in the amount of exhaust gas by causing of the new traffic and so on, and/or whether that impact is examined.

2.5 Method of Selection for Countermeasures

2.5.1 General

This section shows selection criteria of countermeasures of each road disaster. The method of selection for countermeasure is expressed as a flow chart in orders to reach a final solution easily.

2.5.2 Selection Criteria of Countermeasures for Each Road Disaster

1) Objectives of Countermeasures

The objectives of countermeasures for road disaster can be expressed as follows:

- ✓ To prevent the occurrence of unexpected disaster.
- ✓ To pass smoothly without blocking a road section to traffic and people.
- ✓ To keep property of public and private, and
- ✓ To decrease of maintenance and rehabilitation cost for road.

Countermeasures to the disaster are divided into the following three categories of disaster characteristic.

- ✓ Permanent Countermeasures
- ✓ Temporally Countermeasures
- ✓ Emergency Countermeasures

a) Permanent Countermeasures

Permanent countermeasure defined as the following items.

- ✓ The lifetime of countermeasure should be least (20) years during the maintenance work.
- ✓ An adequate budget for permanent countermeasures should be safeguarded at all times

b) Temporary Countermeasures

Temporary Countermeasure are defined as the following items:

- ✓ The lifetime of countermeasures should be at least ten (10) years during the maintenance work.

c) Emergency Countermeasures

Emergency Countermeasure focuses as follows:

- ✓ It means the serious and dangerous spot must be improved immediately.

✓ The lifetime of counteremeasrure should be until the next rainy season or less than a half year.

✓ It is necessary to decide upon the implementation of temporary countermeaseres or permanent ones during the lifetime of the emergency countermeasures.

2) Kind of Countermeasure and applicability of countermeasures

Table2.5.1 Applicable Countermeasures against Slope Failures

Classification	Type of Work	Type of Slope Failure											
		Rock-fall/ Collapsing			Rock Collapsing			Slope Slide			Debris Flow		
		E	T	P	E	T	P	E	T	P	E	T	P
(1) Earth Work	Removal	○	○	○	○	○	○	○	○	○	○	○	○
	Recutting	○	○	○	○	○	○	○	○	○	○	○	○
	Rock splitting	○	○	○	○	○	○	×	×	×	○	○	○
	Embankment	○	○	○	×	×	×	○	○	○	△	△	×
(2) Vegetation	Hydroseeding	○	○	○	△	△	△	○	○	○	○	○	○
	Vegetation	○	○	○	×	×	×	○	○	○	○	○	○
(3) Surface Drainage	Crest ditch	○	○	○	△	△	○	○	○	○	×	×	×
	Berm ditch	△	○	○	△	○	○	△	○	○	×	×	×
	Toe ditch	△	○	○	△	○	○	△	○	○	×	×	×
(4) Structure	Stone pitching	○	○	△	×	×	×	○	○	△	×	×	×
	Shotcrete	△	○	○	△	○	○	△	△	△	△	○	○
	Sprayed concrete crib	×	△	○	×	△	○	×	△	○	×	△	○
	Gabion Wall	○	○	△	○	○	△	○	○	△	○	○	△
	Stone masonry wall	△	○	○	△	○	○	△	○	○	△	△	△
	Gravity-type retaining wall	△	○	○	△	○	○	△	○	○	△	△	△
	T-shaped retaining wall	×	△	○	×	△	○	×	△	○	×	△	△
	Pilling	×	×	×	×	×	×	△	○	○	×	×	×
(5) Protection	Prevention net	△	△	×	△	○	○	×	×	×	×	×	×
	Prevention fence	×	△	○	△	○	○	×	×	×	×	×	×
	Barrier with concrete wall	×	△	○	△	○	○	×	×	×	×	×	×
	Rock bolt	△	×	×	○	○	○	×	×	×	×	×	×
	Rock shed	×	×	△	×	△	○	×	×	×	×	△	○
	Concrete dam	×	×	×	×	×	×	×	×	×	×	○	○

Note: E; Emergency Countermeasure, T; Temporary Countermeasure

P; Permanent Countermeasure

○; Most Appropriate, △; Applicable, ×; Not Applicable

Table2.5.2 Applicable Countermeasures against Bridge Foundation Scouring

Classification	Type of work	Abutment			Pier		
		E	T	P	E	T	M
Bridge protection	Concrete revetment	×	○	○	×	○	○
	Stone riprap	△	○	○	○	○	○
	Gabion mat for pier	×	×	×	○	○	△
	Dumped rock	○	×	×	○	×	×
	Concrete for foot protection	×	○	△	×	○	△
	Precast concrete block for protection	×	○	△	×	○	△

3) Selection Method of Countermeasures

a) Rock-fall/ collapsing

i) Emergency of Countermeasures

A selection procedure for emergency of countermeasures in the case of rock-fall/collapsing is shown in Figure 2.5.1.

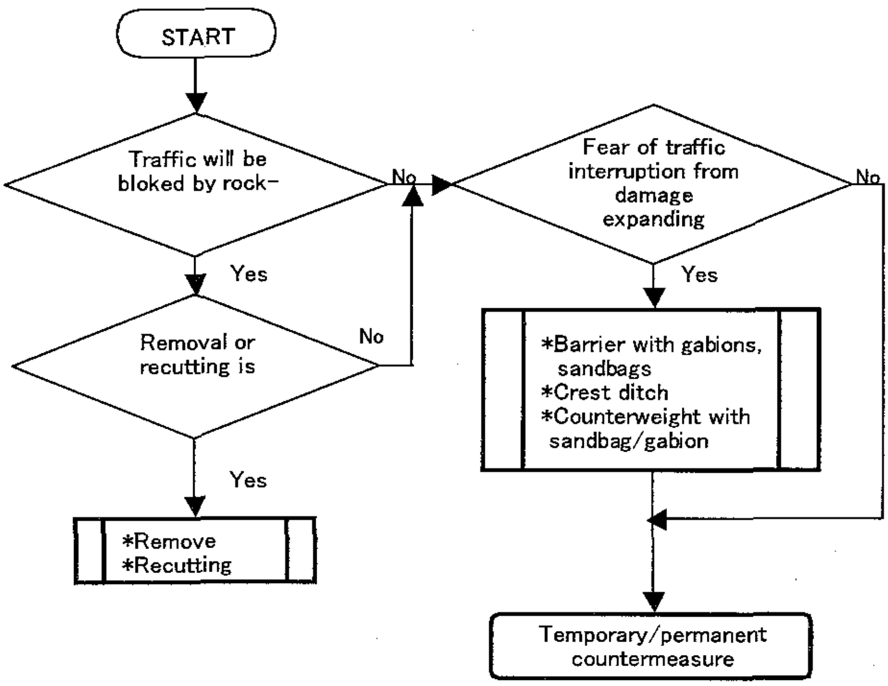


Figure 2.5.1 Selection of Emergency Countermeasure in Case of Rock-fall/Collapsing

ii) Temporary/Permanent Countermeasures

The flow chart in Figure 2.5.2 and Figure 2.5.3 explain the selection procedure for a temporary and permanent countermeasure.

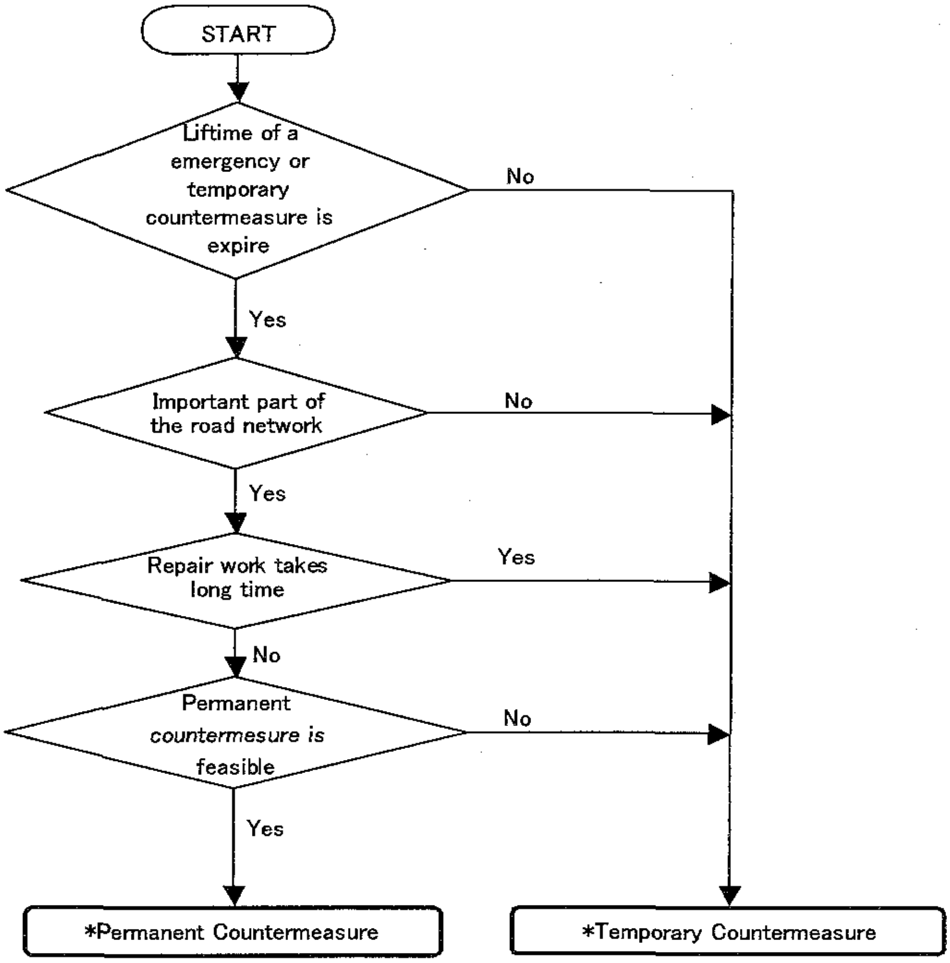


Figure 2.5.2 Selection of a Temporary and Permanent Countermesure

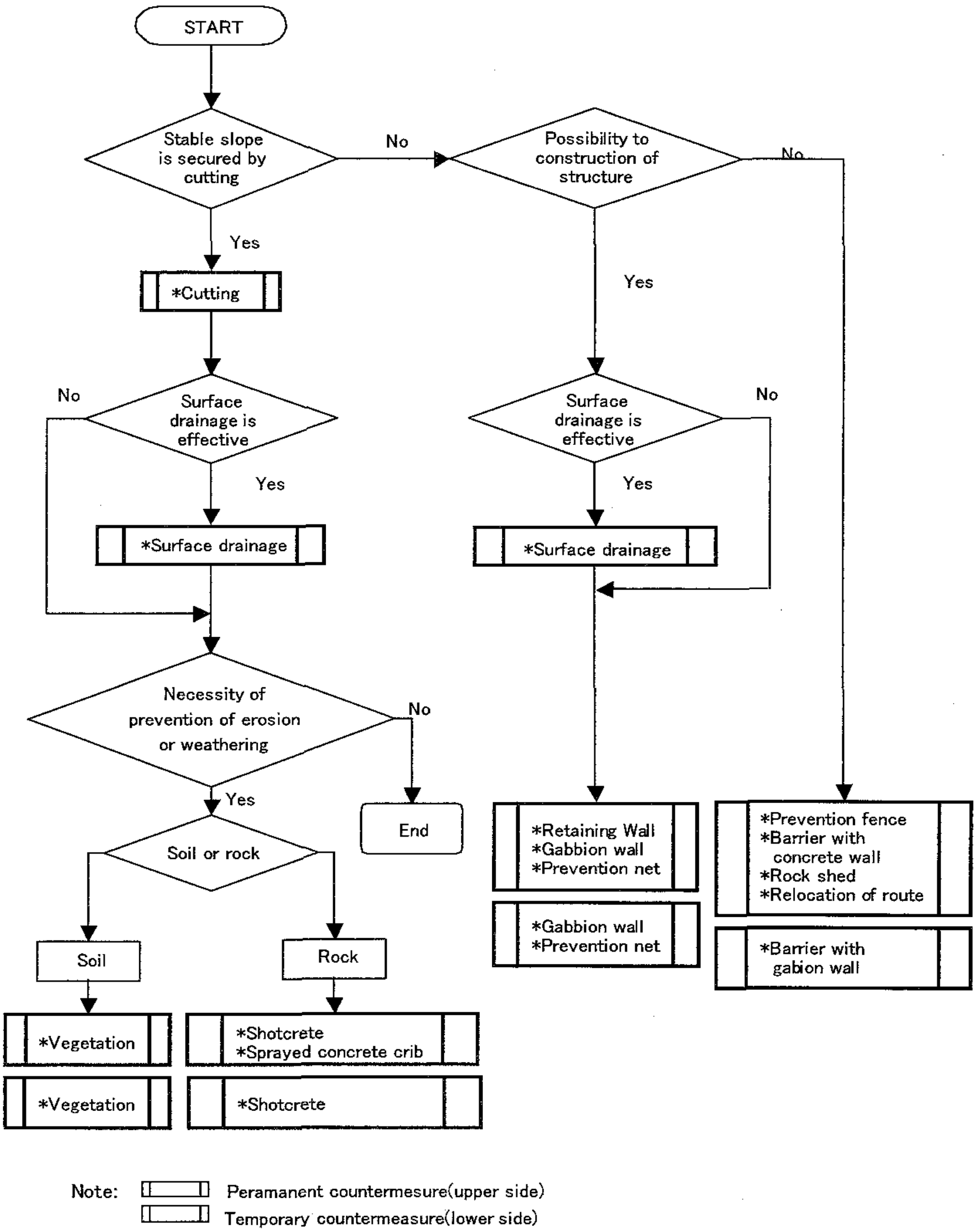


Figure 2.5.3 Selection of Temporary and Permanent Countermeasure for Rock-fall/Collapsing

b) Rock collapsing

i) Emergency of Countermeasures

A selection procedure for emergency of countermeasures in the case of rock collapsing is shown in Figure.2.5.4.

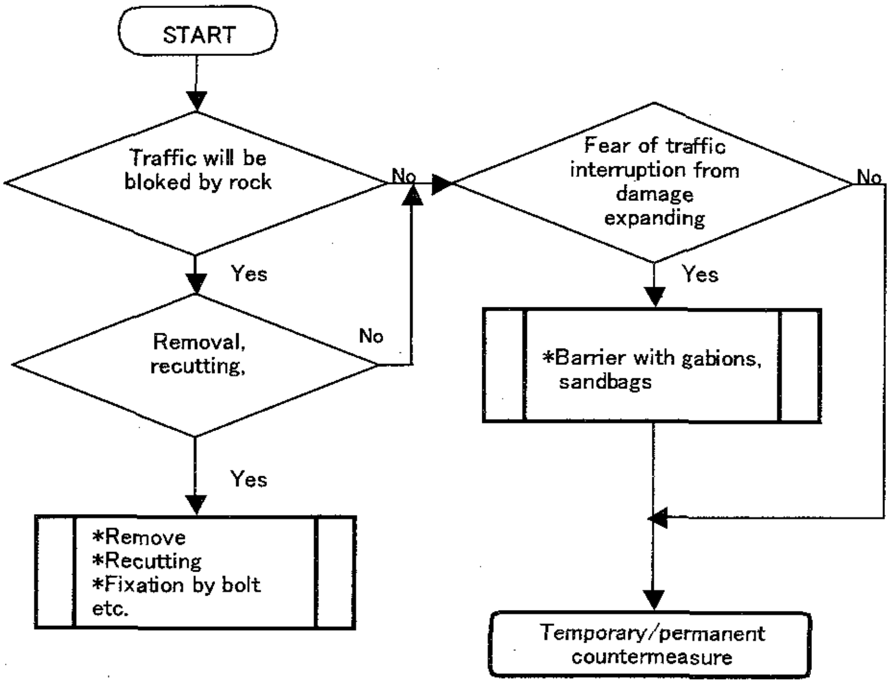


Figure 2.5.4 Selection of Emergency Countermeasure in Case of Rock Collapsing

ii) Temporary/Permanent Countermeasures

The flow chart in Figure 2.5.2 and Figure 2.5.5 explain the selection procedure for a temporary and permanent countermeasure.

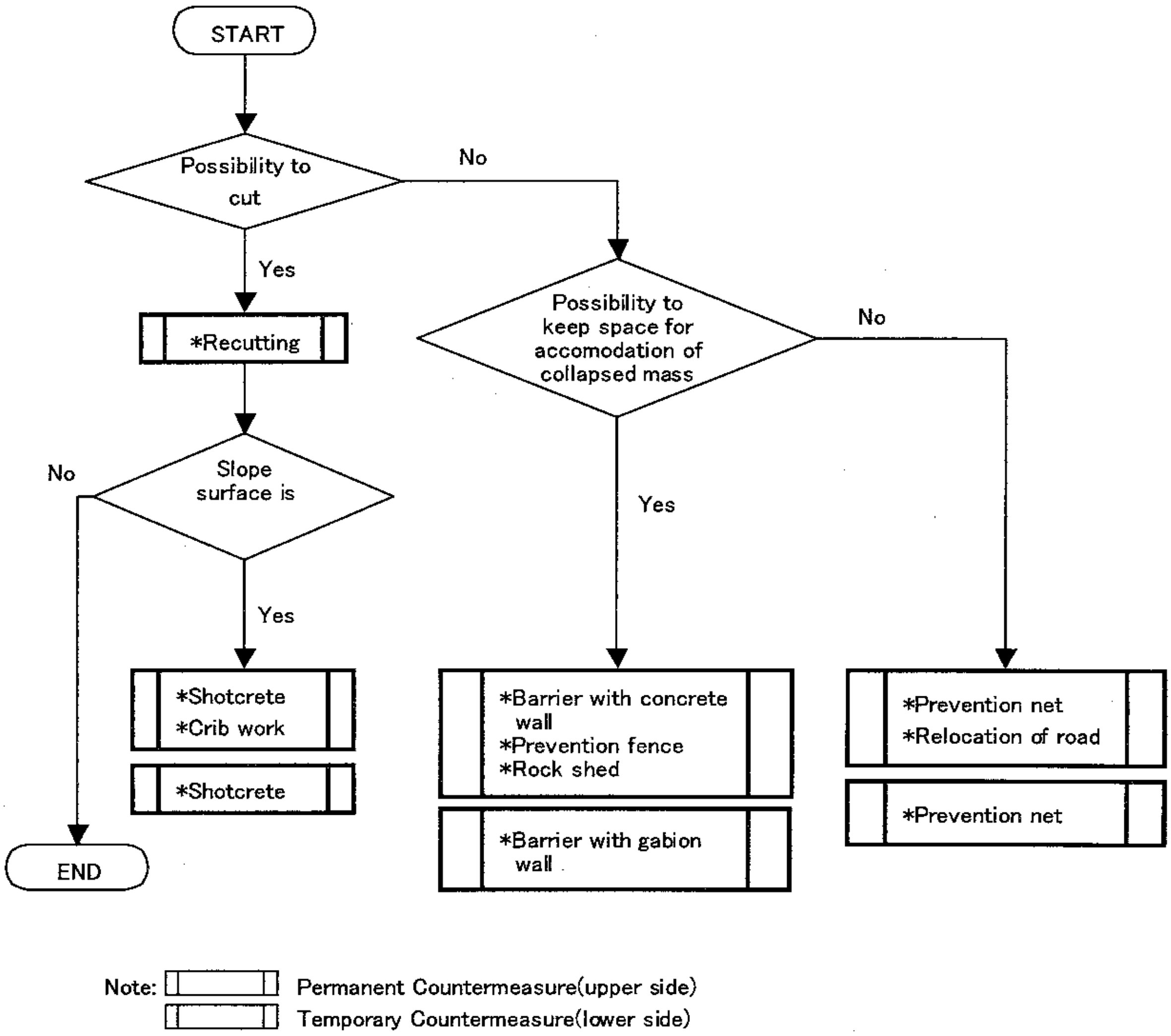


Figure 2.5.5 Selection of Temporary and Permanent Countermeasures for Rock Collapsing

c) Slope damage

i) Emergency of countermeasures

A selection procedure for emergency of countermeasures in the case of slope damage is shown in Figure.2.5.6.

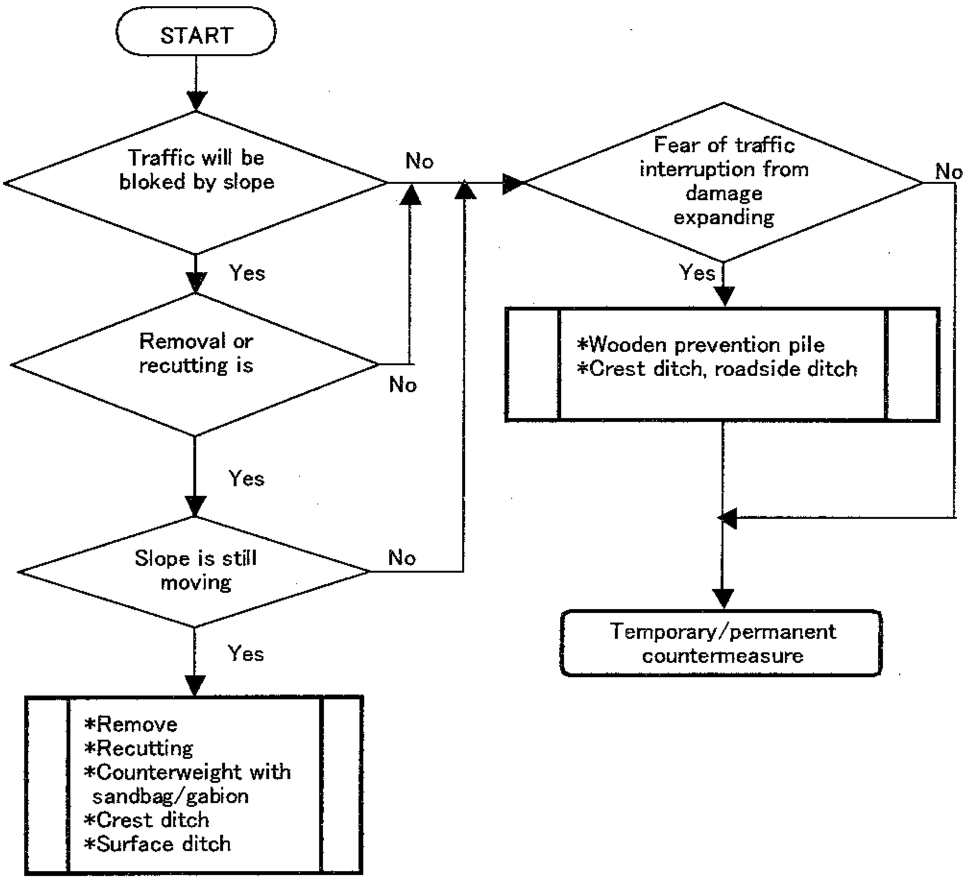


Figure 2.5.6 Selection of Emergency Countermeasure in Case of Slope Damage

ii) Temporary/Permanent Countermeasures

The flow chart in Figure 2.5.2 and Figure 2.5.7 explain the selection procedure for a temporary and permanent countermeasure.

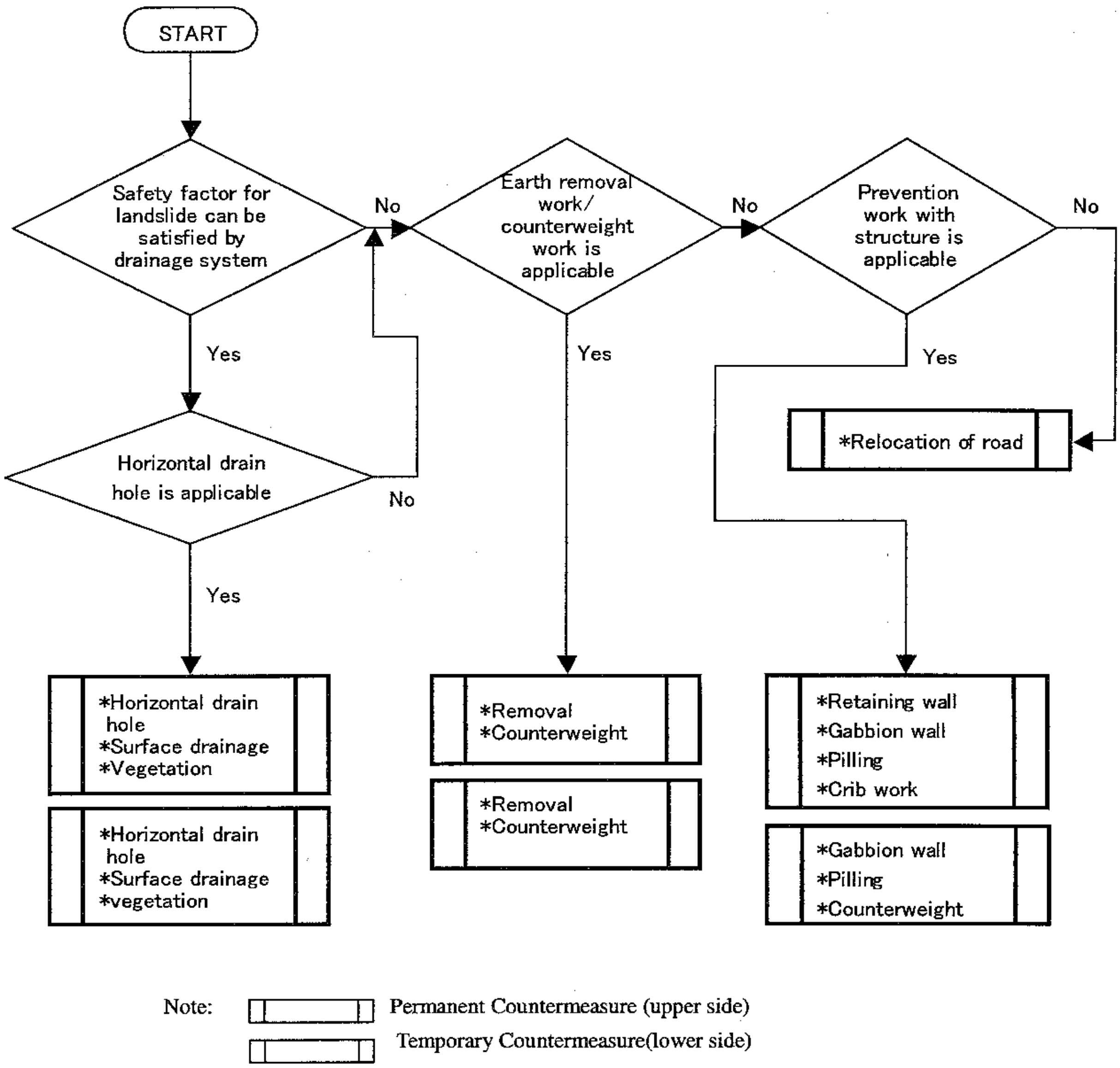


Figure 2.5.7 Selection of Countermeasure for Slope Damage

d) Debris flow

i) Emergency of Countermeasures

If further debris flows are anticipated, the following measures will be effective in preventing debris flow from reaching the road's surface:

-To remove debris

-To lock debris by fence, retaining wall, dam

-To control traffic

ii) Temporary/Permanent Countermeasures

The flow chart in Figure 2.5.8 explains the selection procedure for an emergency and temporary/permanent countermeasure.

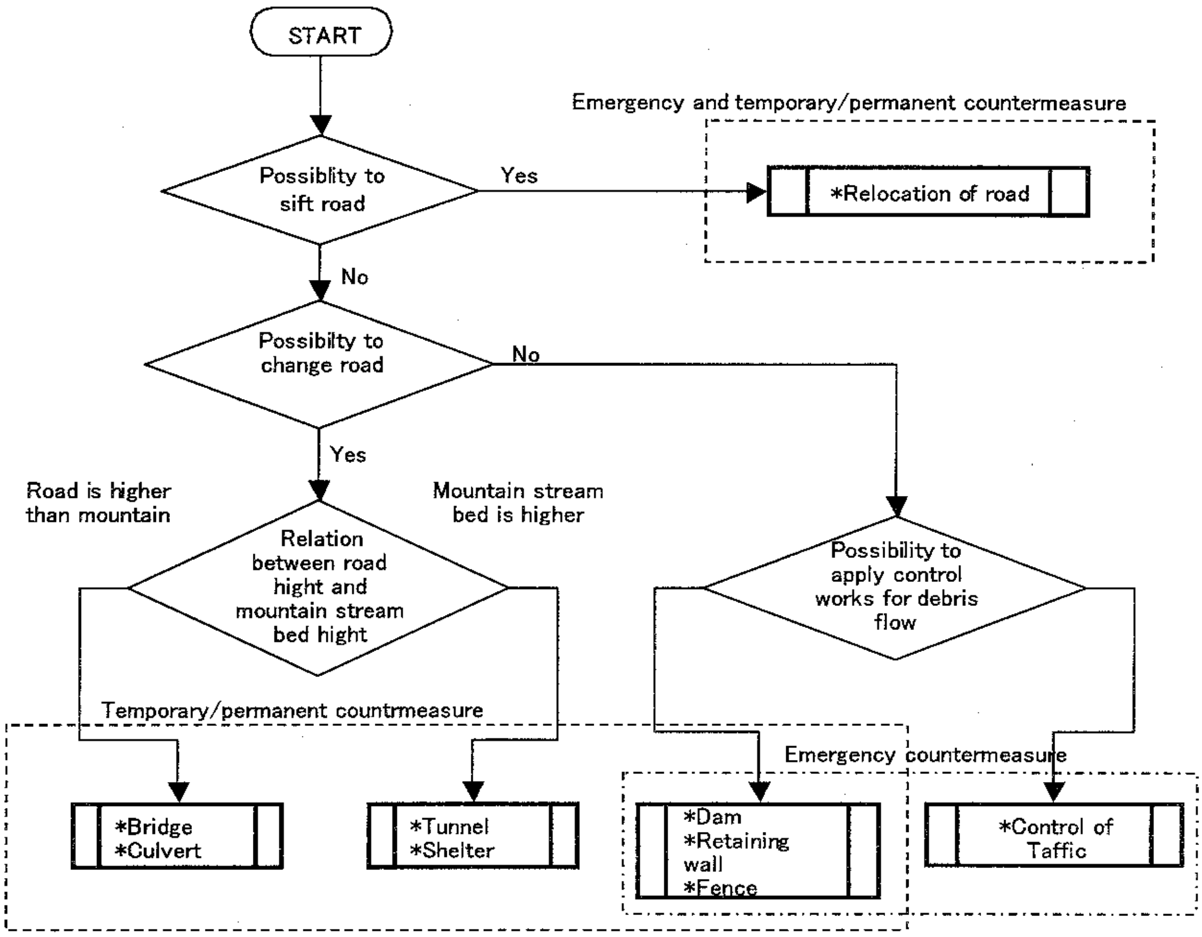


Figure 2.5.8 Selection Countermeasure for Debris Flow

e) Bridge foundation scouring

i) Emergency of Countermeasures

A selection procedure for emergency of countermeasures in the case of bridge foundation scouring is shown in Figure.2.5.9.

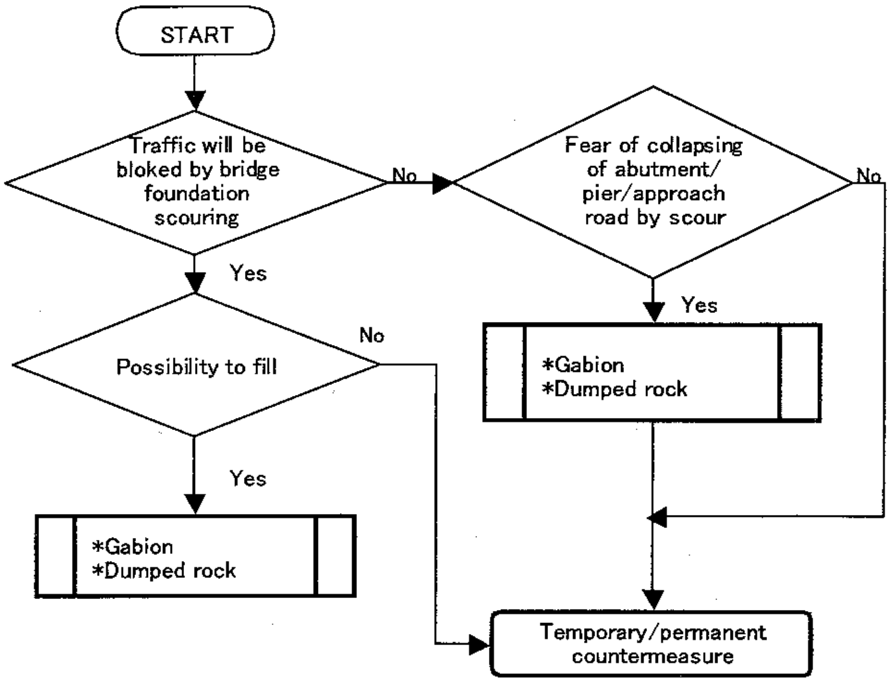


Figure 2.5.9 Selection of Emergency Countermeasure in Case of Bridge Foundation Scouring

ii) Temporary/Permanent Countermeasures

The flow chart in Figure 2.510 explain the selection procedure for a temporary and permanent countermeasure

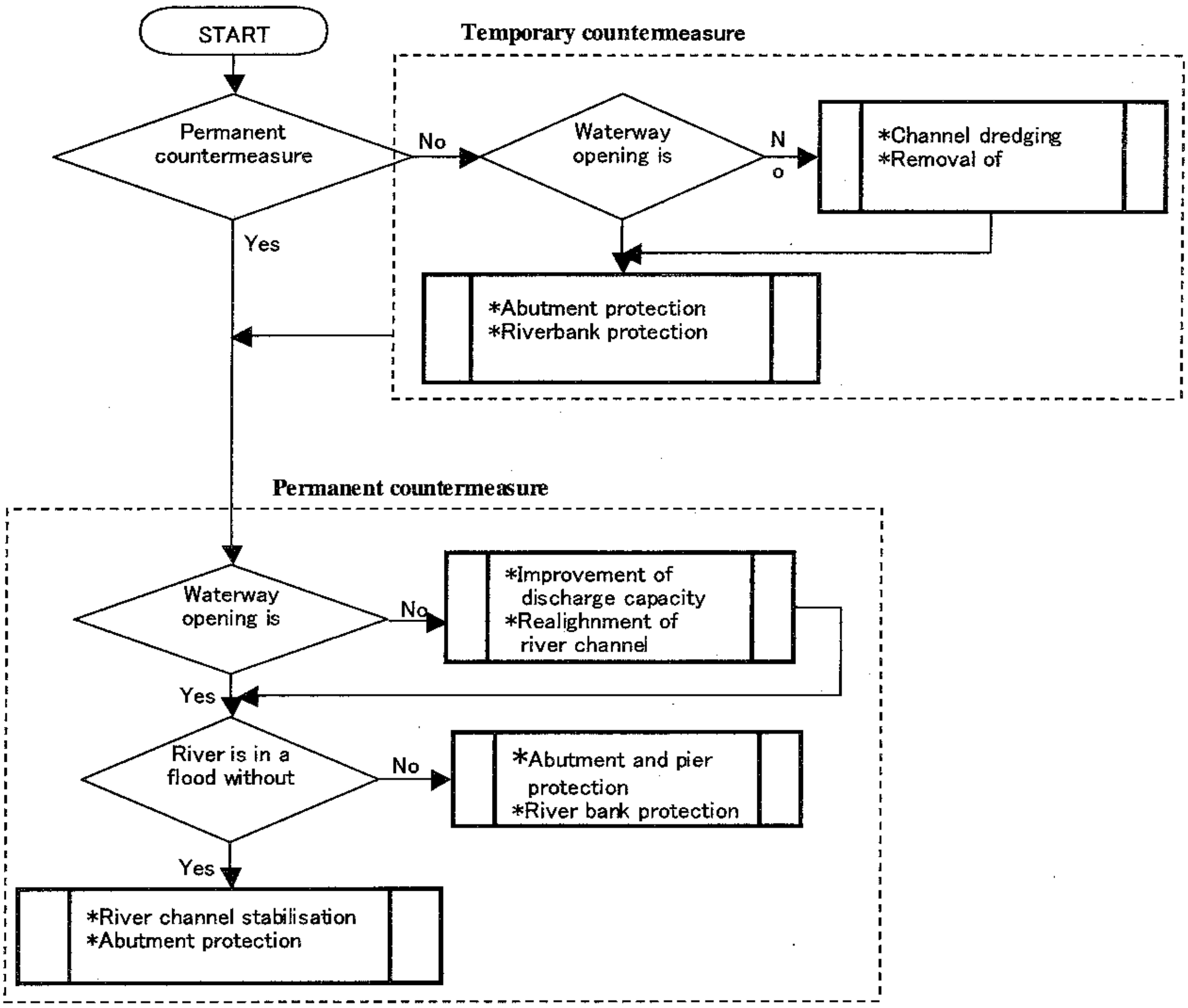


Figure 2.5.10 Selection of Tenporary/Permanent Countermeasure in the Case of the Bridge Foundation Scouring

f) Summary of Prevention Countermeasures for Disaster

The prevention disaster countermeasures are classified into six groups, in consideration of purpose and application. The relation between objects of prevention countermeasures and type of works is shown in Figure 2.5.11.

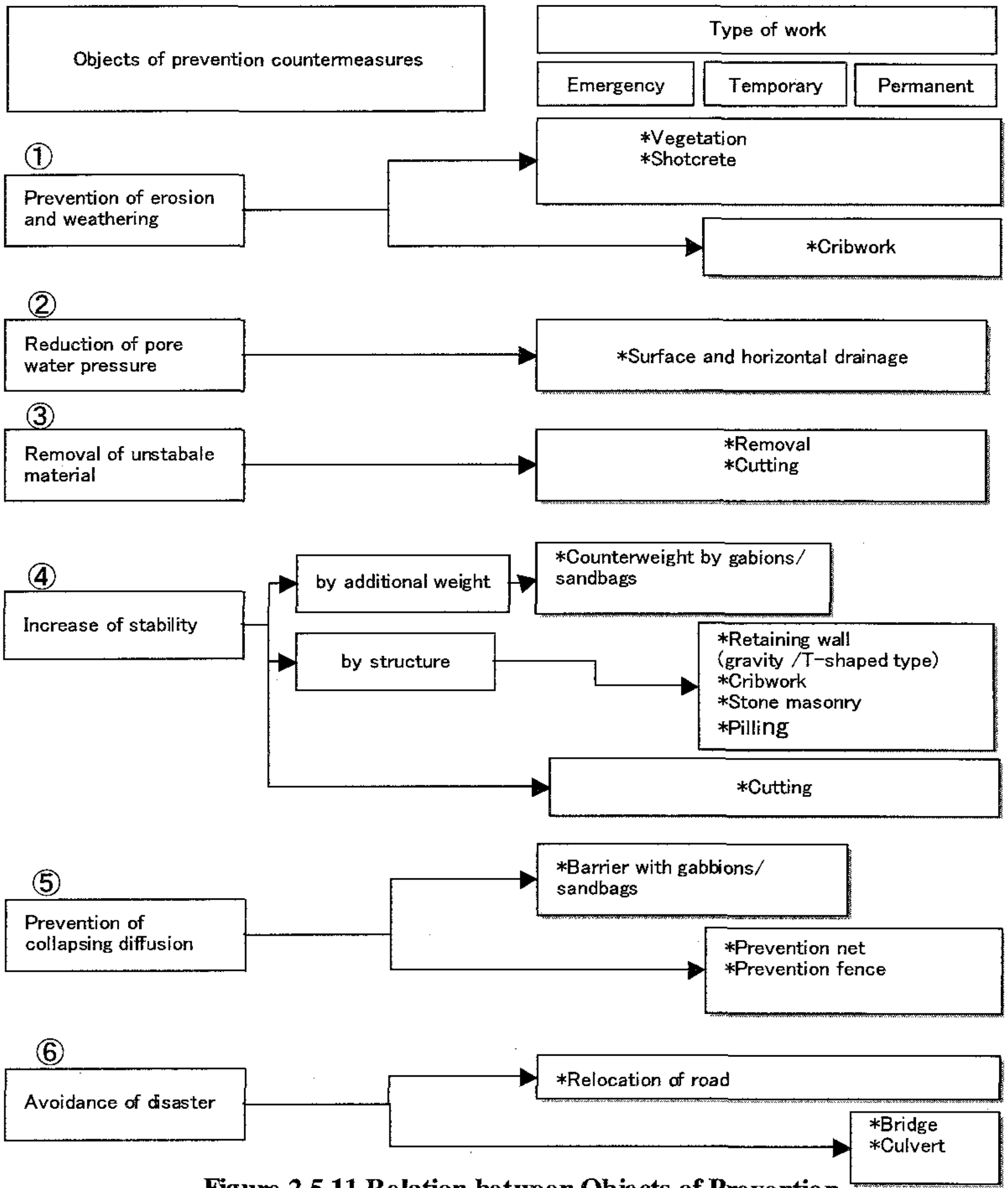


Figure 2.5.11 Relation between Objects of Prevention Coutermeasures and Type of Works

g) Countermeasure of Road Alignment Shift

The selection of the countermeasure methods in such case as the road is shifted is shown in figure 2.5.12.

This figure is a flow chart to judge the possibility to shift the road from the area of influence of rolling of the falling rock be to be effective.

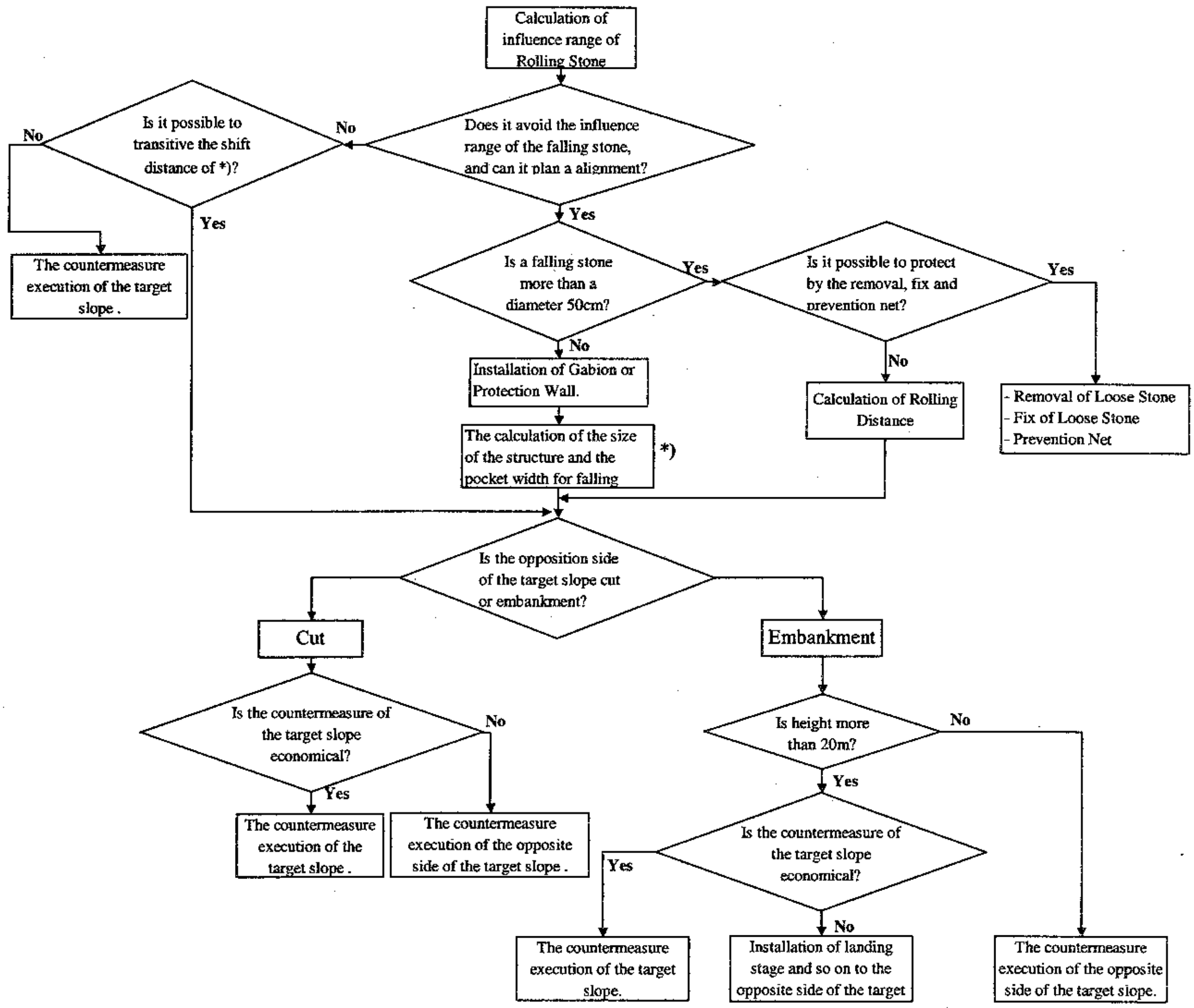


Figure 2.5.12 Flow of Countermeasure of Road Alignment Shift

Table2.5.3 Type of Countermeasures against Slope Damages

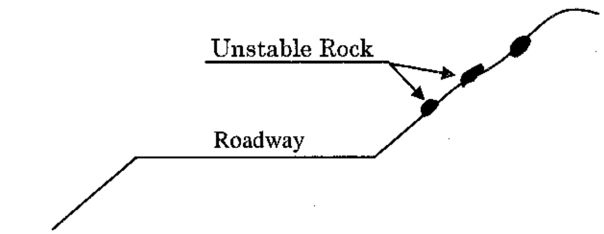
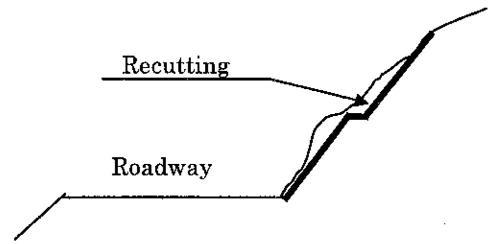
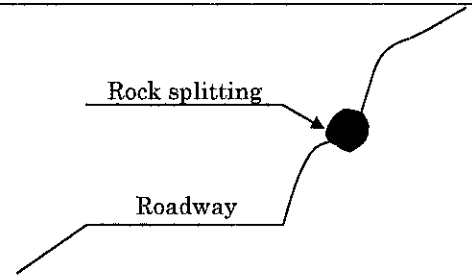
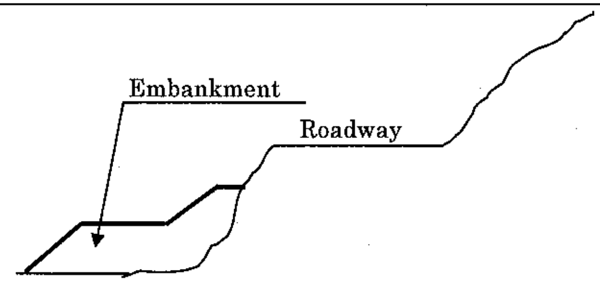
Classification	Type of Work	Functional Characteristics	Application	Illustration
(1) Earth Work	Removal	- To stabilize a slope by removing unstable potions - To remove unstable rocks before they falling down	- Cut slope - Generally applied to huge and medium-size rocks. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Recutting	- To stabilize a slope by cutting it to its optimum gradient.	- Cut slope(soil & rock) **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Rock splitting	- To stabilize a slope by split it.	- Applied to huge rocks. **Rock-falling** **Rock-collapsing** **Debris flow**	
	Embankment (Refiiling)	- To refill a cavity created by erosion, scouring, etc.	- Cut slope, fill slope. **Rock-falling** **Slope Slide** **Debris flow**	

Table2.5.4 Type of Countermeasures against Slope Damages

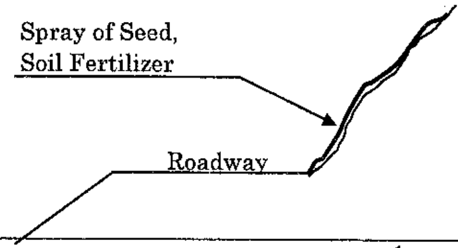
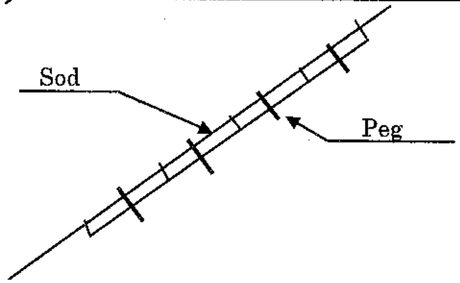
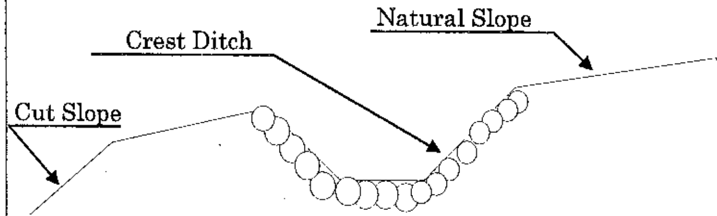
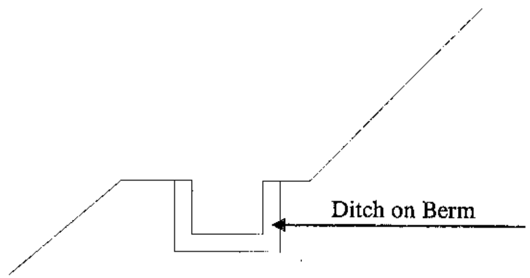
Classification	Type of Work	Functional haracteristics	Application	Illustration
(2) Vegetation	Hydroseeding	- To prevent the erosion, scouring and weathering of a slope by covering it with vegetation.	- Mainly applied to the weathered rock, soft rock and soil surface of a cut and fill slope. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Vegetation	- To prevent the erosion, scouring and weathering of slope by covering it with vegetation.	- Fill slope - Cut slope(soil) **Rock-falling** **Slope Slide** **Debris flow**	
(3) Surface Drainage	Crest ditch	- To prevent the erosion and scouring of a slope surface by collecting runoff water along the top of a cut slope	- Cut slope - Weathered rock, soil **Rock-falling** **Rock-collapsing** **Slope Slide**	
	Berm ditch	- To prevent the erosion and scouring of a slope surface by collecting surface water in berm.	- Cut slope and fill slope. - Weathered rocks and soil **Rock-falling** **Rock-collapsing** **Slope Slide**	

Table2.5.5 Type of Countermeasures against Slope Damages

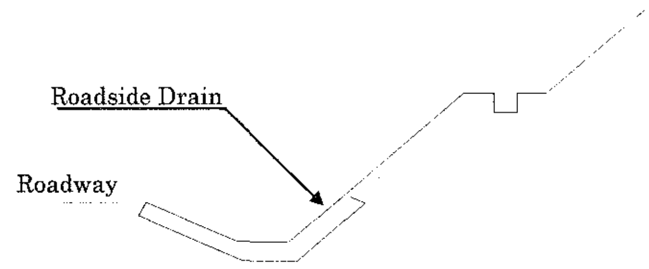
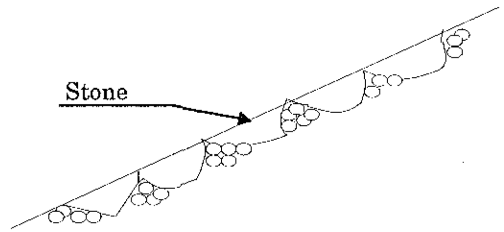
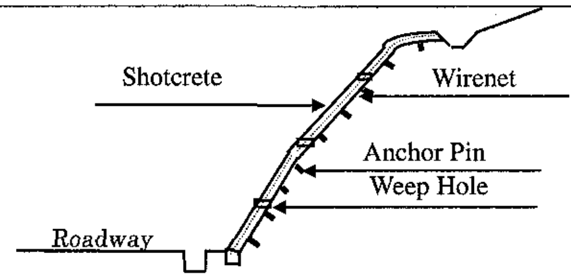
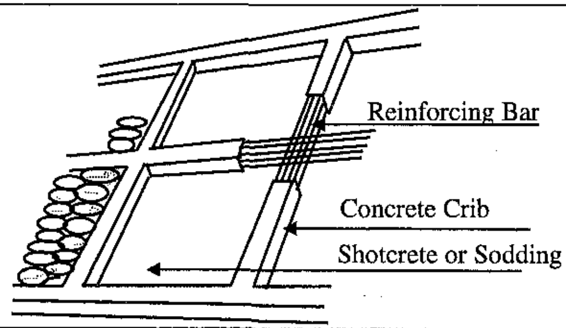
Classification	Type of Work	Functional Characteristics	Application	Illustration
(3) Surface Drainage	Roadside drain	- To prevent runoff water from reaching a road's surface.	- Cut slope, fill slope. **Rock-falling** **Rock-collapsing** **Slope Slide**	
(4) Structure	Stone pitching	- To protect a slope by covering it with stone pitching.	- Usually applied to a slope surface gentler than 1.5:1 **Rock-falling** **Slope Slide**	
	Shotcrete	- To protect a slope by covering it with sprayed concrete(or mortar)	- Cut slope(rock) - Not applicable to a slope surface with much seepage water. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Concrete cribwork	- To protect a slope by covering it with concrete crib.	- Applicable to a slope surface steeper than 1.0:1. - Applicable to an undulated surface. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	

Table2.5.6 Type of Countermeasures against Slope Damages

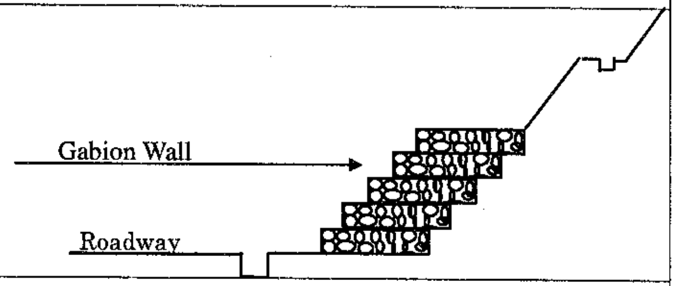
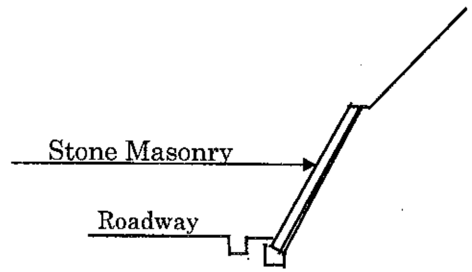
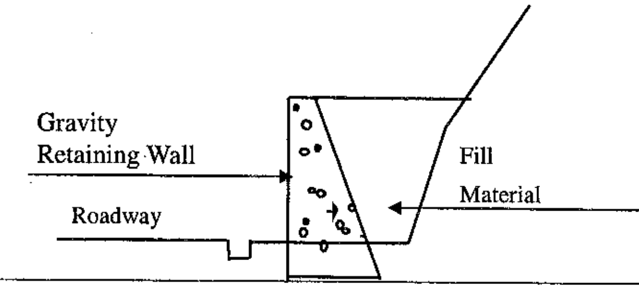
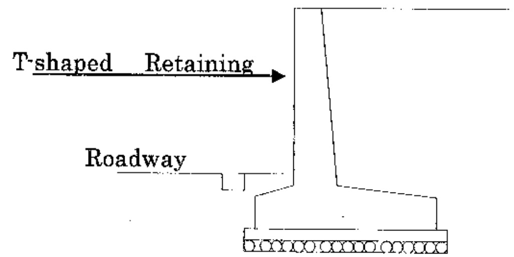
Classification	Type of Work	Functional Characteristics	Application	Illustration
(4) Structure	Gabion Wall	- To protect a slope from landslides by resisting earth pressure.	- Mainly applied to the toe of a fill slope with seepage water. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Stone masonry wall	- To protect a slope from landslide by resisting earth pressure.	- Applicable to a stone masonry wall less than 5 m high. - Generally applied to a cut and fill slope. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	Gravity-type retaining wall	- To protect a slope from landslides by resisting earth pressure.	- Applicable to a wall less than 3 m high. - Generally applied to a cut and fill slope. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	
	T-shaped retaining wall	- To protect a slope from landslides by resisting earth pressure.	- Usually applied to a wall 3 to 10m high. - Generally applied to a cut or fill slope. **Rock-falling** **Rock-collapsing** **Slope Slide** **Debris flow**	

Table2.5.7 Type of Countermeasures against Slope Damages

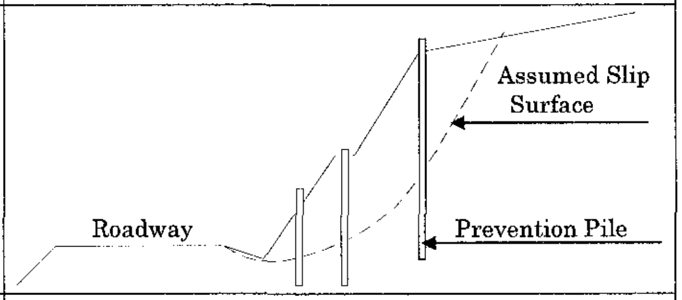
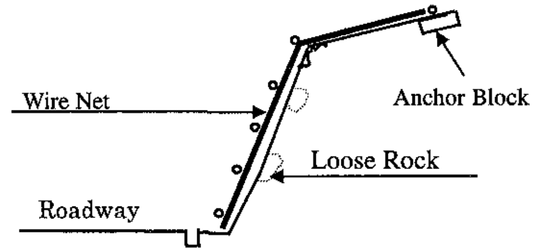
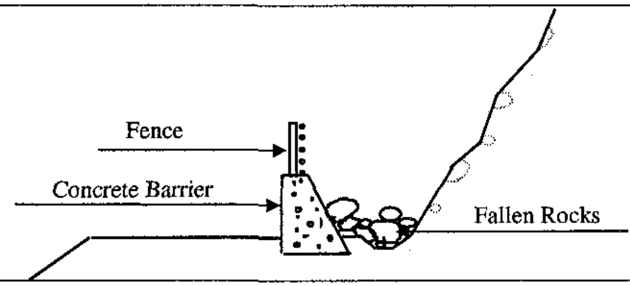
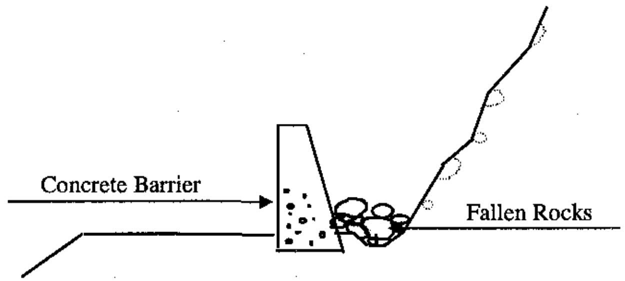
Classification	Type of Work	Functional Characteristics	Application	Illustration
(4) Structure	Pilling	- To prevent a slope from sliding by resisting earth pressure with piles.	- Applicable to a slope surface steeper than 1.0:1. - Applicable to an undulated surface. - **Slope Slide** **Debris flow**	
(5) Protection	Prevention net	- To prevent falling rock from reaching a road by providing a catch wire net.	- Applied where there is no roadside space. - Unsuitable for a slope with rock that easily weathers. **Rock-falling** **Rock-collapsing**	
	Prevention fence	- To prevent falling rock from reaching a road by providing a catch fence.	- Applied where there is sufficient roadside space to contain fallen rock. **Rock-falling** **Rock-collapsing**	
	Barrier with concrete wall	- To prevent falling rock from reaching a road by providing a concrete wall.	- Applied where there is sufficient roadside space to contain fallen rock. **Rock-falling** **Rock-collapsing**	

Table2.5.8 Type of Countermeasures against Slope Damages

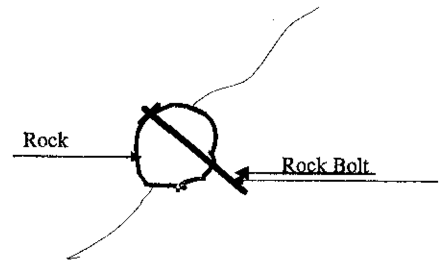
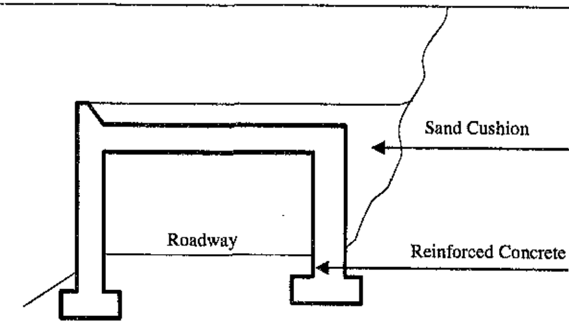
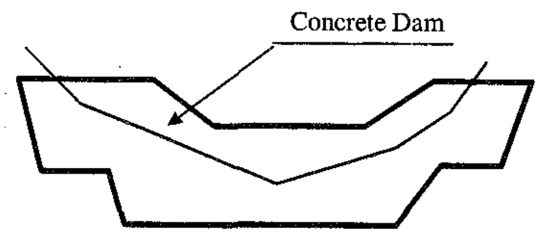
Classification	Type of Work	Functional Characteristics	Application	Illustration
(5) Protection	Rock bolt	- To prevent unstable rocks from falling down by anchoring them to bedrock with rock bolt.	- Applicable to huge rocks. **Rock-falling** **Rock-collapsing**	
	Rock shed	- To prevent unstable rocks from falling down by rock shed and debris flow.	- Cut slope - Debris flow **Rock-falling** **Rock-collapsing** **Debris flow**	
	Concrete dam	- To prevent a slope from debris flow by concrete dam.	- Debris flow **Debris flow**	

Table2.5.9 Type of Countermeasures against Bridge Foundation Scouring

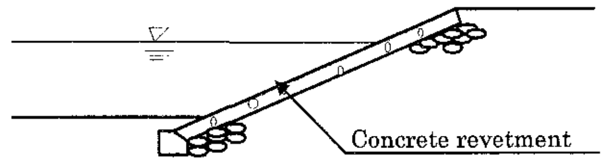
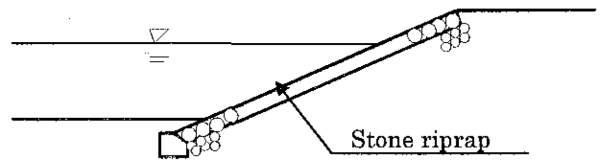
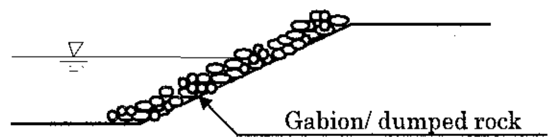
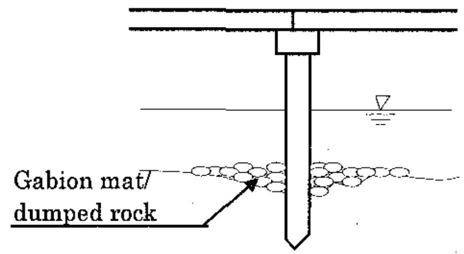
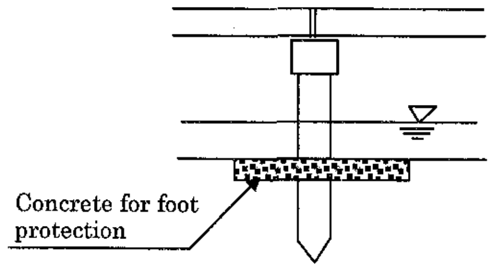
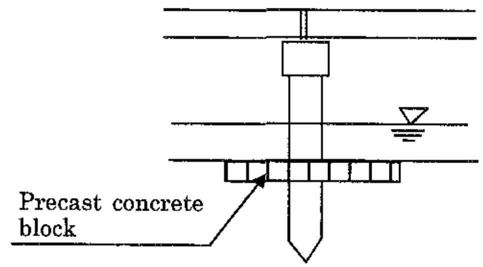
Classification	Type of Work	Functional Characteristics	Application	Illustration
(6)Abutment and pier protection	Concrete revetments	- To protect an abutment fill slope from scouring.	- Usually applied to a slope gentler than 1:1 **Bridge**	
	Stone riprap revetments	- To protect an abutment fill slope from scouring.	- Usually applied to a slope gentler than 1:1 **Bridge**	
	Dumped rock/ Gabion mat protection	- To prevent an abutment from scouring by dumped rock or placing gabion mat.	- Applicable to a long and short bridge. -Generally applied to emergency work. **Bridge**	
	Gabion mat protection	- To prevent a pier from scouring by placing gabion mat or dumped rock.	- Applicable to a long and short bridge. -Generally applied to emergency work. **Bridge**	

Table2.5.10 Type of Countermeasures against Bridge Foundation Scouring

Classification	Type of Work	Functional Characteristics	Application	Illustration
(6)Abutment and pier protection	Concrete for foot protection	- To protect a pier from scouring.	- Usually applied to a high flow velocity part - It is preferable that there is no water for construction at the dry season. **Bridge**	
	Precast concrete block for foot protection	- To protect a pier from scouring.	- Usually applied to a high flow velocity part. **Bridge**	

2.5.3 Selection Criteria of Maintenance/Repair Work for Countermeasure

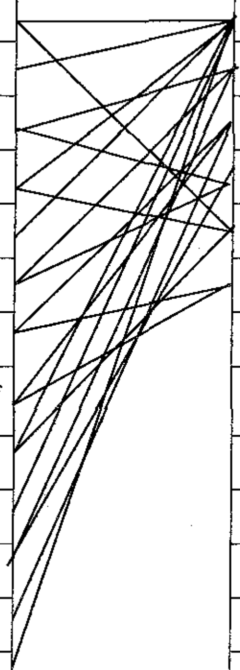
The maintenance and repair works after countermeasures are constructed are very important. Its performance is demonstrated by executing maintenance and repair. The selection methods of maintenance and repair works are shown in table 2.5.11 and 2.5.12. When the best method is selected, it is necessary to decide method in consideration of a site situation.

Table 2.5.11 Selection Criteria of Maintenance/Repair Work for Countermeasure of Slope Damage

Countermeasure Method	Phenomenon	Selection of Countermeasure for Maintenance
Recutting	Rock falling	Recutting
	Rock collapse	Partial removal
	Weathering	Shotocrete
	Erosion	Prevention net
Embankment	Sliding	Counterweight
	Erosion	Refilling
Vegetation	Settling of vegetation	Vegetation
Drainage	Storage of falling rock and earth	Cribwork
	Destruction	Increase of drainage facilities
	Collection shortage of water	Review at temperature of try planting and rainfall time
Retaining wall	Deformation	Change of construction method
	Destruction	Removal of storage debris
Cribwork	Loosening and sinking of fill material	Restructuring of fragmentation
	Cracking	Change of gradient
	Outflow of fill material	Improvement of bearing capacity
	Decrease in anchor tension	Compaction
Shotocrete	Cracking	Filling of soil or boulder
	Bulge	Strengthening
	Cave	Fill replenishment of soil
Prevention net	Damage of net	Injection of mortar
	Slack of rope	Construction of new crib in old crib
	Anchor's loosening	Installation of drain pipe
Gabion mat	Corrosion of wire	Re-tightening
	Disappearance of stuff stone	New replace
Concrete barrier	Deformation	
	Destruction	

Table 2.5.12 Selection Criteria of Maintenance/Repair Work for Countermeasure of Bridge Foundation Scouring

Countermeasure Method	Phenomenon
Concrete revetments	Cracking
	Destruction
	Cave
Stone riprap revetments	Cracking
	Destruction
	Cave
Gabion mat protection	Corrosion of wire
	Disappearance of stuff stone
Concrete for foot protection Drainage	Cracking
	Destruction
	Cave
Precast concrete block for foot protection Retaining wall	Outflow
	Destruction



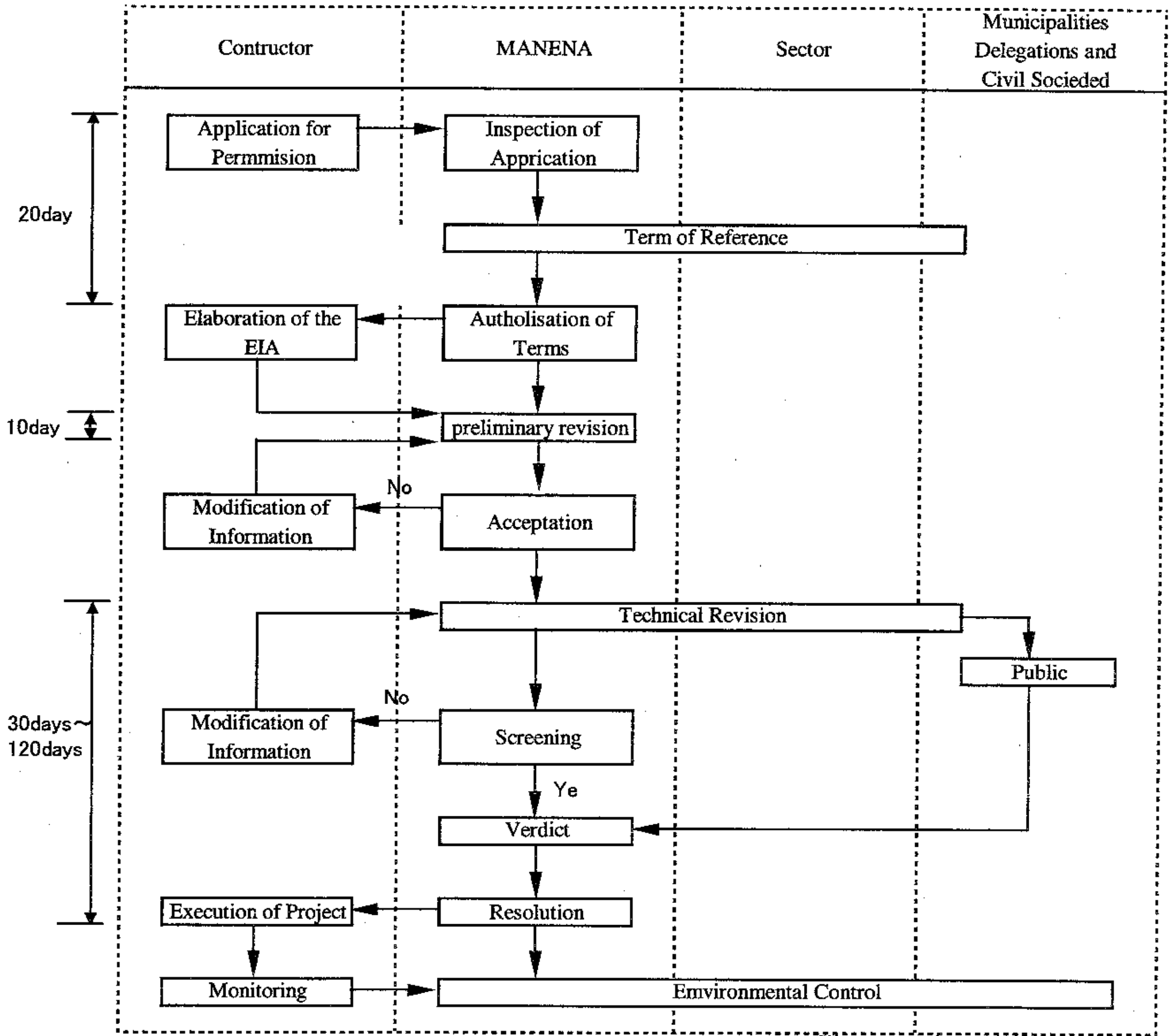
Selection of Countermeasure for Maintenance
Restructuring of fragmentation
Refilling !
New replace
Injection of concrete
Injection of mortar
Partial repair of wire

Appendix A-1.1

Article 5 in Law of Permit regulation and evaluation of the environment impact.

The investigations about the impact on the environment and the presentation of the document are necessary for the acquisition of the permission of the following projects and activities:

a) The prospecting and the mining of gold, zinc, copper, iron, silver, hydrocarbon and other subterranean heat resources.
b) For other minerals, the prospecting and the mining when the lode exists in a fragile biological area or one protected by the law.
c) Intensive or semi-intensive shrimp farms, and intensive or semi-intensive farms of other marine life.
d) The change of use of land in forestry areas, the change of the forest facilities plan of an area grater than 5,000 ha, forestry use of 35% and more of the inclination areas, and the construction of all-weather types of forest road.
e) Energy production plants, of every kind, above 5MW and power cables of 69KW or more.
f) Ports, airports, and airports for agricultural chemicals sprinkling, mineral, hydrocarbon and terminals of source products.
g) Railways and new trunk roads.
h) Laying of oil pipe lines, gas pipe lines and mineral pipe lines.
i) The construction of large drainage systems, water purification plants, sewage systems, sewage pipes and dams (including small dams).
j) Dredging construction and change of flow channel of surface running water.
k) The management and reclamation of an incinerator for industry, and incinerators for chemical material, poisonous and other materials.
l) Reclamation, compound facilities for sightseeing, building, and sport facilities in fragile biological areas or those protected by the law.
m) The construction of fishing compound facilities or plants, large slaughterhouses, food and drink factories, sugar manufacture factories and alcoholic distillation plants, fibre and sewing factories, tanneries, agricultural chemical factories, paint and lacquer solvent factories, petroleum refineries, ironworks, metallurgy factories, chromium factories, chemical and petro-chemcial factories, cement works and battery manufacturing industry.



The source) MARENA 1998

Sector : The section which influences a project

Figure A -1.1 Process of Environment Evaluation

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