INVESTIGATION REPORT
ON
THE COUNTER-MEASURES

FOR
THE PHILIPPINE-JAPAN FRIENDSHIP HIGHWAY DAMAGED
BY
TYPHOON DIDANG

AUGUST, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

INVESTIGATION REPORT ON THE COUNTER-MEASURES FOR

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AUGUST 1977

Prepared by the Japanese Mission
for the Philippines Government

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S. Okubo

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Philippine-Japan Friendship Highway was suffered from the heavy disasters caused by typhoon Didang on April 1976 around the Dalton Pass about two hundred kilometers north of Metro Manila.

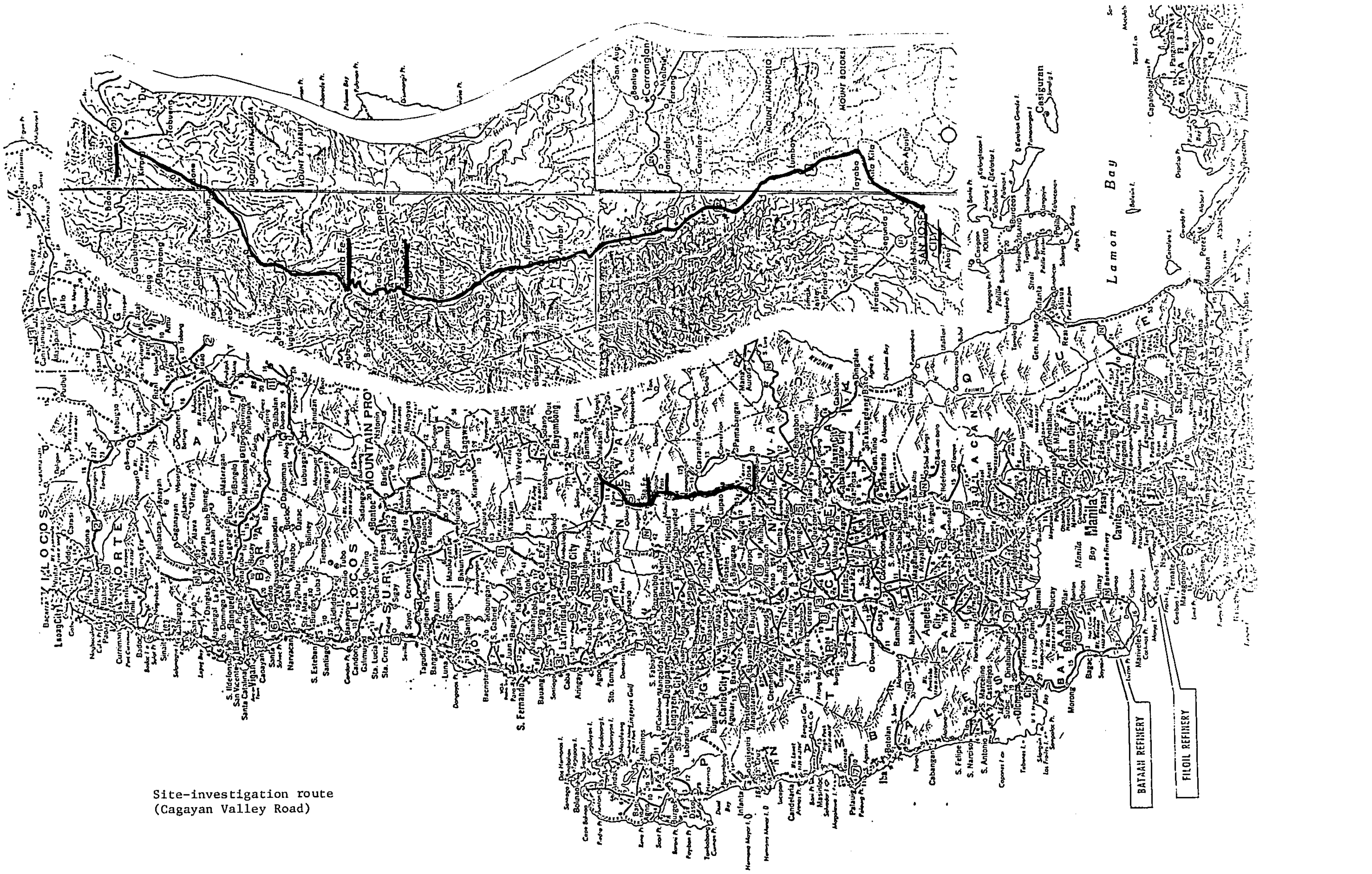
The Japanese Government decided to dispatch the expert engineers to the Philippines under the Colombo Plan, Council for Technical Cooperation in South and South- ast Asia, by the request of the Philippines Government.

Virtually, our mission, composed of one highway, one hydraulic, two soil mechanics engineers, were sent to your country from 30th June to 8th July of 1977.

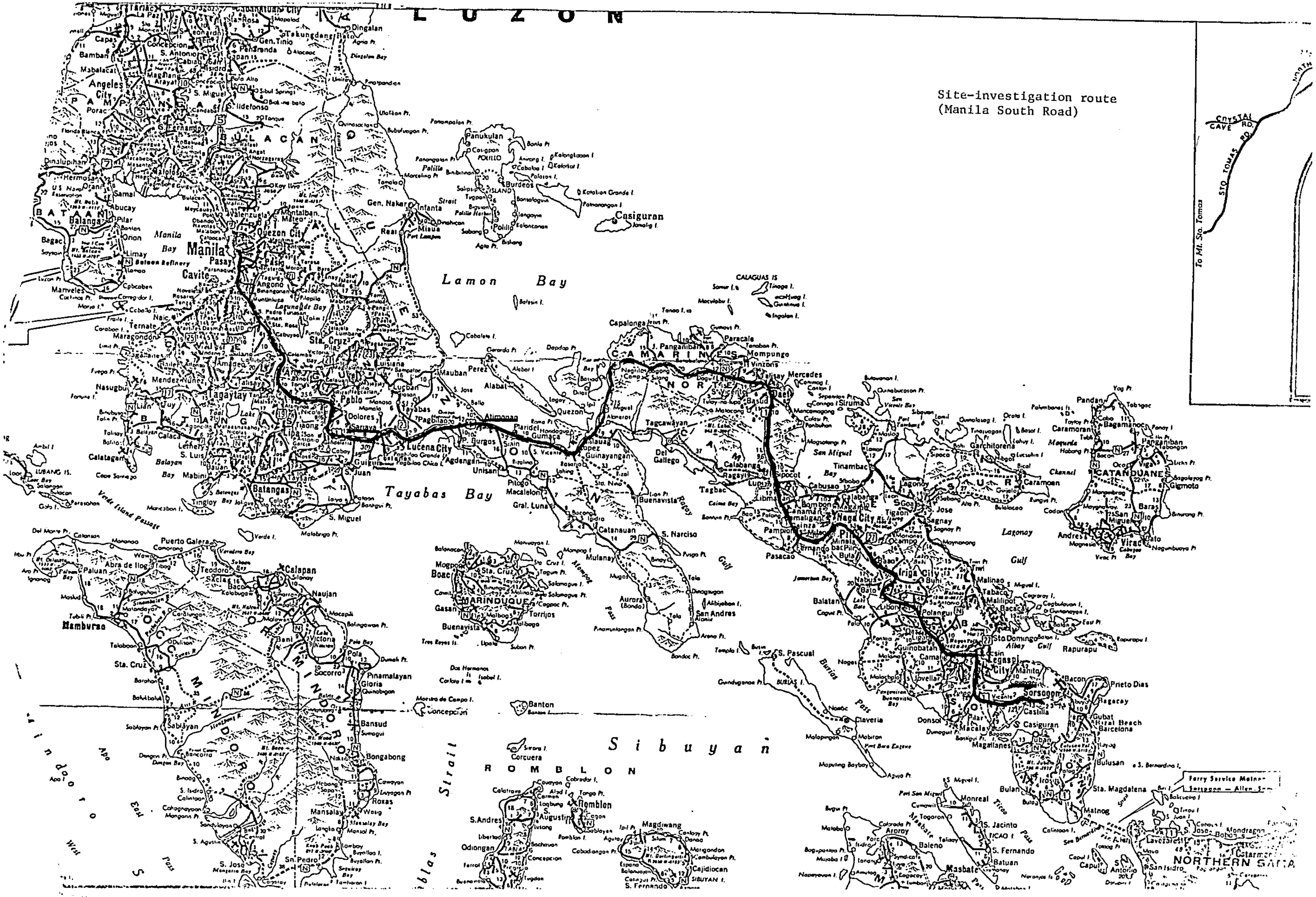
It was a main job for our mission to make clear the major causes of disasters by the typhoon through the field investigations, and to recommend the various aspects of protection works to minimize, if not eliminate, such damages.

Fortunately, we are very happy that successful results have been obtained through our site investiagations and discussions with your excellent counterparts and staffs.

Additionally, by the request of the Department of Public Highways, we visited to the Manila South Road, where were some damaged portions caused by typhoon Didang, and the diversion road under counstruction.
And also we discussed the problems and recommended protection works for them.



Site-investigation route
(Cagayan Valley Road)


LUZON
Site-investigation route
(Manila South Road)
CRYSTAL CAVE RD.
STO. TOMAS RD.
To Mt. Sta. Tomas
Manila
Manila Bay
Quezon City
Pasay
Cavite
Angeles City
BULACAN
BATAAN
Lamon Bay
Tayabas Bay
Sibuyan
ROMBLON
MARINDUQUE
CATANDUANES
CAMARINES NORTE
Naga City
Legaspi City
Sorsogon
Lucena City
Atimonan
Gumaca
Calauag
S. Pablo
Tagaytay
Batangas
Lipa
Calapan
Puerto Galera
Mamburao
Boac
Romblon
Masbate
Iriga City
Daet
Virac
Polillo
Infanta
Lagonoy Gulf
Albay Gulf
Ferry Service
NORTHERN SAMAR

ITINERARY

Date		Record of Trip
May 30, 1977	Monday	(1) Mr. Kotorii, Mr. Sakai and Mr. Kobayashi left Tokyo by P.L at 3 00 P.M. for Manila. (2) Arrived at the Manila International Airport at 7:10 P.M. (3) 9:00 P.M. - 10:00 P.M. Meeting with Mr. Kono the first secretary of the Embassy of Japan, for arrangement of the schedule during stay.
May 31	Tuesday	(1) 9:00 A.M. - 12:00 A.M. Visiting the Embassy of Japan. Meeting with Mr. Kono of the Embassy of Japan, Mr. Yoshida of JICA, Dr. Iwama and Mr. Ohnishi of Katahira & Engineers INC, and pre-arrangement the schedule and basic principles of the investigation.
June 1	Wednesday	(1) Morning: Pre-arrangement at PJHL PROJECT OFFICE (2) Visiting Mr. Aquino, the DPH Secretary, at 2:00 P.M. Asked by the Secretary for investigation on the under-construction areas and damaged areas of the Manila South Road. (3) Reviewed the schedule at PJHL PROJECT OFFICE
2	Thursday	(1) Departure at 6:00 A.M. (2) Manila South Express Highway - Manila South Road - Atimonan - Construction Area on Pagbilao Diversion Road - Damaged portions of filled-up grounds on the road along the River Sapaan - Damaged areas of filled-up grounds on St. No. 190 - Damaged portions of filled-up grounds on St. No. 227 + 100 (Under construction) - Damaged portions of filled-up grounds around St. No. 253 + 800 (7 spots) (3) Stayed at Deat

Date		Record of Trip
June 3	Friday	(1) Departure at 8:00 A.M. (2) Visited Region 3 (3) Bridge Construction On-Site Area over the River Deat - Pagsanghan Bridge On-Site - investigated repairing conditions of the filled-up grounds on a level terrain near City of Naga - visited Region 2 - On-Site investigation of the River Cawayan and Cawayan Bridge. (4) Stayed at Legaspi
4 5	Saturday Sunday	Day-off (Flew back to Manila)
6	Monday	(1) Pre-arranged the schedule for the coming week and inspected the equipments to be used for investigation, at PJHL PROJECT OFFICE. (2) Dalton Pass at 4:00 P.M. (3) Arrangement with the members of Region 2 and Region 3. (4) Stayed at the Rest House
7	Tuesday	(1) Departed the Rest House at 7:30 A.M. (2) Investigated the damaged portions in Region 3. (3) Mr. Kōno of the Embassy of Japan visited us in the evening.
8	Wednesday	(1) Departed the Rest House at 8:00 A.M. (2) Investigated the damaged portions in Region 2. (3) Stayed at the Rest House.
9	Thursday	(1) Departed the Rest House at 7:30 A.M. (2) Carried on survey at the 3 spots for Case Study which were selected from the damaged portions in Region 3. (3) Stayed at the Rest House

Date		Record of Trip
June 10	Friday	(1) Departed the Rest House at 7:30 A.M. (2) Investigated the damaged portions in Region 3. (3) Carried on survey at the same spots as yesterday. (4) Installed an extensometer on a landsliding slope in Region 3. Gave guidance in the method of measurement using the extensometer to the members of Region 2 and 3. (5) Left the Rest House at 4:30 P.M. for Manila. (6) Arrived at Manila at 9:00 P.M.
11 12 13	Saturday Sunday Monday	Day-off (Independance Day) (Transferred Holiday)
14 15 16 17	Tuesday Wednesday Thursday Friday	Desk work at PJHL PROJECT OFFICE
18 19	Saturday Sunday	Day-off
20 21	Monday Tuesday	Desk work at PJHL PROJECT OFFICE
22	Wednesday	(1) Desk work at PJHL PROJECT OFFICE (2) Mr. Okubo arrived at 11:30 P.M. Reported to him the findings of the investigation during the past weeks and prearranged the coming schedule.
23	Thursday	(1) Departed hotel at 6:30 A.M. for Dalton Pass. (2) Re-investigated the on-site in Region 3. Reviewed the protection works. (3) Stayed at the Rest House.

Date		Record of Trip
June 24	Friday	(1) Left the Rest House at 8:00 A.M. for Manila. (2) Re-investigated the on-site in Region 2. Reviewed the protection works. (3) Afternoon: On-site investigation of Access Road to the Pantabangan Dam. (4) Arrived at Manila at 8:30 P.M.
25 26	Saturday Sunday	Day-off
27 28	Monday Tuesday	Drafting the preliminary report at PJHL
29	Wednesday	(1) A.M. 11:00 Visited the Japanese Embassy and submitted preliminary report to the Ambassador. (2) 1:00 P.M. Desk work at PJHL
30	Thursday	(1) Mr. Sakai and Mr. Kobayashi left Manila for Tokyo (2) Drafting the report at PJHL
1	Friday	(1) Drafting the report at PJHL (2) Discussed with counterparts on the causes of the damages.
2 3	Saturday Sunday	Day-off
4	Monday	Drafting the report at hotel (Fil - American Day)
5	Tuesday	(1) Drafting the report (2) Discussed with the counterparts on the recommendation for prevention works. (3) Discussed with the staffs in Region office 4 on the problems of Atimonan-Pagbilao Road.
6	Wednesday	(1) Drafting the report (2) Discussed with the counterparts on the final report.

Date	Record of Trip
July 7 Thursday	(1) Drafting the summary of final report. (2) Discussed with the staffs, counterparts of PJHL and the first secretary of the Japanese Embassy, Mr. Kōno on the final report. (3) Submitted the summary of the final report. PJHL (1) Japanese Embassy (1) JICA (1)
8 Friday	(1) Mr. Kotorii and Mr. Okubo left Manila for Tokyo at 11:30 A.M.

PART-A CAGAYAN VALLEY ROAD (CVR)

I. FINDINGS

PART-A CAGAYAN VALLEY ROAD (CVR)

I. FINDINGS

1. SOCIAL BACKGROUND AND OUTLINE OF CVR

1.1 Social Background of CVR

The Cagayan Valley Road is a part of the Pan-Philippines Highway traversing the Philippines land from the northernmost Luzon Island to the southernmost Mindanao Island.

The Pan-Philippines Highway has been eagerly performing the construction to promote the economic development of the Philippines. Specially, after the conclusion of agreement between both countries of the Philippines and Japan as for the loan of the construction expenses to the Philippines Government by the Japanese Government in 1969, the construction of this highway has been being executed at high speed owing to the endeavor of the Philippines Government, though there is some delaying of the completion by the difficulties of procurement of Pesos and the influence of oil embargo and so on.

The CVR is a only one main route connecting the Cagayan Valley Region constituted by the Cagayan, Isabela, Ifugao, Kalinga Apayao and Nueva Vizcaya Provinces to the Greater Manila and is extremely important highway for the economic development of the Luzon Island.

The industry structure of the Cagayan Valley Region depends on the agriculture overwhelmingly and the agriculture employee exceeds more than 80 percent by the 1970 census. (Table I-1-1 [*1])

Table I-1-1 Employee Percentage

*1

Province	Cagayan	Isabela	Nueva Vizcaya	Ifugao	Kalinga Apayao	Cagayan Valley Region	Philippines
Primary Industry	75%	78%	76%	78%	90%	79%	55%
Secondary Industry	8	7	7	6	2	7	17
Tertiary Industry	17	15	17	16	8	14	28

*1 JICA : Report on the Electrification Project in the Cagayan Valley Region, September 1975

However, the Cagayan Valley Region retains the abondoned natural resources such as vast fertile land, various undeveloped minerals and forest accumulation.

The alienable land in the Cagayan Valley Region is about 600,000 ha and 470,000 ha area corresponding more than 77 percent is cultivated. (Table I-1-2 *2). The cultivated land produces the Palay (rice), corn, fruits and nuts, root crops, tabacco and coffee, ordering by the production value. However, the cultivation method in this region is primitive without any irrigation facilities. The Philippines Government is eagerly promoting the development of this region, the welfare improvement of people living in this region and the production supply to the Greater Manila through the agricultural production increase and the effective utilization of alienable land. *3

Table I-1-2 Land Utilization

*2

	Alienable land		Cultivated land	
	Area(A) (10^3ha)	Percentage (%)	Area(B) (10^3ha)	Ratio (B)/(A)%
Cagayan Valley Region	595	100	469	78
Cagayan	249	42	143	57
Isabela	212	36	204	96
Nueva Vizcaya	53	9	40	75
Kalinga Apayao	58	10	58	100
Ifugao	21	4	21	100

*2 JICA : Report on the Electrification Project in the Cagayan Valley Region, September 1975.

*3 : Regional Development Projects Supplement to the Four-Year Development Plan (FY 1974-77)

It is estimated that mineral resources such as manganese, iron ore, limestone, copper, sulfur, silver and gold are amply reserved in this region.

However, some of them are not enoughly mined yet. In future, the mining of these mineral resources is highly expected.

As for the timber resources, in Cagayan Province, only 40 percent of the 30 million cubic meters of standing timber measuring 50 centimeters and over in diameter can be found in accessible forests.

Isabela Province keeps the highest timber production in Luzon Island by the statics of 1973.

Nueva Vizcaya Province is covered by forests more than 80 percent of the land. As mentioned above, the harvesting and timber producing in this region is comparatively progressive.

An addition to this fact, the development of timber productions in unaccessible forests and the transportation them to the Greater Manila or appropriate harbours is highly expected.

The CVR is becoming more important to connect this region to the Greater Manila and to bear the function for the transportation route by the further development of the Cagayan Valley Region.

Table I-1-3 shows the comparison of traffic volume at Dalton Pass measured in 1967, before the construction or improvement of the Pan-Philippines Highway, and in 1976, after completion the highway portions in the vicinity of Dalton Pass. Although these data are not enough to analyze the accurate traffic volume situations, we can find out that the traffic volume is exceedingly increasing recently falling into step with the development of the Cagayan Valley Region.

Table I-1-3 Traffic Volume at Dalton Pass

Per day

	Car	Jeep	Bus	Truck	Total
1967	76	20	26	53	175
1976	583	220	417	740	1960

The traffic volume is not so large compared to the suburban or urban area, but this table shows that the CVR is presented for the transportation between long distance areas and has the characteristics for the industrial highway from the point of view that the proportion of trucks is reasonably high.

1.2 Outline of CVR

The Cagayan Valley Road before its improvement is an existing 6.00 meters gravel road. The Sauti Consulting firm designed the Road for Improvement as follows: (Figure I-1-1)

(1) Portland Cement Concrete Pavement is 6.70 meters in width and 0.23 meter in thickness.

(2) The base course is gravel, 0.60 meter in width and 0.20 meter in thickness.

(3) The selected borrow base course is 7.30 meter in width and 0.20 meter in thickness.

(4) The width of the shoulder is 2.50 meter and has a thickness of 0.20 meter (0.10 meter gravel and 0.10 meter selected borrow base course.)

(5) The gradient of the side slope in embankment side is $1\frac{1}{2}$: 1 to 4 : 1 (variable).

(6) The gradient of the hill side cut is $\frac{1}{4}$: 1 (Rock), 1 : 1 (Rippable Rock) and $1\frac{1}{2}$: 1 in ordinary earth.

The improvement of this road was advertized for public bidding way back in 1973. In the process of construction there comes the inflation and oil embargo that resulted the delay of the project for almost one year. Another factor that made the construction difficult is that during rainy season, erosion, slides and scouring occur during heavy rain and flash flood from the mountain area.

The construction of the road was almost finished in May 1975 when typhoon Didang strikes the area. Several slide, erosion and scouring occurs and almost the whole sections of Dalton Pass, from San Jose City to Sta. Fe, Nueva Vizcaya was closed to traffic for almost one month period.

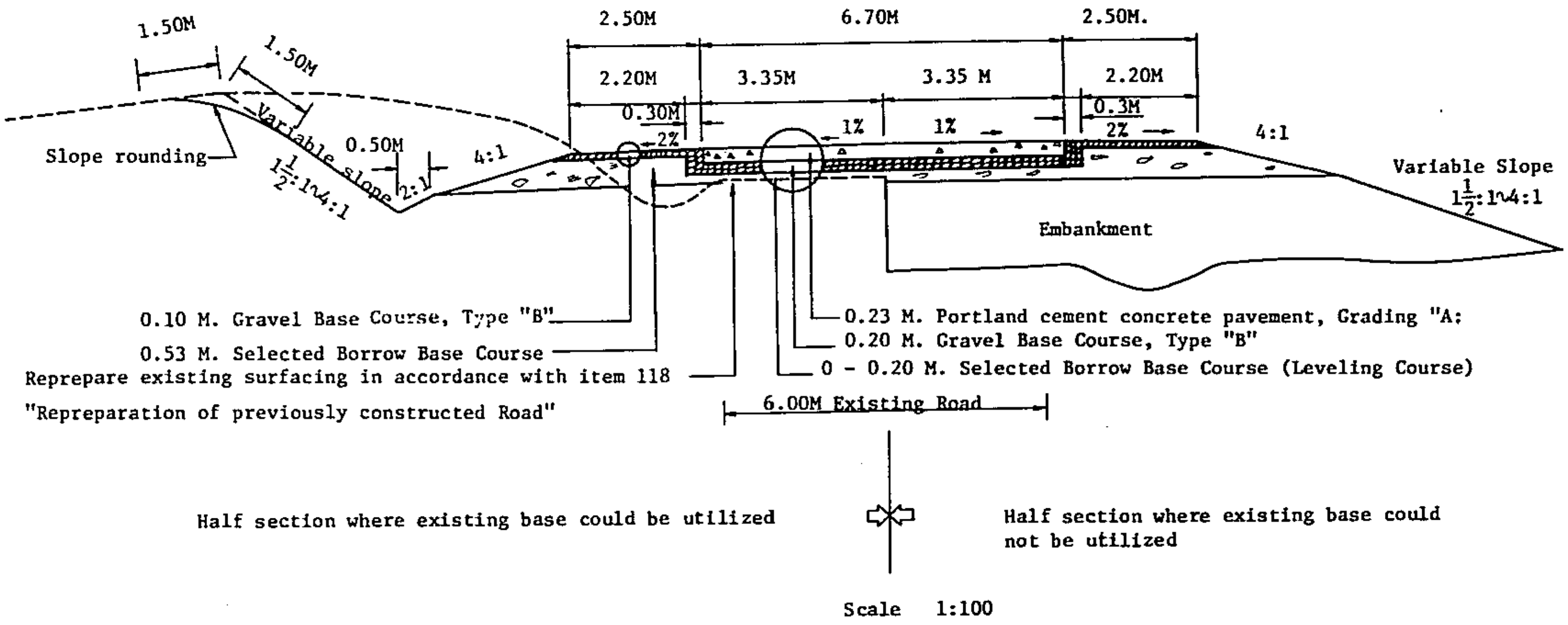


Figure I-1-1 Typical Roadway Section Philippine-Japan Friendship Highway

2. TOPOGRAPHICAL AND GEOLOGICAL CONDITIONS

2.1 Topography

(1) Outline

Figure I-2-1 and I-2-2 show the geologic map around area of CVR. The elevation of mountains in the vicinity of Dalton Pass ranges from 200 meters to 900 meters. The slopes are generally steep. The summit of the mountains in granitic area is considerably gentle and developes the flat terrain compared to the Palaeozoic system area. In Tertiary area the terrain developes rolling hills. In both sides of the Talavera River and the Santa Fe River, two or three steps of terraces are formed.

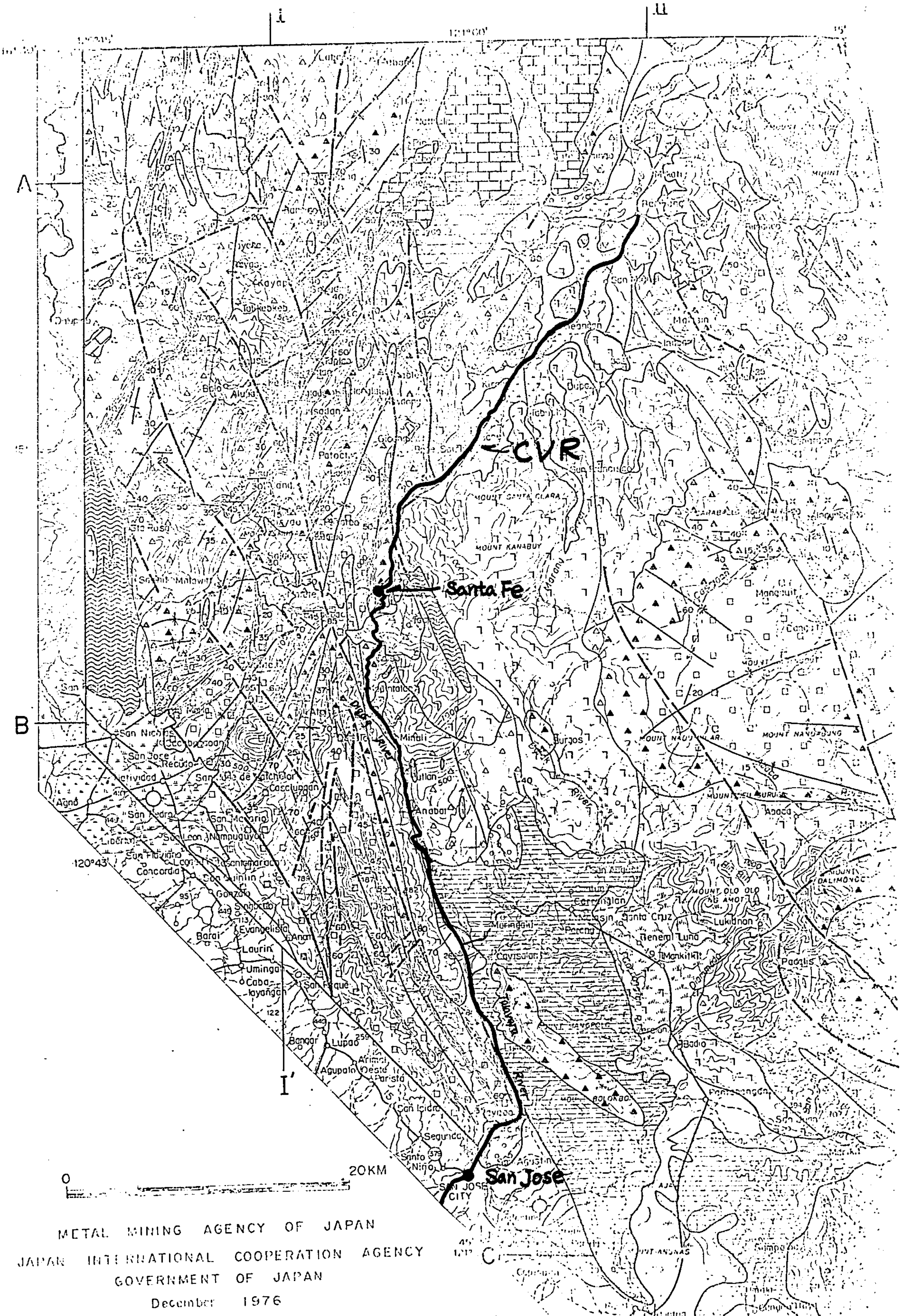
(2) Characteristics

① The Digdig River and the Talavera River between Rosaldo and Dalton Pass, its linear stretch is about 30 kilometers, are considered to be formed in fault valley from following reasons.

ⓐ The direction of fault valley is N 20° ∿ 30°W and extends linearly.

ⓑ The geologic condition surrounding the fault valley is extremely disturbed and fragile.

ⓒ In the vicinity of the fault valley, slope failures are frequent.



METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1976

Figure I-2-1 Geologic Map

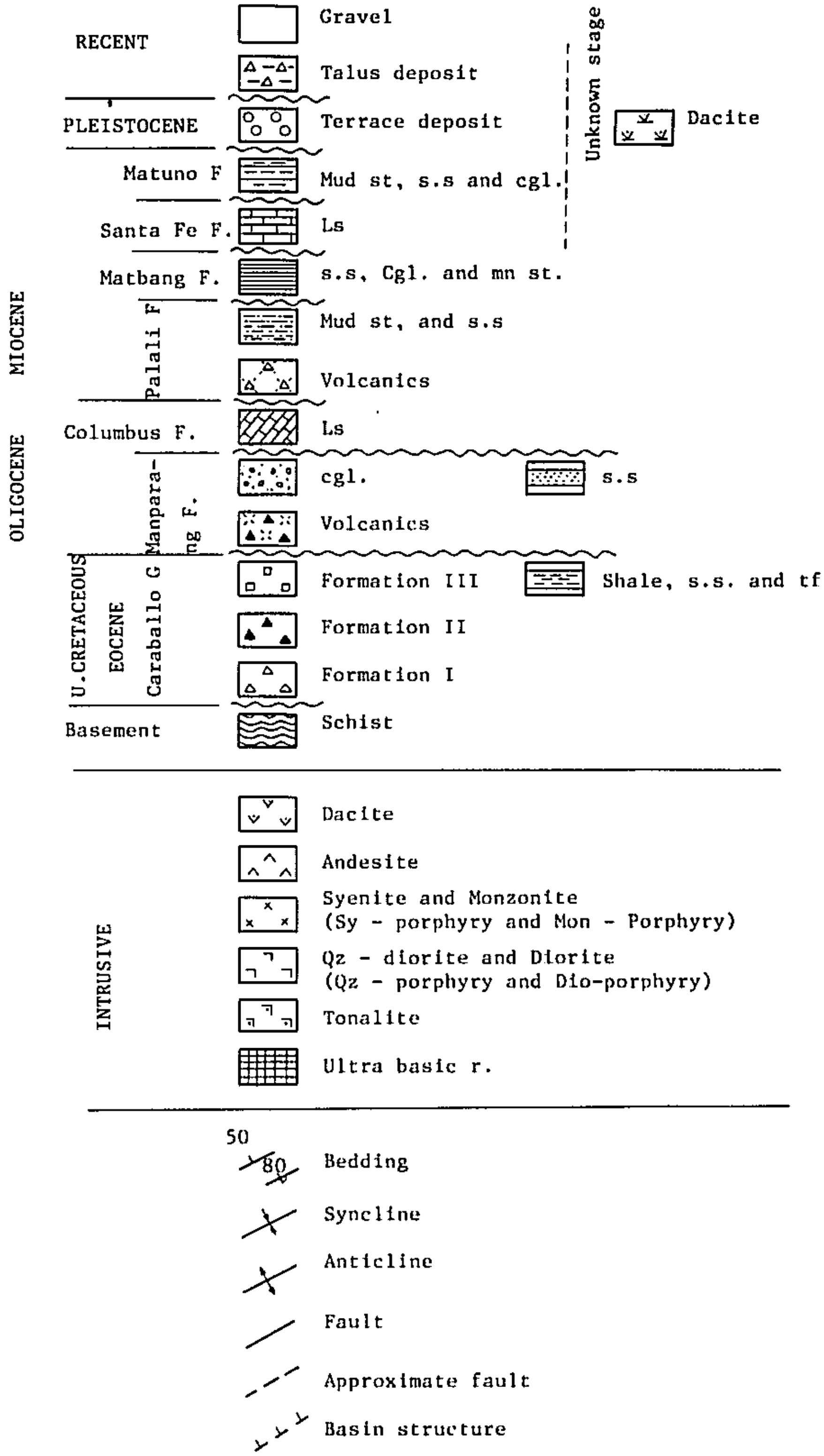


Figure I-2-2 Legend of Geologic Map on Figure I-2-1

ⓓ In these areas, the summit level is commonly recognized.

ⓔ On cut slopes, many fractured zones being paralleled to or branched from the main fault are confirmed.

② Surrounding area of Digdig developed two or three terraces.

ⓐ The uppermost terraces locate on the elevation about 300 meters. These terraces develope on the mountain-side and gently inclining small flat lands.

ⓑ The middle terraces locate on the elevation from 260 meters to 280 meters and are covered by gravels.

ⓒ The lowermost terraces locate on the elevation from 250 meters to 260 meters and form the vast flat lands. The thickness of terraces is about two or three meters and it is considerably thin.

③ Slope failures

ⓐ Slope failures occur in every kinds of rocks.

ⓑ The thin subsurface failures are common.

ⓒ The water spring or seepage on the failured slopes is frequently recognized.

ⓓ The general causes of failures are following.

- Fragile geologic conditions affected by faults.
- Wide distribution of cracky and heavily weathered rocks.
- Water spring and seepage on the slope.
- High erodibility of surface by heavy rain.
- Climatic condition to make weathering easy.

2.2 Geology

(1) Geologic structure

The relation among the sandstone, slate, schalstein and limestone is conformity. The strike of stratification is N 20° ∿ 40°W and the dip is 40° ∿ 70°W.

The relation between granite and sandstone, slate, schalstein and limestone is partially fault and partially intrusion.

The relations among conglomerate and sandstone of tertiary, sandstone slate and schalstein of Paleozoic, and granite are unconformity each other.

Unconsolidated rock such as talus deposit and terrace deposit distributes unconformitically with base rock.

Figure I-2-3 shows a typical cross section of geologic stratification.

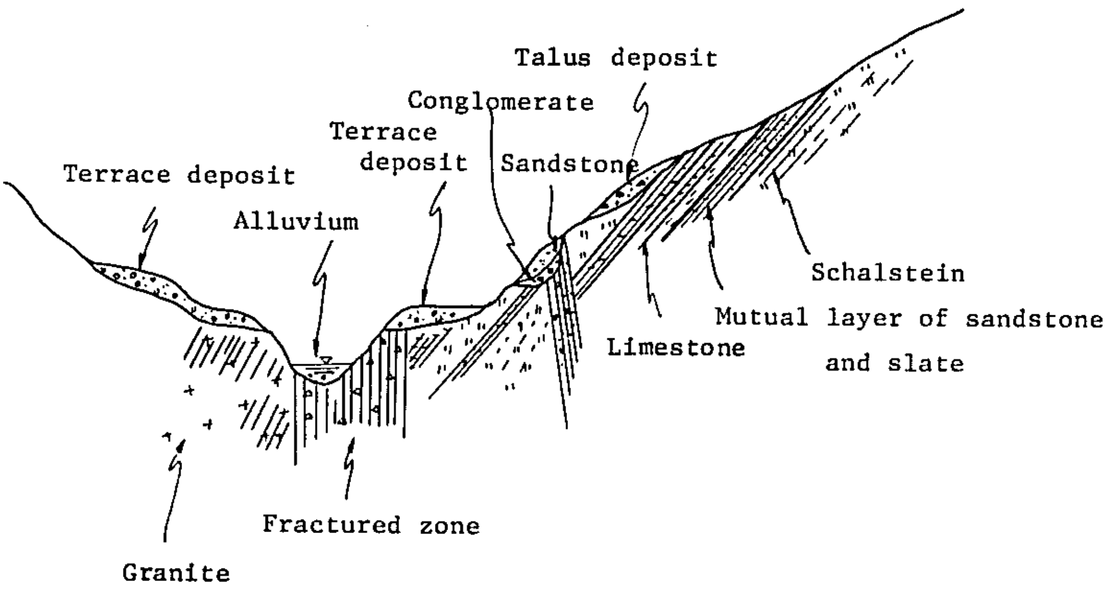


Figure I-2-3 Typical Cross Section of Geologic Stratification

① Fault

Main fault extends from Rosald to Dalton Pass with the direction of N 20° ∿ 30°W.

By the influence of fault, the stratification has much variations and is highly disturbed and resulted to be fragile.

Several small faults distribute by the direction of EW between main fault and N-S fault.

② Intrusion direction of granite

The granite intrusion is estimated to extend to N-S direction.
The direction of granite intrusion is approximately same with the main fault direction and partially contact with the fault. Therefore, the intrusion and faulting is estimated to be repeated each other.

(2) Geologic time

The geologic horizon is estimated in this region as shown on Figure I-2-4.

- Cenozoic
  - Quaternary
    - Alluvial Epoch
      - River bed material
        sand, gravel
      - Alluvial deposit
        sand, gravel, clay
      - ⓑ Talus deposit
        rock fragment, gravel
    - Diluvial Epoch
      - Clay, sand
      - ⓐ Terrace deposit
        sandy soil bearing round gravel
  - ⓒ Tertiary --- Pliocene ------ sandstone, conglomerate
- ⓓ Mesozoic --- Cretaceous ---------------- andesite, porphyrite / quartz porphyry, / granite porphyry, granite
- ⓔ Paleozoic --- Permian ------------------ sandstone, limestone / schalstein, slate

The characteristics of ⓐ ~ ⓔ will be described below.

Figure I-2-4 Geologic Horizon

(3) Characteristics

ⓐ Terrace deposit

Two or three steps of terraces distribute on both sides of the Talavera River and the Santa Fe River.

The gravel ratio of terraces ranges from 30 percent to 50 percent. The matrix material is sandy soil. Gravels are round or semi-round and have maximum diameter of 1.0 meter.

Almost of gravels originates to granite, sandstone, slate and schalstein.

ⓑ Talus deposit

The talus deposit distribute on the slopes in the range from middle slope to toe in the mountainous area.

The inclination of talus deposit is reasonably gentle. The talus deposit bears sharp edge gravels and sometimes rock fragments. This often developes in the fragile rock area such as fractured and heavily weathered zones. The mixing ratio of gravels is about 30 to 50 percent. The matrix material is clayey rather than sandy.

The gravel size is generally 5 to 20 centimeters and sometimes extends to 1.0 to 1.5 meters.

ⓒ Tertiary

The Tertiary distributes in the vicinity of Lumboy. The terrain of Tertiary area is comparatively gentle. The rock of upper part in Tertiary area is sandstone which is constituted by fragile and rough grains, on the other hand conglomerate originated to granite, sandstone and slate is the main contribution in lower part which has well sorted grain distribution. The average grain diameter is 3 to 5 centimeters and the mixing ratio of gravels is 30 to 40 percent.

Both rocks of sandstone and conglomerate has poor foliation.

ⓓ Mesozoic rock

The main rock of Mesozoic period is granitic rocks and their intrusions.

The granitic rocks vary their quality as qualtz porphyry and granite porphyry by the location of their distributions. These differences are not originated to the time of intrusion formation but to the influence by the quality of surrounding rocks.

The granitic rock in the vicinity of Dalton Pass is mainly constituted by black mica-granite and is heavily weathered.

The granitic rock in the vicinity of Rosaldo changes its aspect by the locations and is wholly fractured, sometimes changes to gneiss. In the vicinity of Capintalan, it shows white color and contains scarce black mica, changes to the rock like quartz porphyry.

The intrusions are mainly constituted by andesite and porphyrite. Around Dalton Pass, porphyrite is advantage and shows remarkable porphyritic structures.

ⓔ Paleozoic rock

The Paleozoic formation is constituted by schalstein, slate, sandstone and limestone. The schalstein distributes in vast area and shows extreme varieties in color such as green to dark green and in rock quality such as breccia to diabase.

The foliation is poorly developed. Surrounding area of fractured zone, the rock is highly changed to clayey soil.

Main part of sandstone is dark green to gray colored graywacke. Sometimes it is very hard by contact metamorphism. The foliation is well developed and has 15 to 20 centimeters space with open cracks.

Black-gray or black colored slate constitutes the thin mutual layers with sandstone and schalstein.

The foliation is well developed and has 5 to 10 centimeters space with open cracks.

The limestone is non-crystal hard rock of gray-white to white colored.

This distributes in Minuli and Dalton Pass. In these areas, many boulders having 3 to 5 meters maximum diameter are remarkably recognized.

3. CHARACTERISTICS OF TYPHOON DIDANG

The May 1976 flood is one of the worst floods that affected Central Luzon. In the Pampanga River Basin the destructive flood waters lasted for more than a week in many areas causing heavy damages to property and a number of lives loss.

The typhoon Didang entered the Philippine Area of Responsibility on the 13th of May and remained quasi-stationary for sometimes before it moved on a west northwesterly track at an average speed of 16 kph until the 19th (Figure I-3-1). At this time, she packs maximum winds of 100 kph near the center. Didang intensified into a thyphoon afterwards and slowed down consequently becoming quasi-stationary movement plus the fact that the weakening was slight despite staying inland for two days, dumped in heavy rains over Metro Manila and Central Luzon. The passage of typhoon Didang resulted in record breaking rainfall amounts.

As to the Pampanga River Basin, a comparison of rainfall amounts between this flood and the major floods of October 1973 and August 1974 is shown in Table I-3-1.

Table I-3-1 Meteorological Conditions for The Recent Major Floods

	May 1976	August 1974	October 1973
Maximum daily rainfall	211.5 mm	183.7 mm	208.4 mm
Total rainfall	836 mm	457 mm	254 mm
Rainfall duration	9 days	5 days	54 hours

According to the rainfall intensity-duration-frequency analysis, the intensity of rainfall at the Port Area by typhoon Didang might be estimated 2 to 5 years for return periods. (Table I-3-2)

As far to the data around the Dalton Pass, in Bayombong City (about 40 km north), total rainfall during 20th to 28th recorded 423.2 mm, and also it was recorded 130.4 mm for maximum daily rainfall, 10.4 mm, for maximum hourly rainfall. And in Rizal City (about 50 km south) it was recorded 945.3 mm for the total rainfall during 19th to 28th, 273.2 mm for the maximum daily rainfall, 26.2 mm for the maximum hourly rainfall.

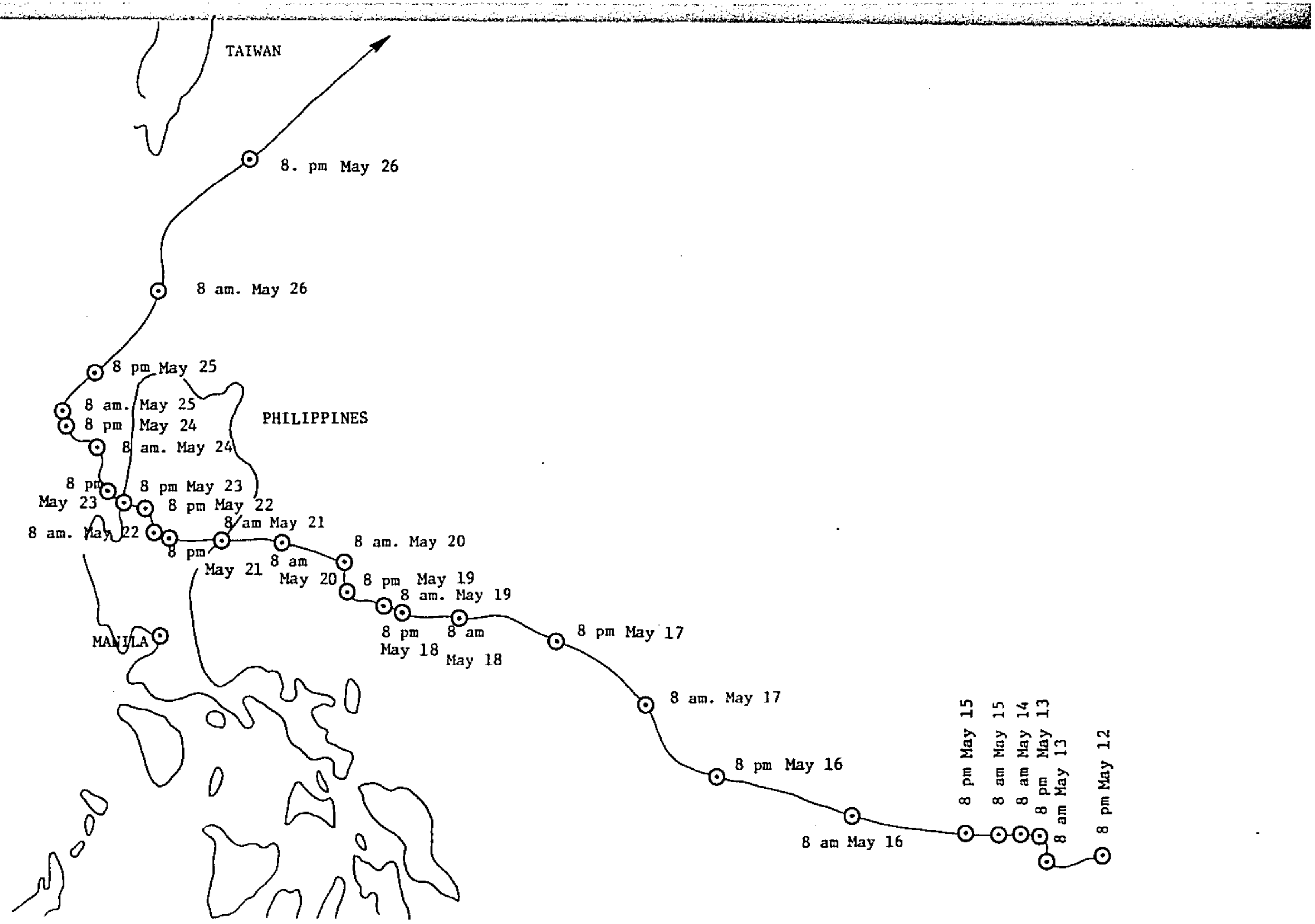


Figure I-3-1 Cyclone Track of Typhoon Didang May 12 ∿ 27, 1976

Table 1-3-2 Rainfall Intensity

Station : Port Area Manila

RETURN PERIOD (years)	EXTREME RAINFALL AMOUNT FOR THE INDICATED DURATIONS (millimeters)														
	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins	80 mins	100 mins	120 mins	150 mins	3 hrs	6 hrs	12 hrs	24 hrs
2	13.5	22.0	28.7		43.2	.	59.7			74.9		83.9	106.4	131.0	170.3
5	17.3	28.8	37.9		56.6		76.0			98.0		110.5	144.7	185.1	247.8
10	19.8	33.2	44.0		65.5		86.8			113.3		128.1	170.1	220.9	299.1
15	21.2	35.7	47.4		70.5		92.9			121.9		137.8	184.2	240.9	327.8
25	23.0	38.8	51.7		76.8		100.5			132.7		150.2	202.1	266.1	363.9

prepared by

the HYDROMETEOROLOGICAL DIVISION

p.a.g.a.s.a

The statical data concerning this area are shown in the following table.

Table I-3-3 The Rainfall Intensity for Return-periods

millimeters

	2 years		10 years		25 years	
	1 H	12 H	1 H	12 H	1 H	12 H
Rizal	40-50	100	70-80	150-200	90	200
Bambang	20-30	100	20-30	150	30	150

The rainfall recorded 269.6 mm for 12 hours in the maximum in Rizal City. This intensity of rainfall excesses more than 25 years return periods. But in Bambang, the maximum 12 hours rainfall was 83.2 mm which did not exceed 2 years return periods.

In comparison to the data in Bambang City and Rizal City where was the nearest stations available, there was great difference in rainfall between two cities. So it was difficult to estimate directly the weather conditions during typhoon Didang at Dalton Pass from the rainfall data in Bambang and Rizal City.

But it was the fact that the conditions of disasters north-side and south-side of Dalton Pass were very different. Especially the damage was very heavy along the Talavera River south-side of Dalton Pass, but the damage was comperatively slight along the Cagayan River north side of it.

Judging from the actual conditions of disasters and the rainfalls in the both cities, the characteristics of rainfall due to typhoon Didang around Dalton Pass could be assumed as follows:

① At the south-side of Dalton Pass, there was very heavy rainfall similar to the intensity of the rainfall in Rizal City.

② At the north-side of Dalton Pass, there was not so heavy rainfall similar to it in Bambang City.

③ Both daily rainfall and hourly rainfall were not observed so heavy but total rainfall exceeded more than 25 years return periods.

At the conclusion, the major causes of disasters by typhoon Didang was not depending on the intensity of rainfall, but on the total amount of rainfall brought by typhoon Didang.

4. DAMAGES OF ROADS CAUSED BY TYPHOON DIDANG

4.1 Landslides and Embankments Erosion

At the height of Typhoon Didang which lasted for 10 days landslides in the cut section and erosions in Dalton Pass occurred. After the typhoon, massive clearing of debris and removal of slide, boulder and earth were carried out for 24 hours a day. Inspite of this marvelous restoration the road section which was damaged was still unpassable to traffic for 23 days. They used all necessary and available equipments of the contractor and government to open this road to traffic in a record time of 13 days.

This shows the evidence how important of this road to people living in this vicinity and economic growth of the country. However the slope protections, embankment protections and drainage system is not enough to withstand to another disaster that might occur this coming rainy season.

In this chapter, we will report the characteristics of slope failures in the three sections, Sta. 167 - Sta. 174, Sta 182 + 500 - Sta. 209 + 700 and Sta. 209 + 700 - Sta. 222.

(1) Sta. 167 - Sta. 174

Geologically, the base rock is said to be an origin of the Mesozoic Era. The base rock is constituted of sandstone and shale and their mutual layer developing the joints and cracks. Dip and strike on the cut slope is approximately $40° \sim 70°$SW and N $20° \sim 30°$W, and the direction of layers declines opposite to the slope inclination.

Most important geologic characteristics of this area is that the large scale fractured zone is located parallel to the Talavera River. Around this fractured zone, geology is very complex by fractures and faults and keeps high possibility of failures. Accordingly, small slope failures are advanced compared to large massive sliding on cut slopes.

The height of mountains along the river is comparatively low and has flat top, but the gradient of slope is so steep more than 40 degrees.

Surface of slope is covered mostly by low bushes. This shows that the top soil was sometimes washed out by sliding.

From the point of view mentioned above, the reasons of failures are the following:

① The cut slopes are designed more steeply than the angle of repose.
Gradient of cut slopes is too steep to withstand the stability of slopes.

② No protection on cut slopes after construction increases the possibility of failures by weathering and erosion.

③ This area is used to be attacked by high intensity rainfall, the cut slopes are apt to be eroded by surface water concentration.

(2) Sta. 182 + 500 - Sta. 209 + 700 (Dalton Pass)

The Geology of this section mainly consists of volcanic detritus including local granitic rock and limestone. Especially the rock is fractured by faults and becomes soft in the sections of Sta. 193 - Sta. 202 and Sta. 205 - Sta. 207.

The road of this area is located along the left bank of the Talavera River, and the gradient of layer is parallel to the slope directions. This shows that the comparatively large massive sliding is advanced.

As the road of this section climbs up curving to the Dalton Pass, almost all road portions are constructed by cut and fill slope combination. Also the cut slopes are remained without any protections. Accordingly, almost of the cut slopes occurred failures.

The failure is divided into two types as follows:

① Large Massive sliding.

② Subsurface failure by erosion.

(3) Sta. 209 + 700 (Dalton Pass) - Sta. 222.
Base rock consists of granitic rock.

Zigzag road is constructed on the hillside of weathered granite. This section does not have so much cut slope problems but on the other hand vertical erosion of small steep river bed crossing the road and embankment erosion is relatively important.

Performance of the protection and countermeasures against water and sediment discharge from such a small steep river is recommended in this section.

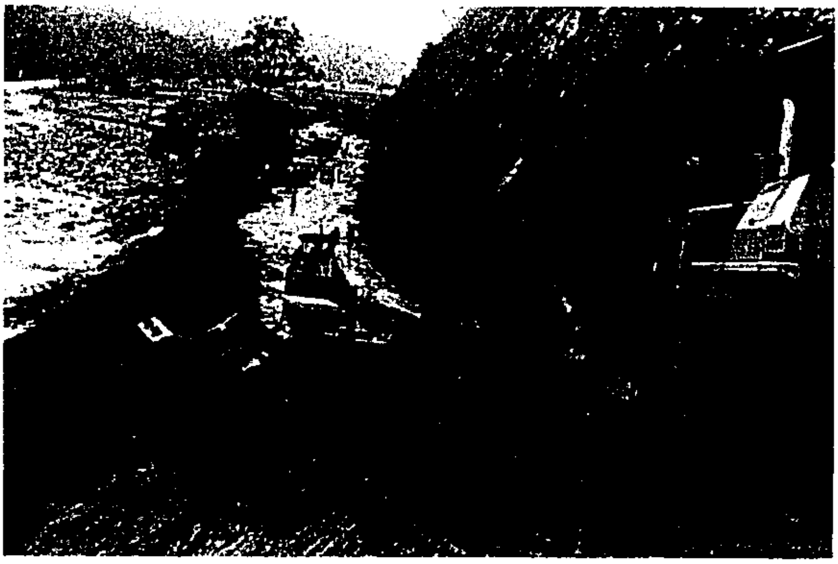


Photo I-4-1 Sta. 170

Photo I-4-2 Sta. 170 + 820

Photo I-4-3 Sta. 171 ∿ 172

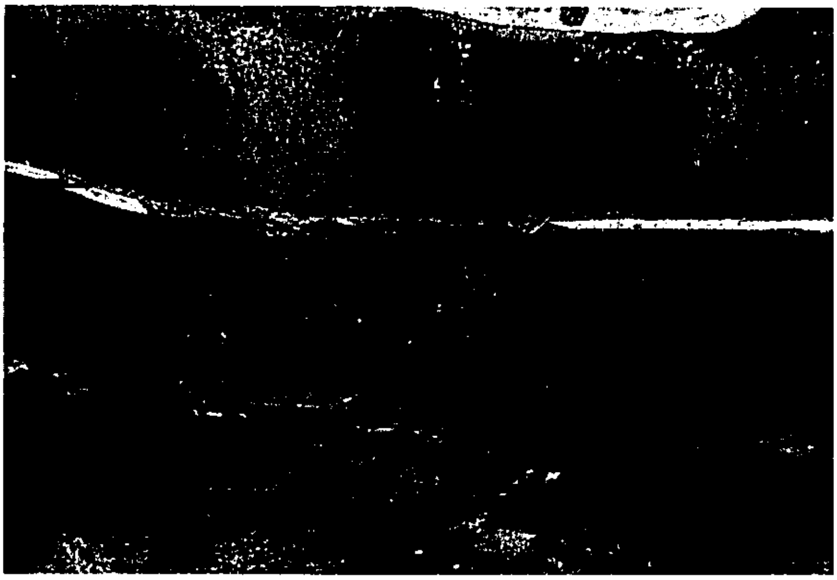


Photo I-4-4   Sta. 204

Photo I-4-5   Sta. 207 ∿ 208

Typical conditions of damaged portions around Dalton Pass caused by typhoon Didang.

4.2 Destruction of Drainage Systems and Influence to Landslides and Embankment Erosion

Damages of drainage systems and their affections to the road are shown as follows.

1) Shoulder Scouring
2) Silting in side ditches
3) Silting in cross drainage inlets
4) Scouring of cross drainage outlets
5) Insufficient water way area for cross drainage.
6) Some of cross drainage are not properly located.

(1) Shoulder scouring

Lateral and vertical scouring of shoulder resulted the destruction of side ditches. Specially, this type of damage is common in mountaineous area, where road is curving continuously.

Figure I-4-1 and Photo I-4-6 show typhical damage of shoulder scouring.

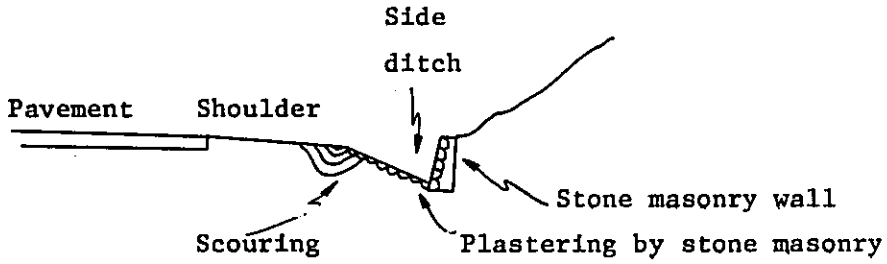


Figure I-4-1 Shoulder Scouring

These kind of shoulders scouring and destruction of side ditches affect to the stability of the road. Influence to the road by overflowing water is summarized as follows:

A : Fill section

a - The destruction of hillside ditches will induce the water to seep or infiltrate through the embankment and will result in the sliding of the entire fill section. (Figure I-4-2)

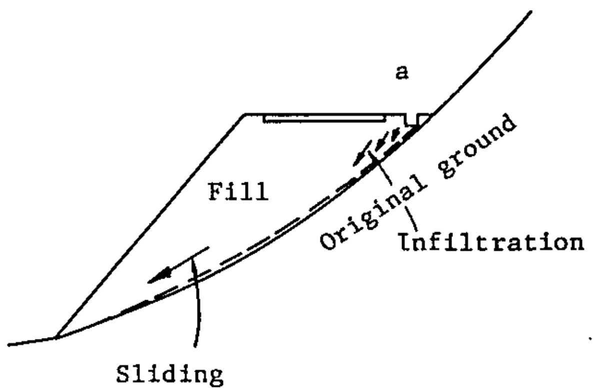


Figure I-4-2 Fill Section

B : Cut section

b - The destruction of hill side ditches by erosion will make the toe of cut slopes unstable. (Figure I-4-3)

C : Cut and fill section

c - Similar type with b.
If the water infiltrates into fill section, sliding of fill section will be expected.
(Figure I-4-4)

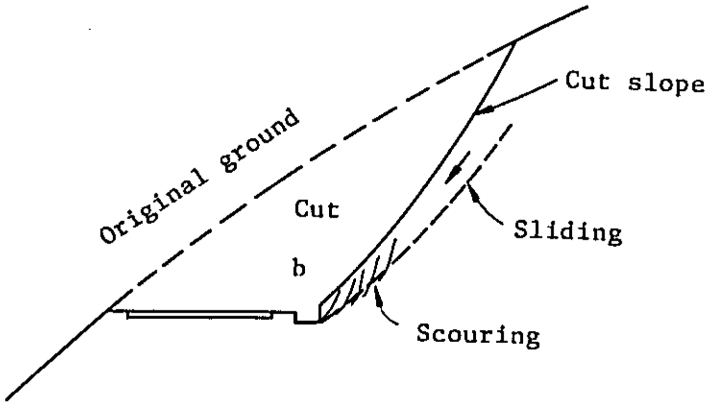


Figure I-4-3 Cut Section

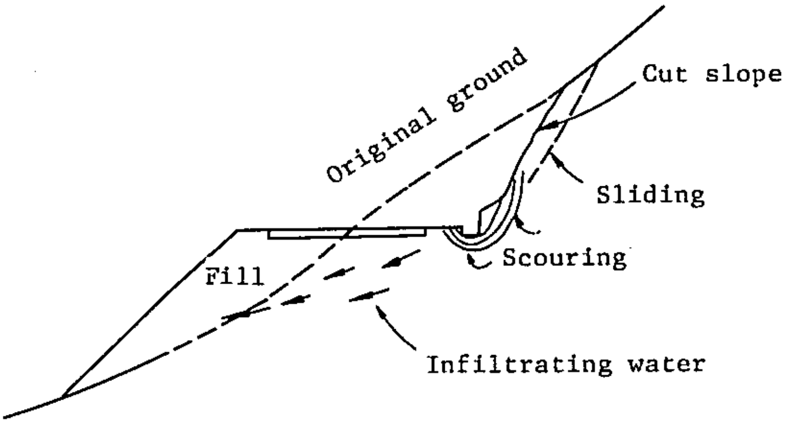


Figure I-4-4 Cut and Fill Section

(2) Silting in side ditches

Extensively silted side ditches will overflow the running water and the runoff will flow across the road pavement and result in the erosion and sliding of embankments.

(3) Silting in cross drainage inlets

Debris from slope failures and sediments carried by surface runoff blocks the inlets and results in the overtopping of roadway.
Photo 1-4-7 shows the shoulder scouring by surface water on pavement to have overflown by the blockade of inlet.

Figure I-4-5 shows the inlet without covering. This type of inlets is very simple and only has small amount of capacity and will be easily scoured. (Photo 1-4-7)

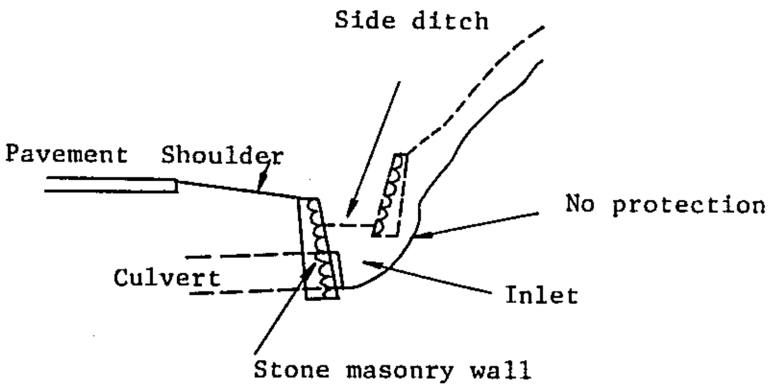


Figure I-4-5 Inlet without Covering

Figure I-4-6 shows the inlet protected by stone masonry wall restored after the Typhoon Didang.
This type of inlets are highly recommended because of their enough capacity and the protection against scouring.

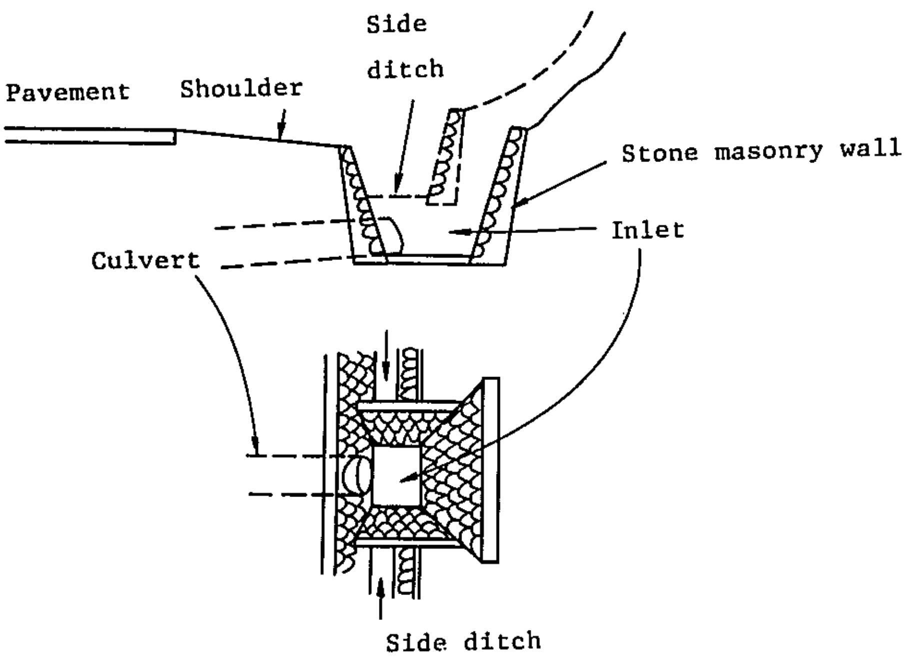


Figure I-4-6 Inlet Protected by Stone Masonry Wall

Photo I-4-6 Shoulder and Side Ditch Scouring
Inlet without covering is also scoured.

Photo I-4-7 Shoulder Scouring

Surface water on pavement overflew by the debris blockade of inlet scoured shoulder.
Sta. 192 ∿ Sta. 193

(4) Scouring of cross drainage outlets

The lack of protection of outlets often causes of the scouring and sliding of slopes. Especially the road portion close to Dalton Pass curving continuously has very much these type of damages.

Photo I-4-8 and Photo I-4-9 show the scouring around the cross drainage outlet by water flow in cross drainage and on pavement surface.

Figure I-4-7 shows the sliding induced by outlet scouring in the vicinity of Sta. 205 - 206.

(5) Insufficient water way area for cross drainage

The cross drainage at least must have enough water way area which can flow down the water concentrating in inlet. If the water way area is not enough, the water flow will pond in inlets and overflow on the pavement and causes of unstability of road. If the slope failures or sediment movement is predicted at the upper part of the channel crossing the road, additional enough allowance of water way area will be recommended. Following are the instances of these kind of damages at the Sta. 213.

Sta. 213(1) :
The surface of slope is covered by weathered granite. The road crosses a small channel. This small channel yielded a great amount of sediment at the height of Typhoon Didang. The sediment deposited on the pavement. The water overflew on the pavement and scoured the embankment and resulted the sliding of embankment including pavement. (Figure I-4-8)

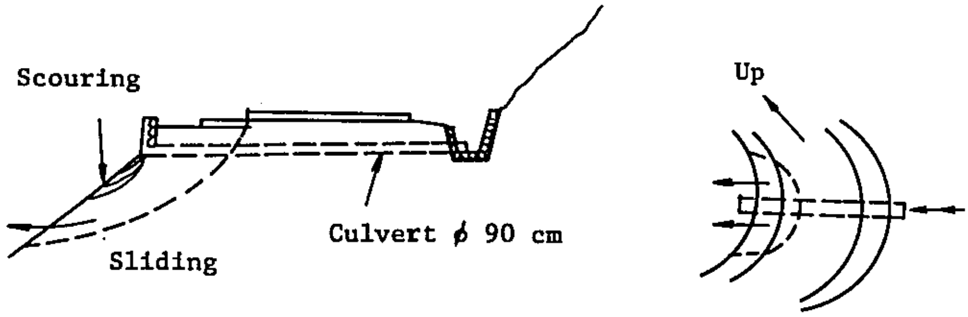


Figure I-4-7 Sliding Sta. 205 ∿ 206

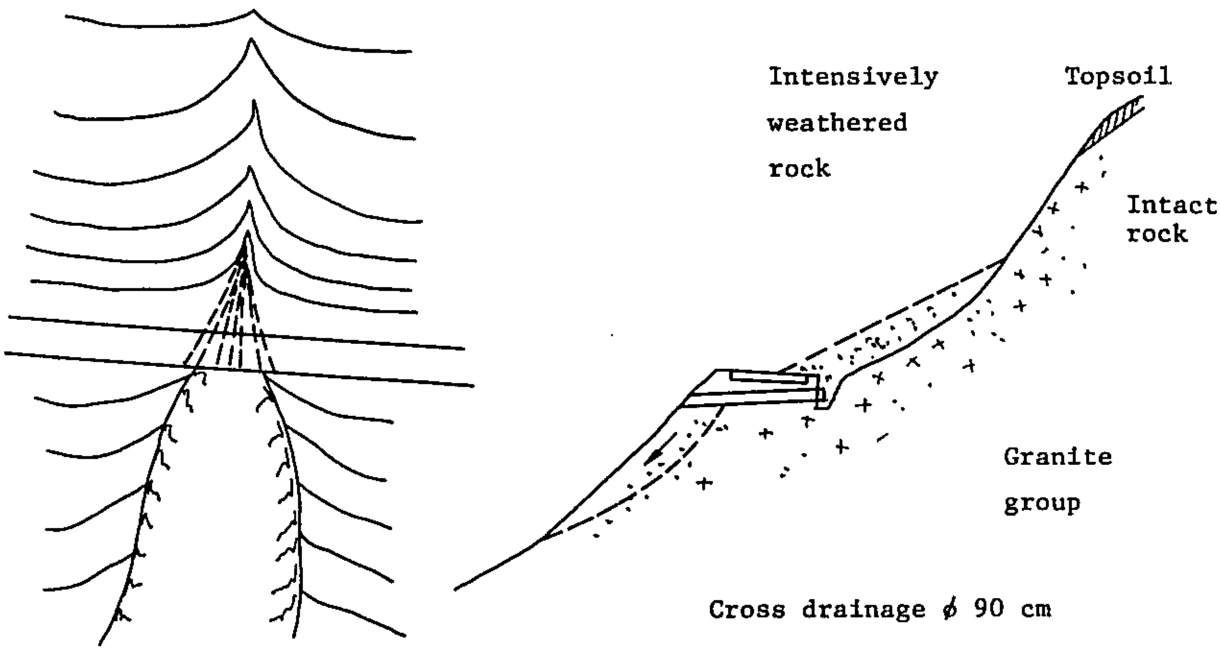


Figure I-4-8 Sta. 213(1)

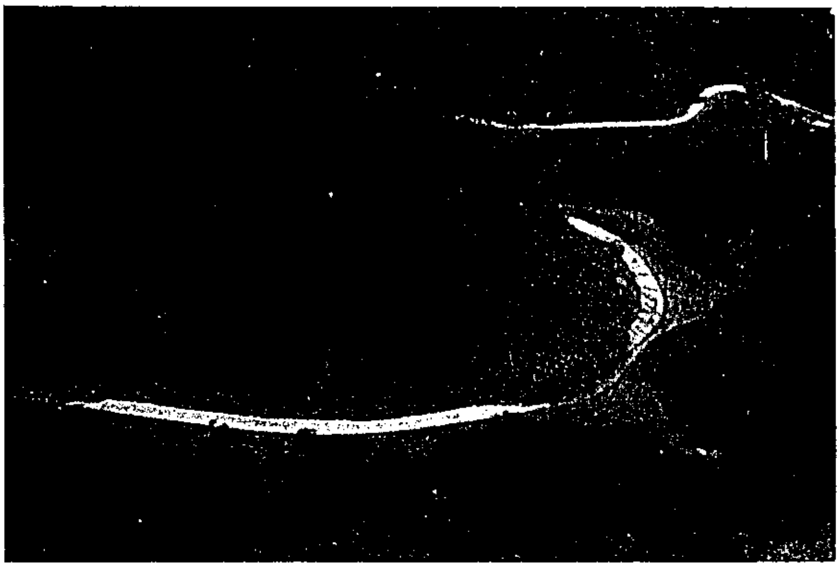


Photo I-4-8

Scouring of fill slope by water flow at cross drainage outlet.
Sta. 204 ∿ 205

Photo I-4-9

Scouring of fill slope by water flow at cross drainage outlet.
Sta. 172 ∿ 173

Sta. 213(2) :

The road was damaged by the same reason of Sta. 213(1).

Figure I-4-9

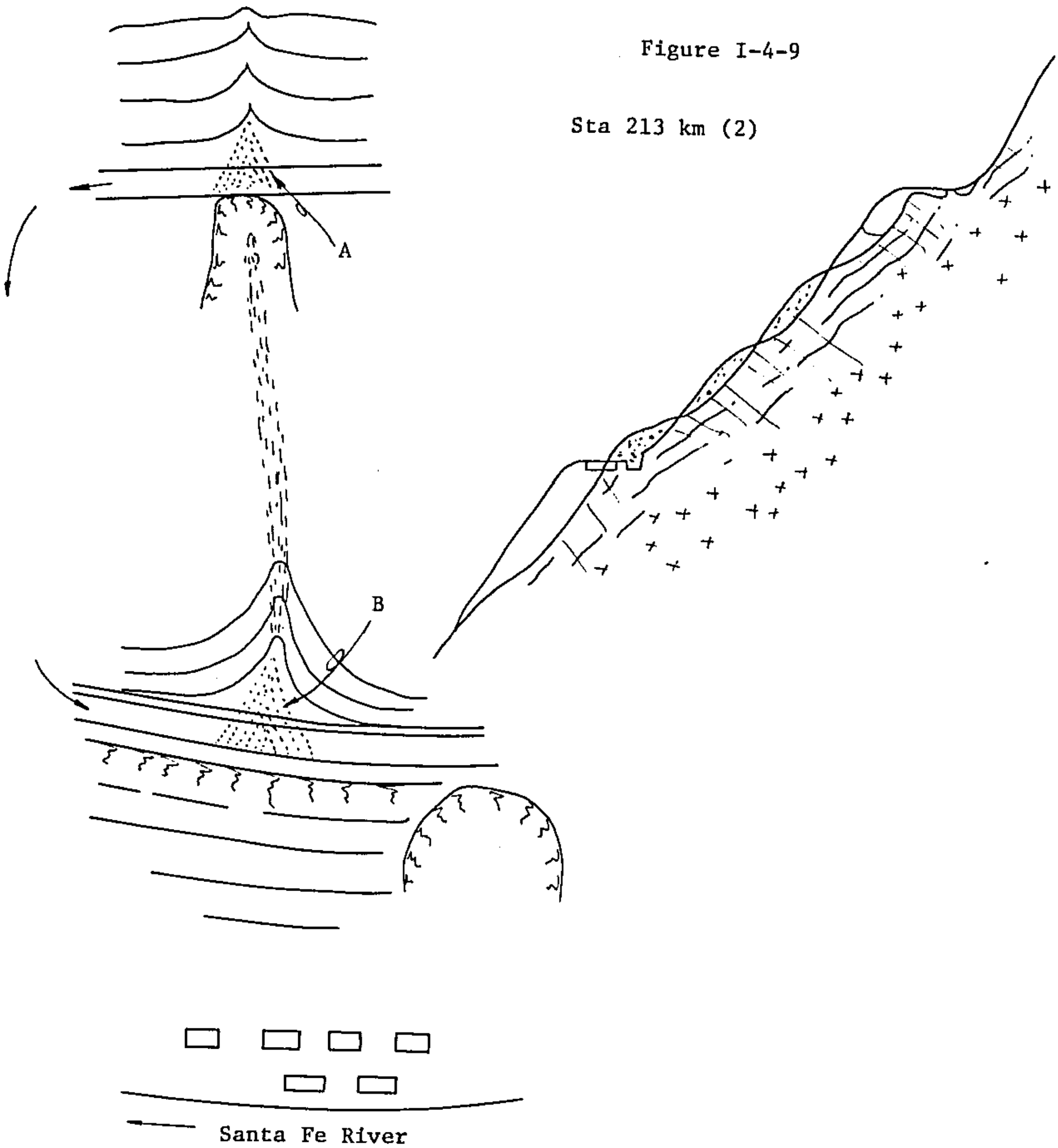


Figure I-4-9 Sta. 213 (2)

(6) Some of cross drainage are not properly located

If the cross drainages are not located properly, surface water on pavement and water flow inside ditches will not be drain outside of road and causes to the erosion and sliding of the embankment. Especially, damaged points due to mentioned above are remarkable at the south road portion of the Dalton Pass, where the drainage system is very complex by continuous curving of road.

4.3 Scouring in Embankments Caused by Flood Water

The field investigation was carried out in the 90 kilometers road portions from the point of 6 kilometers north of San Jose to the point of 40 kilometers north of Santa Fe.

The Talavera River and the Santa Fe River along the highway has their 100 ∿ 400 m width and 1/500 ∿ 1/1000 river bed gradient. These are considered to be medium and comparatively gentle gradient primitive rivers. However, these change to more narrow and steep torrential rivers in the source areas close to Dalton Pass.

Bed material also changes to boulders in the upper reaches from gravel in the lower reaches.

The flood at the height of Typhoon Didang is not an ordinary one. So much so that the flood water elevation rises from 3 meters to 5 meters from the ordinary water level by as per allegation of the people living in the vicinity and the Project Engineers of the said sections.

Due to their flash flood, embankments or river levees are severely scoured especially in the curve sections of the river, the embankment of road was destroyed by the turbulent current. In some sections in which the flood or current changes its direction going toward the embankment sides of the road the filling or embankment was totally washed out or completely scoured.

Embankment scouring is very severe at the Sta. 170, Sta. 187 + 300 and Sta. 192 + 600, Sta. 220 + 500 and Sta. 253 + 800.

At these points scouring reaches to the center of road pavement.

Figure I-4-10 and I-4-11 show damage situations by embankment scouring.

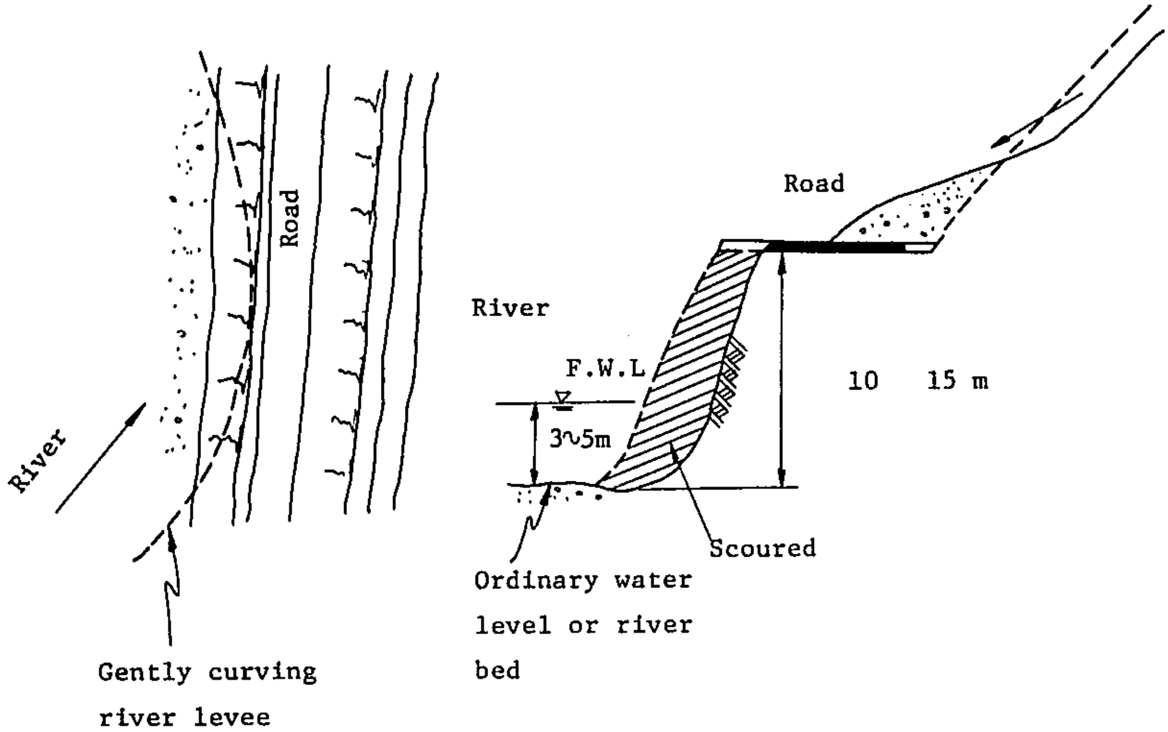


Figure I-4-10 Gently curving portion

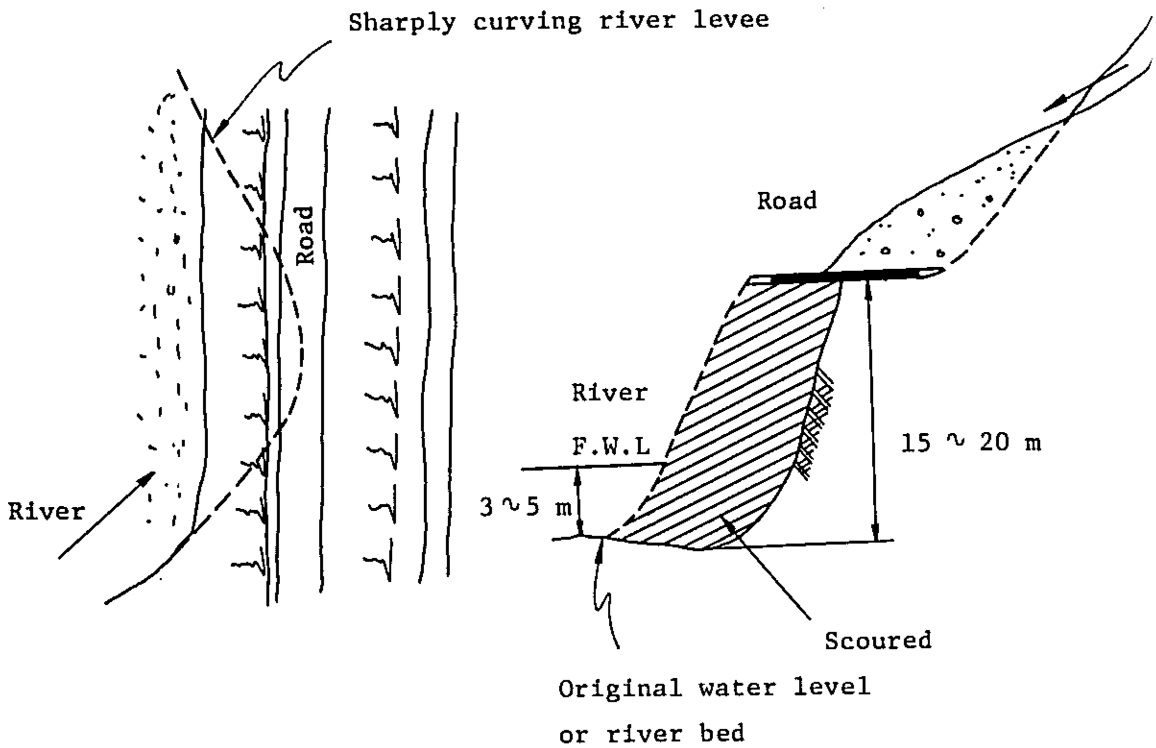


Figure I-4-11 Sharply curving portion

Photo I-4-10 CVR 171 km ∿ 172 km

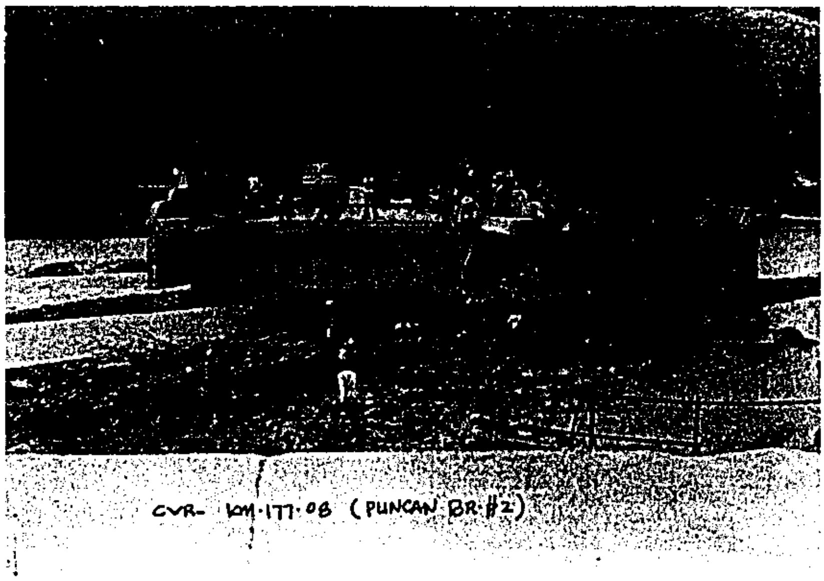


Photo I-4-11 CVR 177 km (Puncan Br)

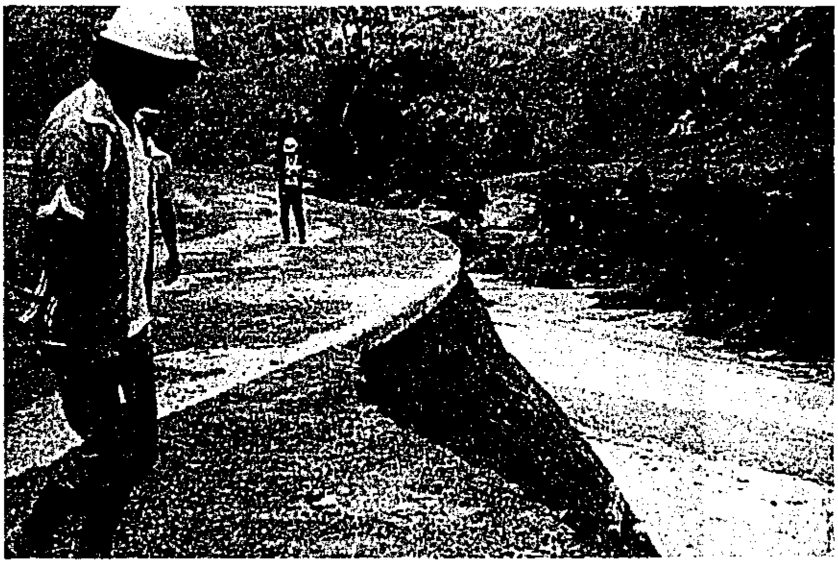


Photo I-4-12 CVR 187 km + 424

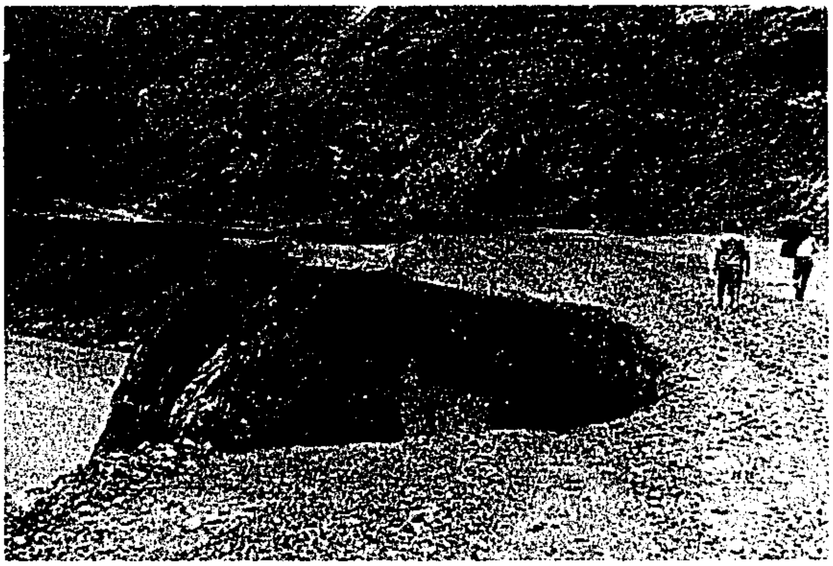


Photo I-4-13 CVR 192 km ∿ 193 km

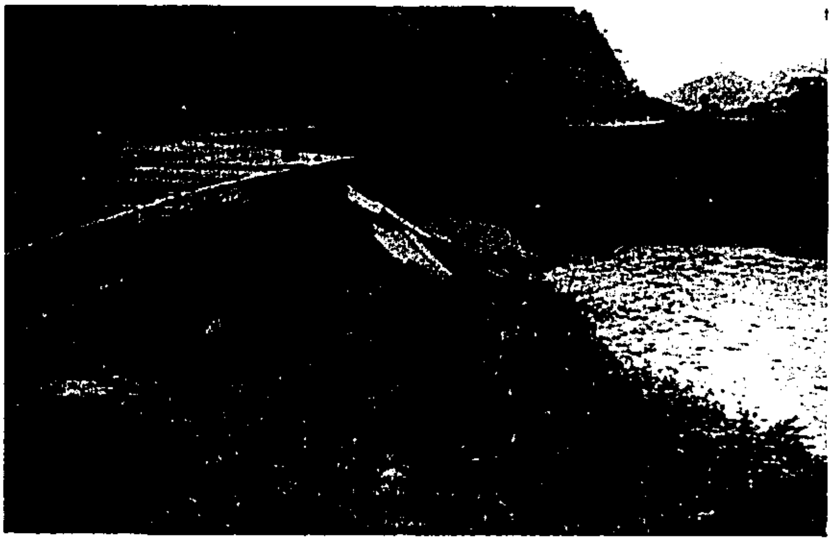


Photo I-4-14 CVR 220 km + 500

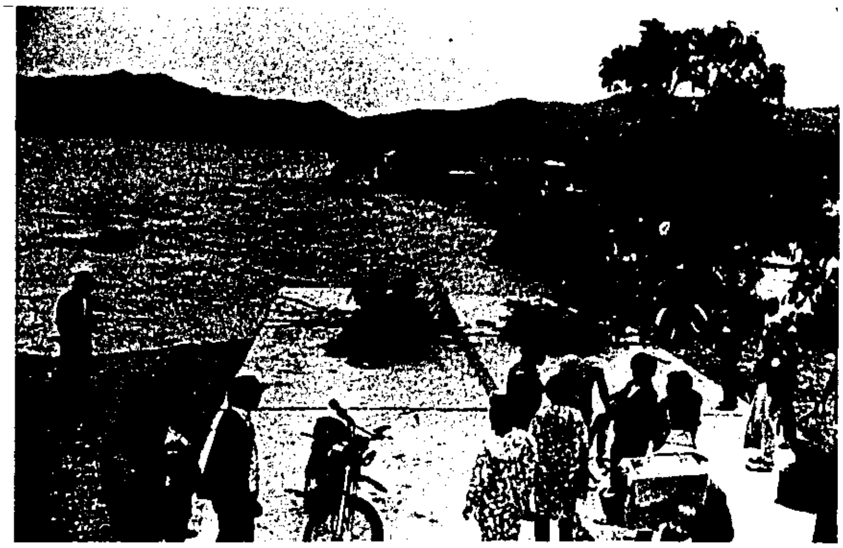


Photo I-4-15 CVR 251 km

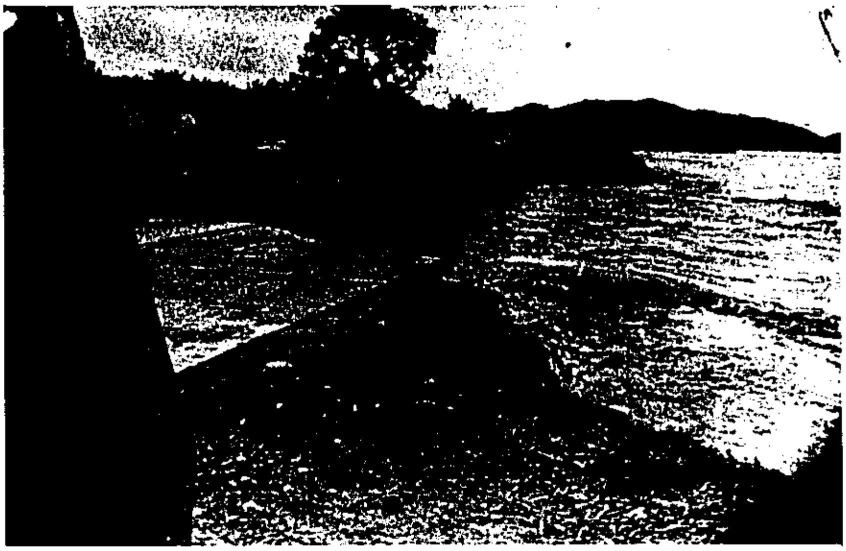


Photo I-4-16 CVR 253 km + 800

PART-A CAGAYAN VALLEY ROAD (CVR)

II. RECOMMENDATIONS

II. RECOMMENDATIONS

1. RECOMMENDATIONS ON THE COUNTER MEASURES FOR SELECTED DAMAGED ROAD PORTIONS

1.1 Recommendations on Landslide Control Works and Slope Failure Prevention Works.

(1) Sta. 167 ∿ Sta. 174

Figure II-1-1, II-1-2, II-1-3 show typical cut slope failures in this section.

① Sta. 167 + 340 (Figure II-1-1)

The Roadway was covered by debris, earth, boulder like rock due to massive slides on cut slope at the height of Typhoon Didang. Immediately after this disaster, all kinds of obstacle or slides were removed, however, they have no definite plans for this slope protections.

If no immediate measure will be done, this slope failure may occur again this coming rainy season because of its unstable geologic conditions such as cracky mutual layers of sandstone and shale, so we recommend the following slope protections.

ⓐ Correcting the slope gradient more gently such as $1\frac{1}{2} : 1 \sim 1\frac{1}{4} : 1$.

ⓑ Distribution of benches every 10 meters height on the slope.

ⓒ Distribution of drainage channels on the top of slope and every benches.

ⓓ Distribution of longitudinal drainage channel at the depression on the slope.

ⓔ Retaining wall remained its behind empty is required to be installed on the toe of slope to expect checking and controlling the debris being yielded by failure, if we expect the elimination of damage due to failure when heavy rain as large as typhoon Didang attacks.

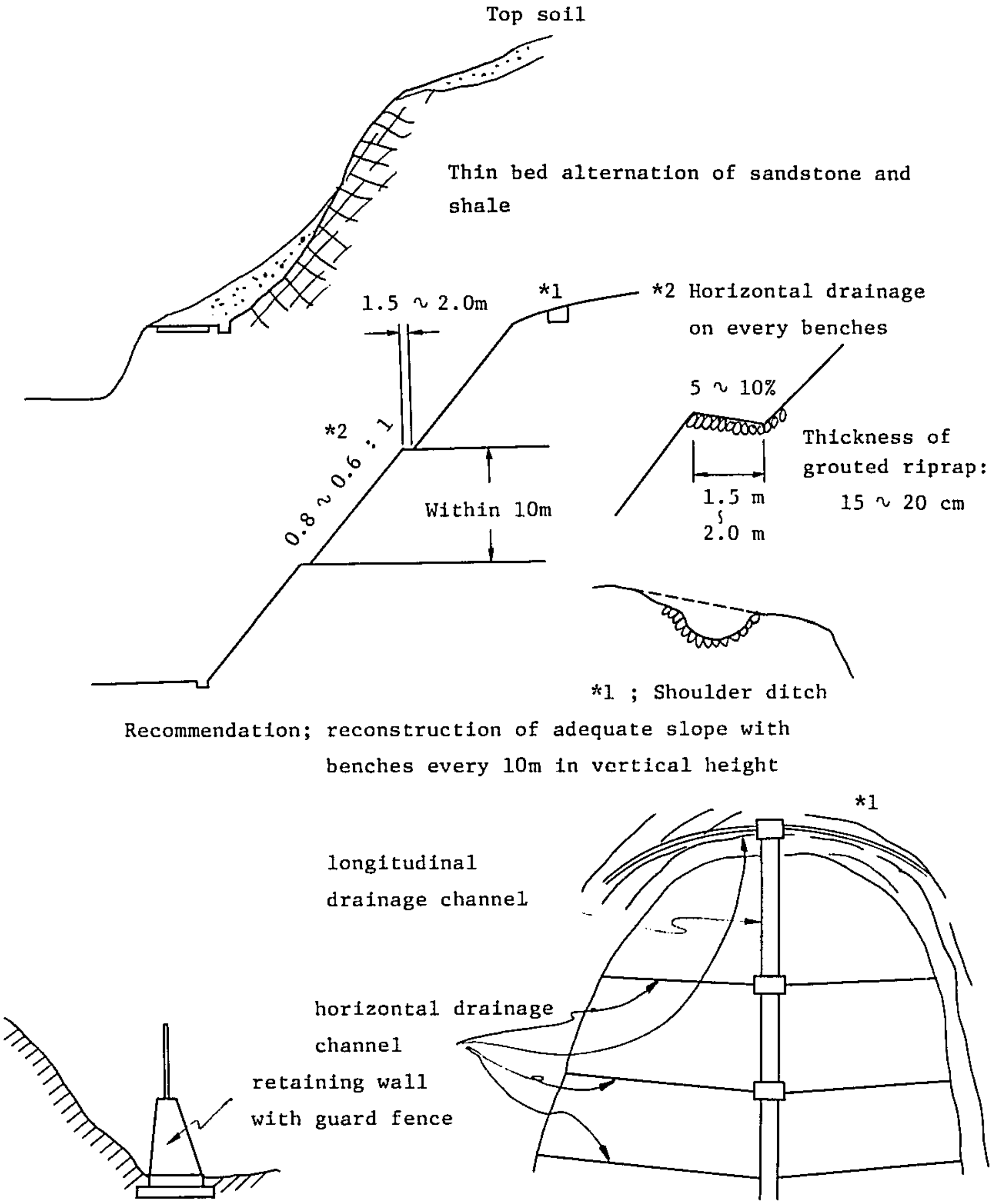


Figure II-1-1 Sta. 167 + 340

② Sta. 170 (Figure II-1-2)

Failure occurred on the upper part of natural slope, and any slope protection works are not planned here. As the surface is highly eroded on its steep (approximately 50 degrees) and long (60 ∿ 80 m length) slope, we can not design the protection works on the failured zone economically. Accordingly followings are recommended on this slope.

ⓐ Improvement of inlet capacity more suitably.

ⓑ Sediment discharge control by installing check dams on the channel bed.

ⓒ Removal of unstable soil or sediment.

ⓓ Removal of silt or sand depositing in inlets and behind check dams by usual rainfall must be necessary.

ⓔ Road protection by shelter will be required to eliminate the damages against heavy rain as large as typhoon Didang.

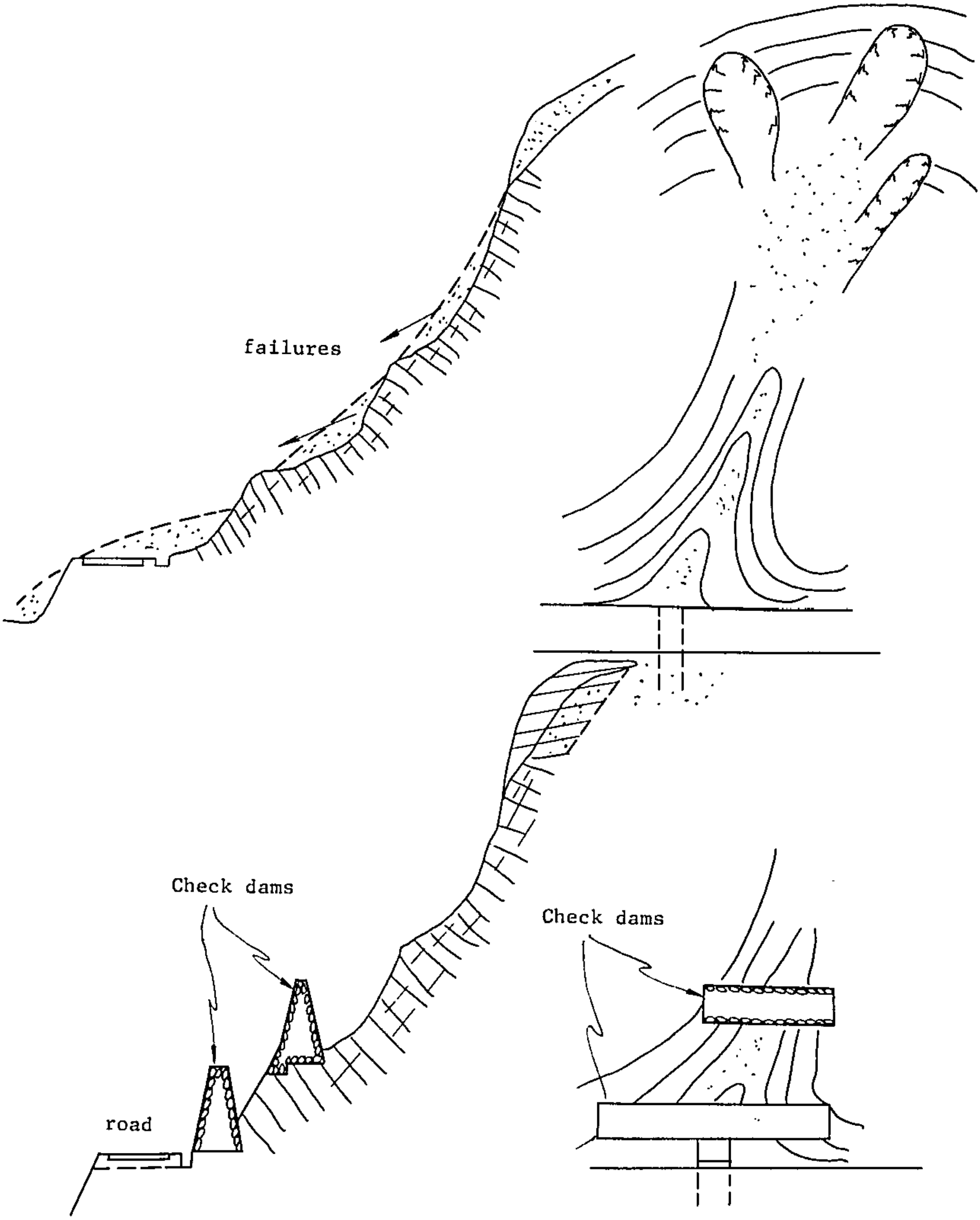


Figure II-1-2(1)   Sta. 170 Case I

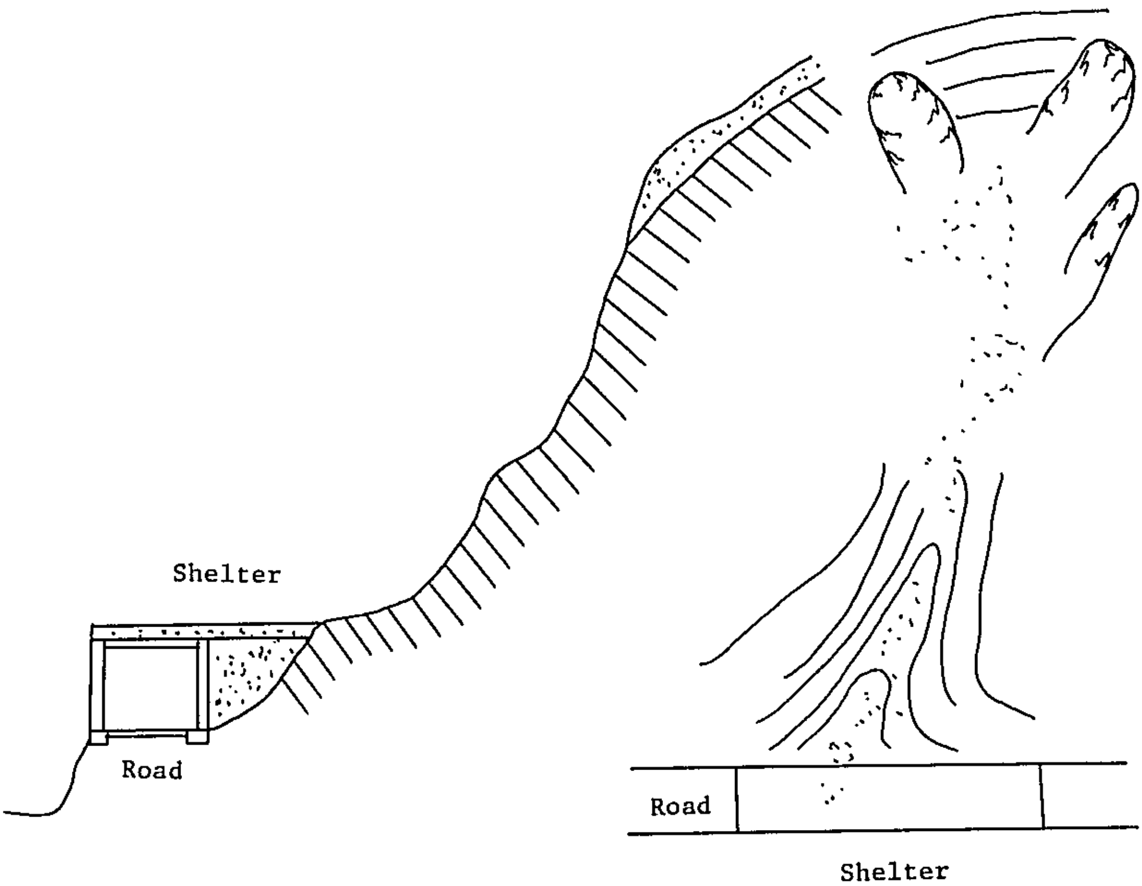


Figure II-1-2(2) Case II

③ Sta. 170 + 600 (Figure II-1-3)

This slope occurred failures twice by heavy rain in 1972 and at Typhoon Didang. At this time of failure, a few buses and jeeps are buried in the debris. From the situations mentioned above, we can estimate the type of failure as follows, that is scouring of weathered layer after erosion of surface vegetative cover occurs the top soil failure rather than a large massive sliding.
By Thphoon Didang, as the embankment toe located on the concave portion of river was scoured by water flow, the center of road was shifted toward the hillside by excavating the slope with its 0.25 : 1 gradient. Nowadays, this slope is still very dangerous and in critical conditions because of existence of several clear cracks on the lower part of slope surface and several water springs on the middle of slope.

We recommend the following counter-measures for this slope.

ⓐ The same measures with Sta. 167 + 340 case will be applied.

ⓑ Installation of grating crib works on the lower portion of this slope are required for the protection against the cracky weathered rock.

ⓒ Another step of grating crib works adding to mentioned above and drainage of water springs will be necessary for the stabilization of this slope against heavy rain as large as Typhoon Didang.

ⓓ As soon as possible the remedy works should be carried out because of the critical and dangerous conditions.

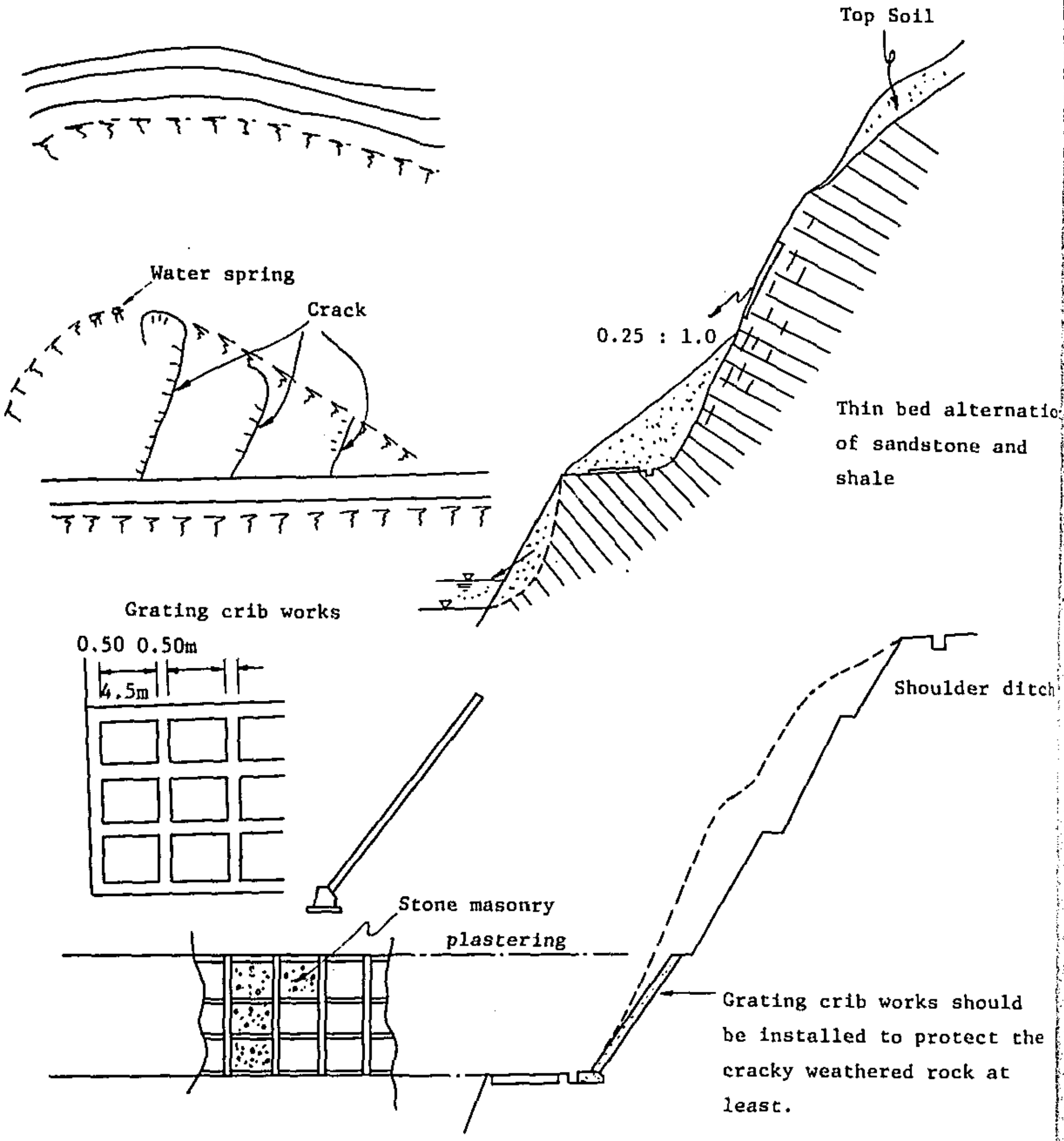


Figure II-1-3 Sta. 170 + 600

(2) Sta. 182 + 500 ∿ Sta. 209 + 700

① Sta. 193 + 200 ∿ 300 (Figure II-1-4)

The base rock of this slope consists of volcanic detritus and is remarkably weathered. We have to say that this slope is very dangerous because of existence of several clear cracks. The slope is on the skinny ridge and has possibility the failures in both sides. In addition to the failures on the slope facing to the road side, failure on the opposite side of slope has danger of violent damage by damming up the water flow and being destroyed by water flow.

We recommend removal of unstable soil or rock mass from the slope to minimize the damages.

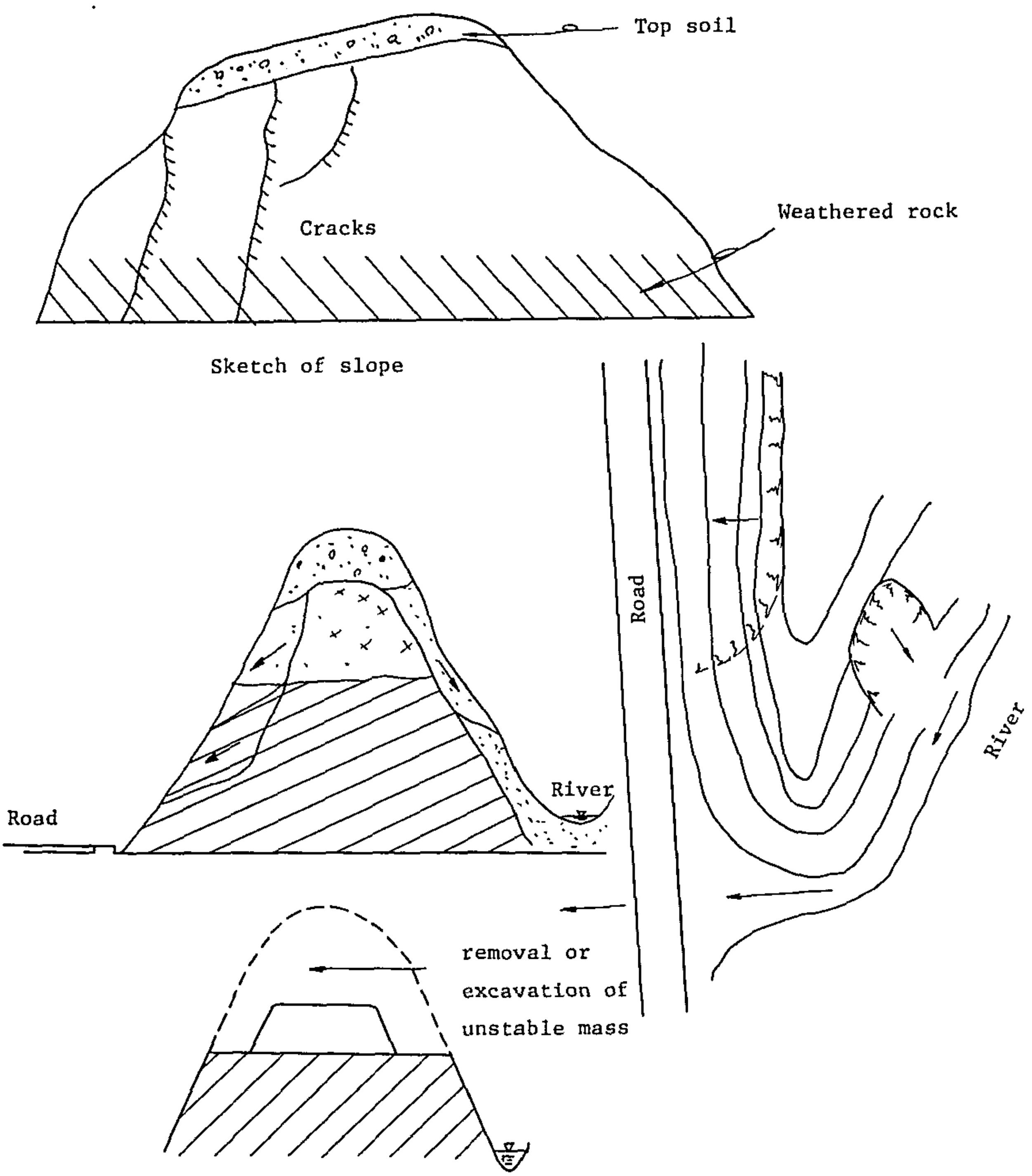


Figure II-1-4 Sta. 193 + 200 ∿ 300

② Sta. 201 + 850 (Figure II-1-5)

This slope consisted of weathered volcanic detritus occurres massive landsliding. This lanslide is estimated to have shallow sliding surface existing in cut slope, judging from the no deformation of road pavement and the crop out of hard intact rock on the toe of slope, there is no proposed plan for counter-measure except for the removal of debris carried out after the disaster. Though there are not any syptoms of movement, this landslide will be mobilized by increasing pore water pressure caused by infiltrating water through the cracks on the top of the slope during rainfall.

We can find out many slopes having similar characteristics with this type of slope. The instance is at Sta. 203 + 674. We installed extensometers on the slope of Sta. 203 + 674 and began measurement of the mobility.

We recommend following counter-measures to stabilize this type of slopes.

ⓐ Underground water drainage by horizontal borings.

ⓑ Cutting off the surface water on the top of sliding.

ⓒ Protection and loading on the toe of sliding by flexible structures.

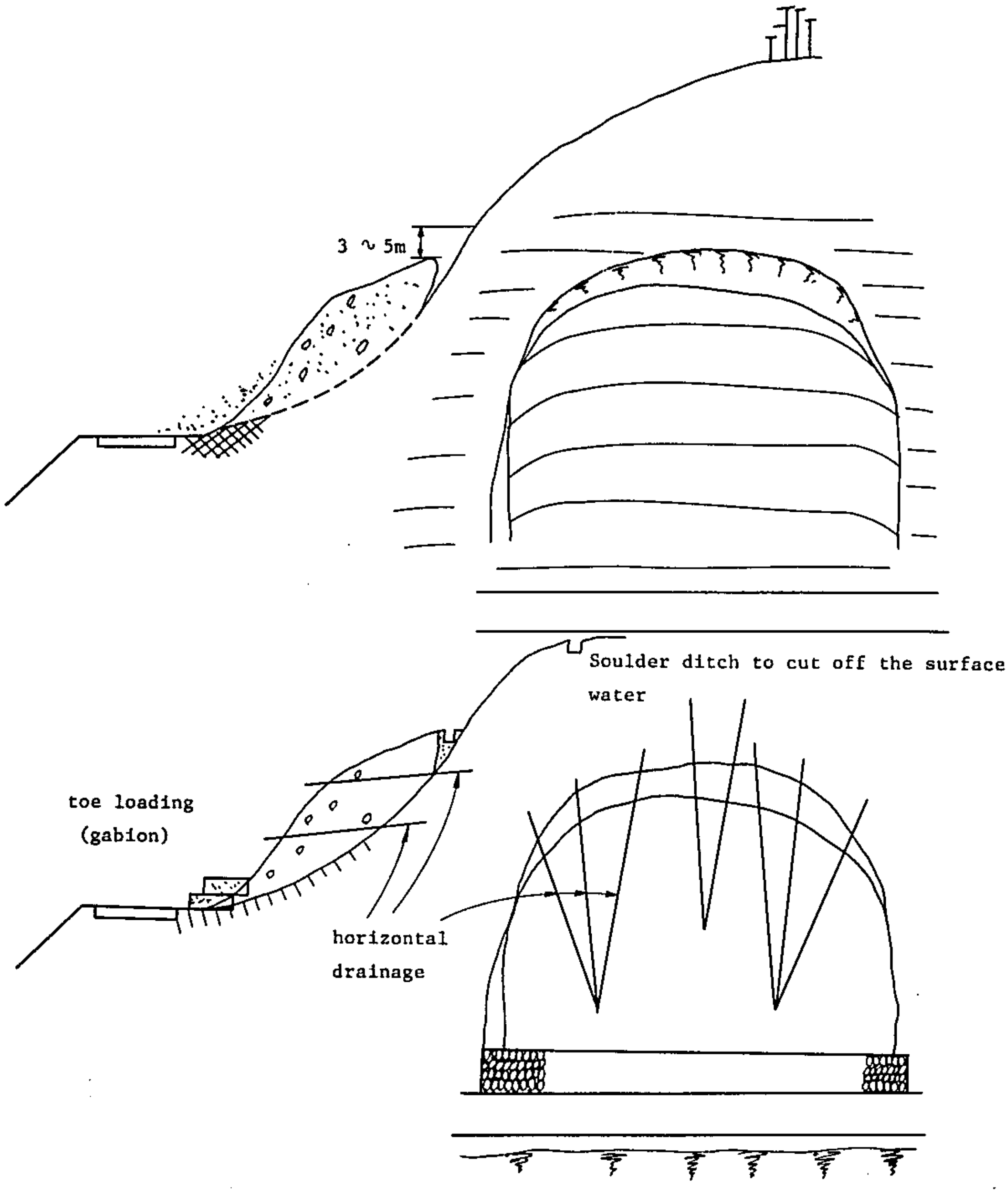
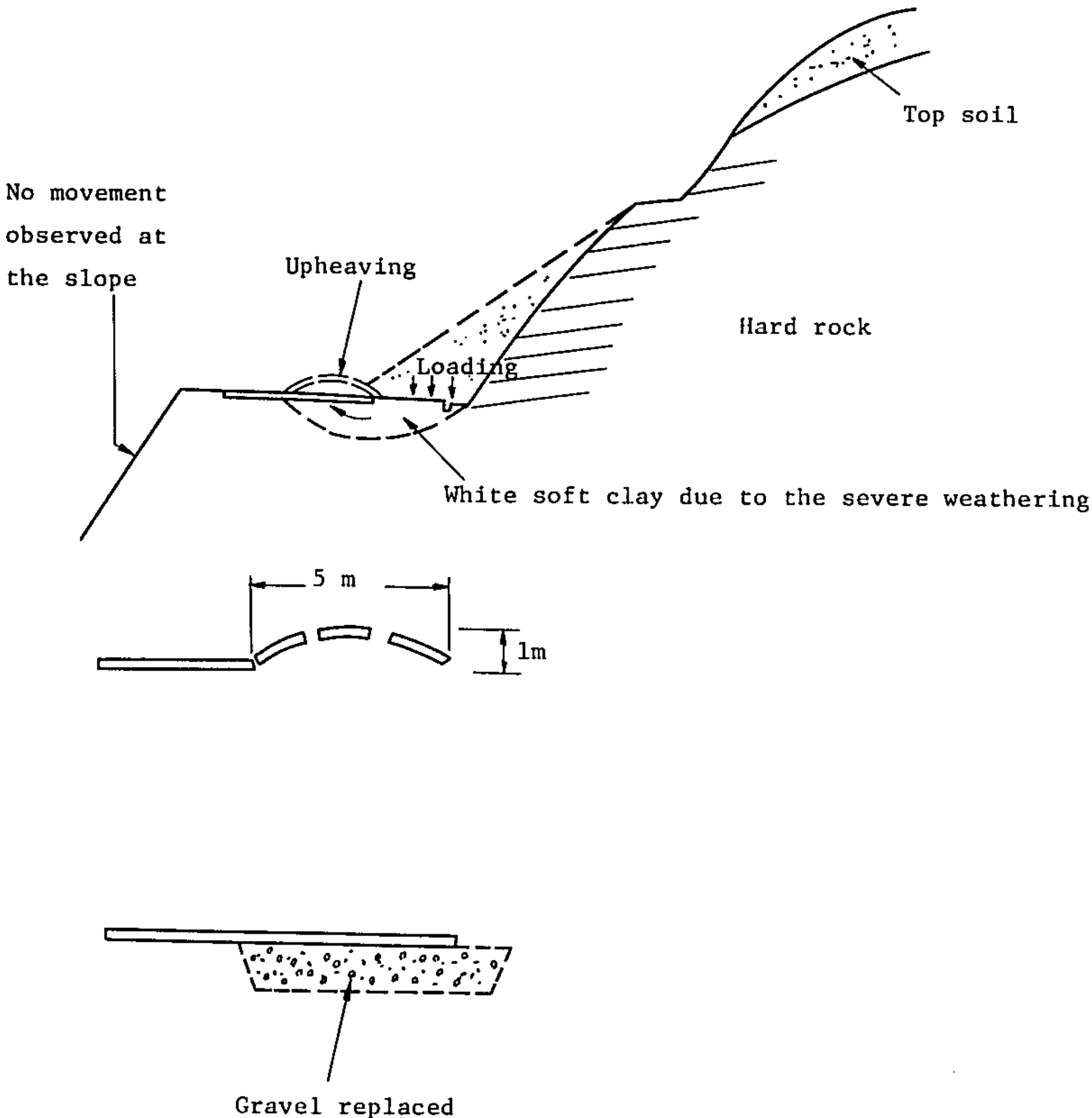


Figure II-1-5   Sta. 201 + 850   Landslide Control Works

③ Sta. 205 + 310 (Figure II-1-6)

At this point, the road pavement upheaved approximately 1 meter extending to the area of 5 χ 10 meters width and length respectively. We can explain the reason of this phenomenum as following: that is, the base under the white soft clay produced by heavy weathering collapsed by loading of failured debris from the slope.

For restoration works, the removal of soft clay and the replacement by gravel was adopted. No syptoms of movement are reported after new pavement. It was suitable remedy works.



The restoration work already adopted to this site is as following:

1) removal of soft material

2) replacement to gravel

3) reconstruction of pavemen

Figure II-1-6 Sta. 205 + 310

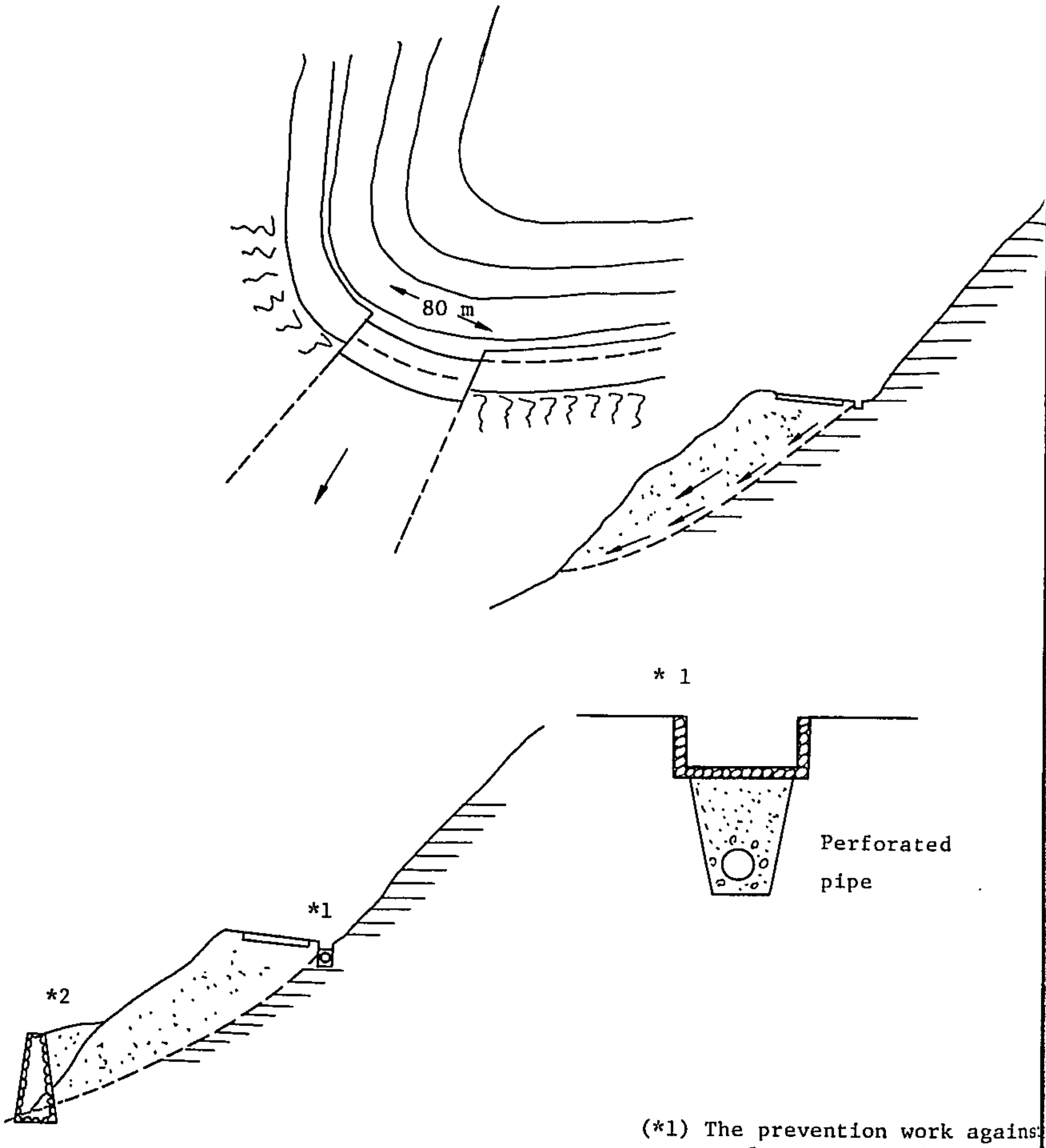
④ Sta. 205 + 959 (Figure II-1-7)

At this point 80 meters long road stretch moved toward the riverside by sliding. The cut slope consists of hard intact road and does not have any slidings. The reason of damage is considered to be a sliding of fill slope at the boundary between fill and original ground surface influenced by the ground water infiltrated into boundary zone.

We recommend the following remedy works.

ⓐ Installation of perforated drainage pipe at the hill side of the road preventing from the infiltrating water into fill section.

ⓑ Installation of retaining wall by stone masonry on the foot of fill slope to add the resistance force against the sliding.



(*1) The prevention work against surface water infiltration

(*2) Retaining wall using stone masonry.

Figure II-1-7 Sta. 205 + 959

⑤ Sta. 206 + 606 (Figure II-1-8)

The large failure extending to 60 meters high and 200 meters wide occurred at this point. Top soil and weathered layer was washed out and deposited on the road by surface water scouring. The slope protection works are not recommended from the stand point of economical aspects and safety of the protection structures, because the slope is so high.

The followings are recommended for the remedy works of this point.

ⓐ Removal of unstable soil or rock mass is only recommended to minimize the damages by usual rainfall.

ⓑ The protection of road by shelter will be required to eliminate the damage by heavy rain as large as Thphoon Didang.

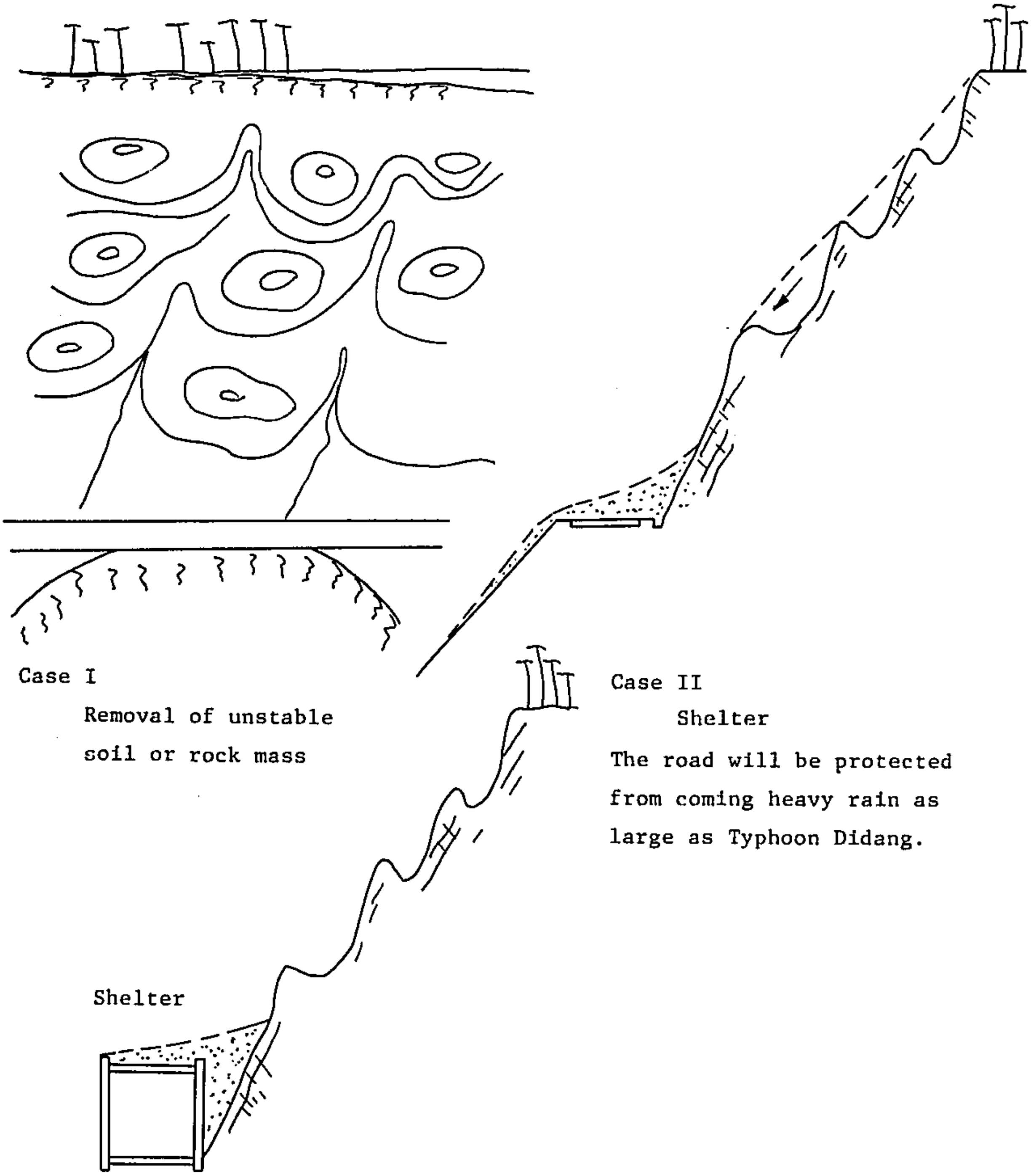


Figure II-1-8 Sta. 206 + 606

(3) Sta. 209 + 700 ∿ Sta. 222

① Sta. 221 (Figure II-1-9)

The road was deposited by debris flow originated from the channel having 5.7 km^2 catchment area. Catchment area spreads in the gentle hillslope constituted by granite. Discharged sediment contains gravels and pebbles as large as 10 to 20 cm diameter originated from the terrace deposit. No counter-measures against debris flow is planned except for the debris removal carried out after damages.

We recommend the debris flow control works installing the check dams on the channel bed for minimizing damage by heavy rain, as large as Typhoon Didang. And we also recommend that only removal of debris deposited on road at each time the debris flow occurres is enough for the restoration of debris flow damage at the usual rainfall.

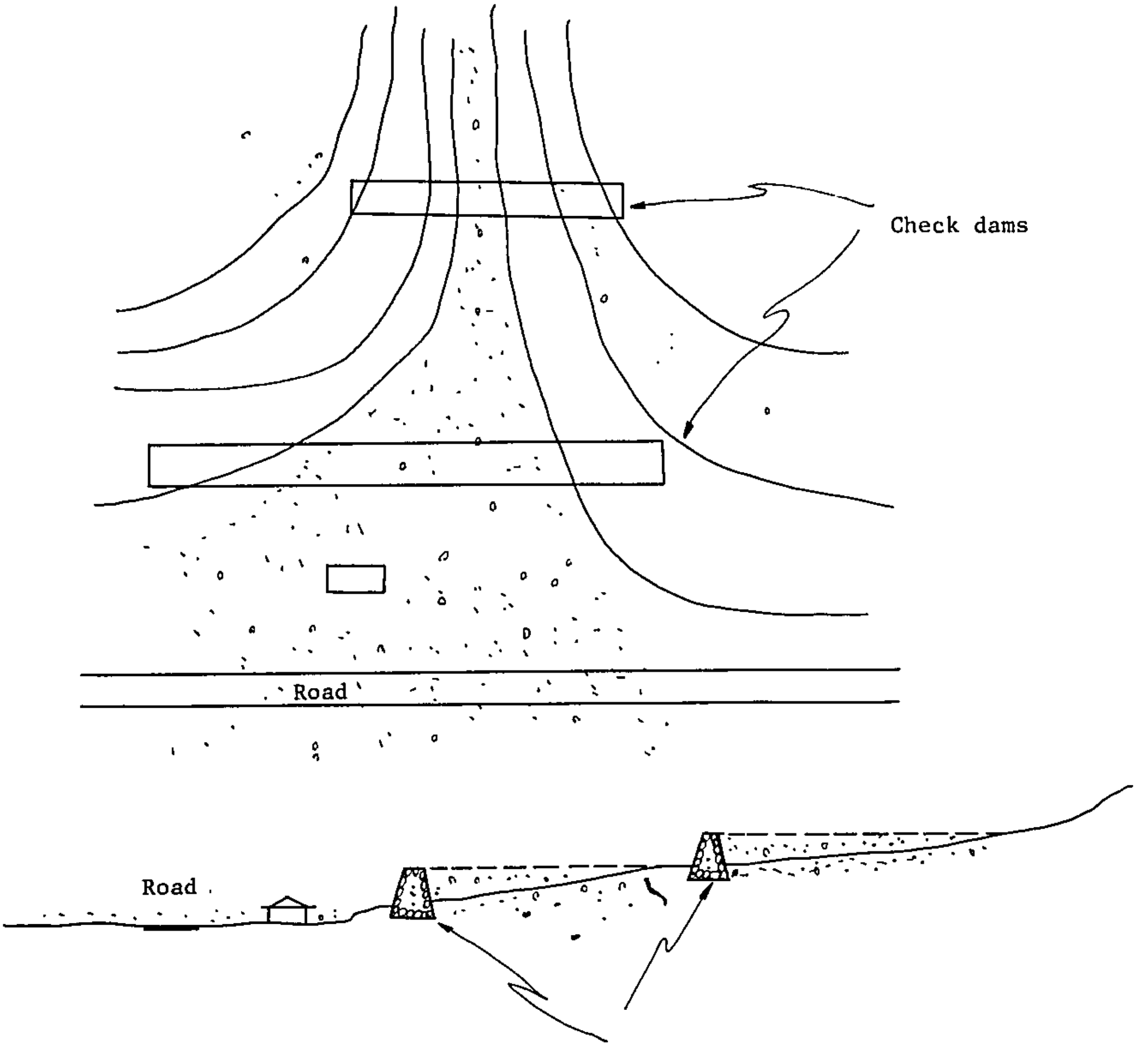


Figure II-1-9 Sta. 221

② Sta. 222 (Figure II-1-10)

The large landslide having its width and height 150 meters and 60 meters respectively occurred at this point. The sliding surface is above the road pavement height. We installed extensometers on this slope and began the measurement to analyze the possibility and extent of movement from the relation between movement and rainfall.

Recommendations for corrective works of this slide are the following:

ⓐ Loading using something like mattress type of gabions on the toe of slope is recommended to stabilize the slope at present.

ⓑ Against coming heavy rain as large as Typhoon Didang, removal of soil mass at the top of slope and vegetative cover shown on Figure II-1-10 will be more suitable.

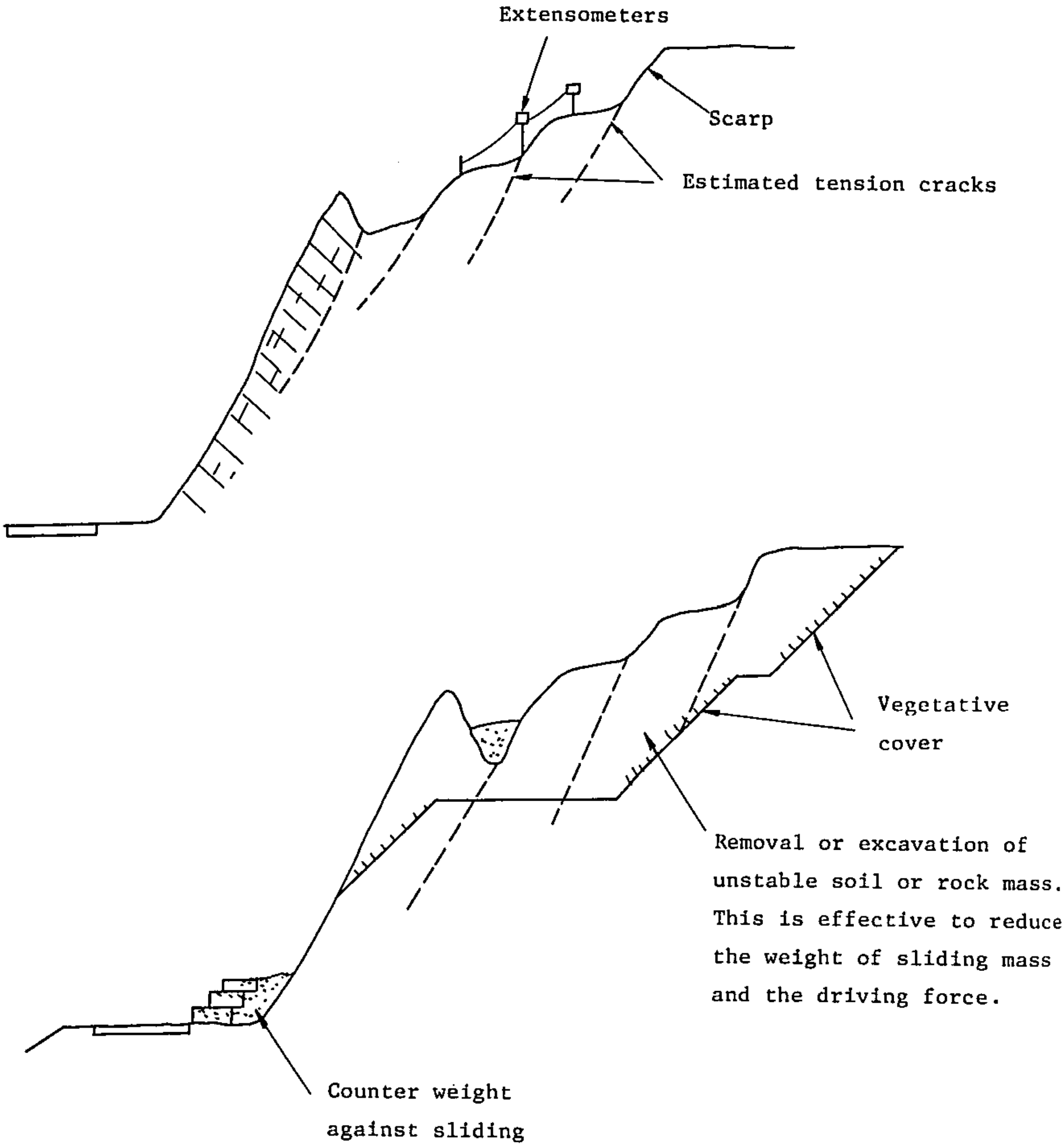


Figure II-1-10 Sta. 222 + 0.00

1.2 Recommendation on the Improvement of Drainage System

(1) Prevention of shoulder scouring

Followings are some kinds of prevention methods to protect the shoulder and side ditches from scouring.

① Suitable distribution of side ditches

Principally, the side ditches should be installed as follows.

ⓐ Cross sectional gradient of road declines towards riverside: distributes side ditches on river side. (Figure II-1-11)

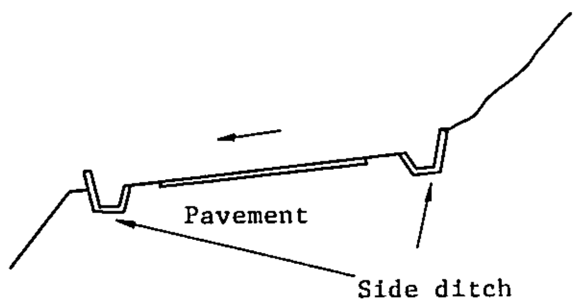


Figure II-1-11 Side Ditch on River Side

ⓑ Cross-sectional gradient of road declines toward hillside: distributes side ditches on hill side. (Figure II-1-12)

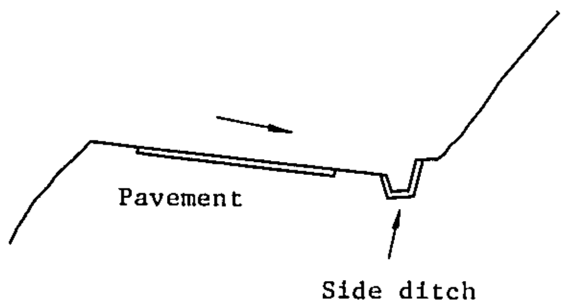


Figure II-1-12 Side Ditch on Hillside

We should distribute the side ditches suitably considering the topography and alignment of road in addition to the principles mentioned above. As in the case of ⓐ the road often crosses the channel, the side ditches on hillside will be necessary.
Especially the side ditches having enough allowance in its sectional area is required to be installed on hillside, if the road has the longitudinal slope.

As in the case of ⓑ the road usually locates on ridge type of mountain side, the side ditches on river side are not always required.

ⓒ If there is no cross-sectional gradient of road, we should decide the distribution of side ditches from the road conditions before and behind this section and hillslope conditions. If the road does not have longitudinal gradient and the surface water on pavement will be allowed to leave, the side ditches are not always required.

If there is the longitudinal gradient on the road, the side ditches must be installed on internal side of the curve. On the foot of cut section on natural slopes, the side ditches collecting the surface water from the slopes is necessary. At the portions where the road curves continuously as the road has longitudinal slope and the cross-sectional gradient changes its direction, the side ditches are required to be installed on both sides of hillside and riverside as shown on Figure II-1-13 and the carefull distribution of cross drainage is also necessary.

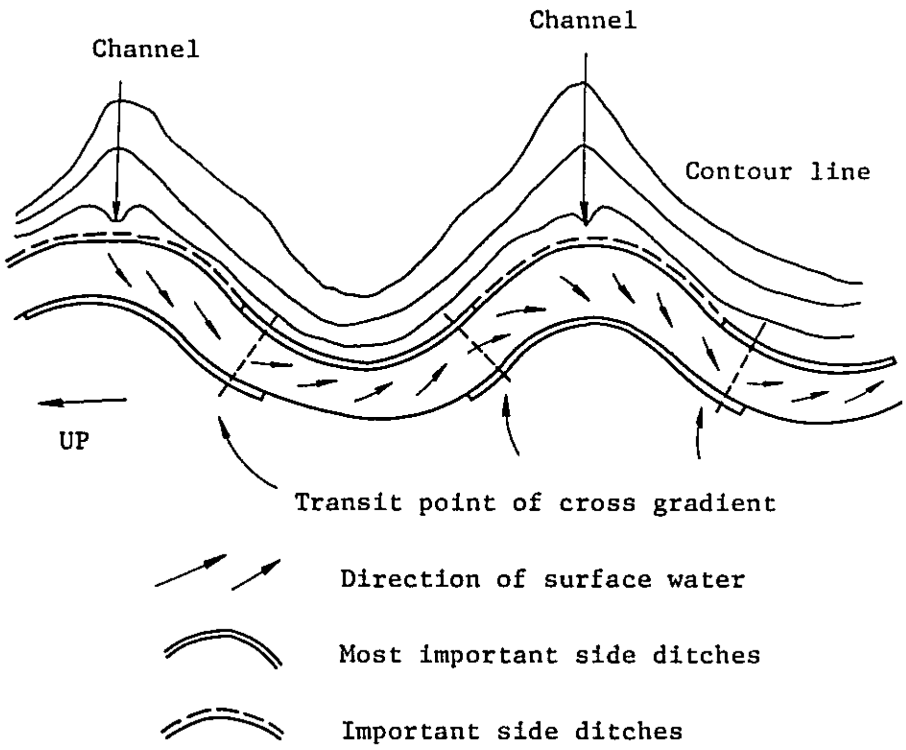


Figure II-1-13 Side Ditches in Curving Road

Photo II-1-1 shows the fill slope sliding at the transit point of cross-sectional gradient.
The cause of this sliding is the surface water concentration to the fill section where side ditch was not installed.

Photo II-1-1

An example of fill slope sliding by surface water concentrating at the transit point of cross-sectional gradient of road. Sta. 203-204

② Shoulder cover

The destruction of side ditches originates to the shoulder scouring mentioned in chapter 4.2. For the prevention of side ditches destruction, the shoulder cover must be effective.

Followings are the alternatives of shoulder cover types:

ⓐ Stone riprap plastering (Figure II-1-14)

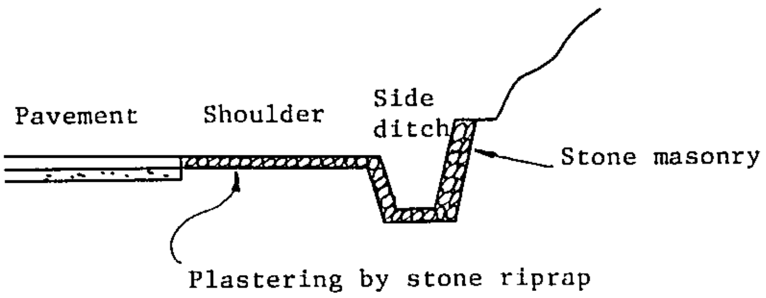


Figure II-1-14

ⓑ Thin concrete or asphalt plastering (Figure II-1-15)

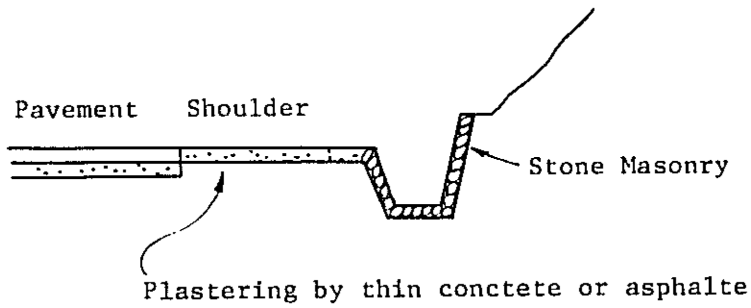


Figure II-1-15

The foundation using gravels or boulders should be installed under thin concrete plastering to protect the cover from the emergency traffic. (Figure II-1-15)

ⓒ Turfing or sodding (Figure II-1-16)

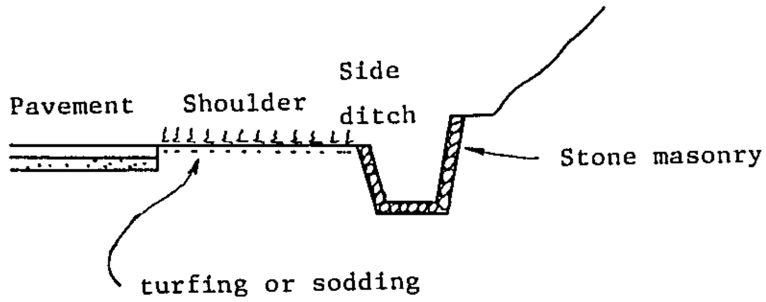


Figure II-1-16

This method has some erosion control effect, but it sometimes interrupts the smooth surface water flow and needs considerable maintenance in future. (Figure II-1-16)

ⓓ No covering on shoulder but having the gradient toward side ditches and making step at the edge of shoulder as shown on Figure II-1-17.

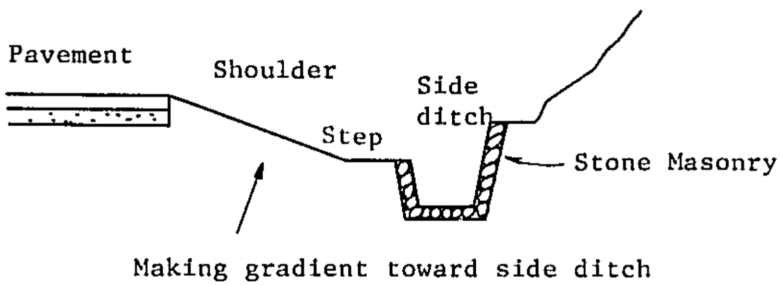


Figure II-1-17

The sediment scoured on shoulders by surface water will go into side ditches and considerable maintenance will be necessary from time to time. (Figure II-1-17)

Among the methods above, we recommend to adopt stone riprap cover or thin concrete or asphalt plastering.

③ Prevention of overflowing from side ditches

For prevention of overflowing from side ditches, the side ditches has to be designed having enough cross sectional area to flow inside water promptly, and avoiding the abnormal curving and abnormal changing in longitudinal slope.

Water discharge capacity of side ditches is calculated by following equation:

$$Q = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2} \cdot A \qquad \text{(Eq. II-1)}$$

where :

Q = Water discharge (m^3/sec)

n = Roughness (Refer to Table II-1-1)

R = Radius depth (m)

I = Gradient of ditch

A = Cross sectional area of water flow (m^2)

And inflowing water discharge into side ditches is gained from following equation.

$$Q = \frac{1}{3.6} \cdot C \cdot r \cdot A \qquad \text{(Eq. II-2)}$$

where :

Q = Water discharge (m^3/sec)

C = Runoff ratio

r = Effective rainfall intensity (designed rainfall intensity) (mm/hr)

A = Catchment Area (km^2)

C =	pavement, cutslope	0.9
	steep mountain	0.8
	gentle mountain	0.7
	rolling hillside	0.6
	forest	0.3

Usually, the cross sectional area of side ditches is designed to have 20% allowance area more than calculated area from equation mentioned above against the inflow of sediment and silting.

The minimum gradient of side ditches is principally to be designed more than 2% and the velocity of water flow should be designed in ranging 0.6-3m/sec to avoid the deposition of sediment.

In the case of stone masonry ditches, suitable velocity will be 0.6 to 1.8 m/sec. Table II-1-2 shows the allowable average velocity.

The mitigation of gradient using such as ground sills on the ditch bed will be recommended to deal with the abnormal change of longitudinal slope. The side ditches of access road approaching to Pantabangan Dam is designed suitably using this kind of gradient mitigation method.

④ Alternatives of side ditches

Before Typhoon Didang, the L type ditches are often used as shown on Figure II-1-18. We recommend to improve this ditches to U type which was already adopted to the restoration works after Typhoon Didang (Figure II-1-19)

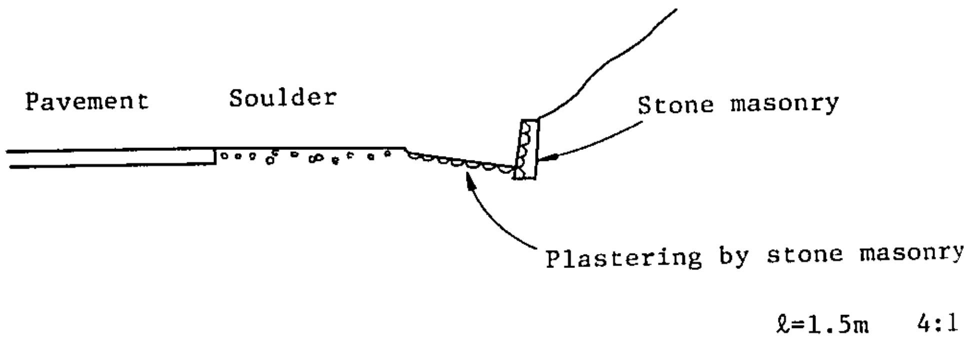
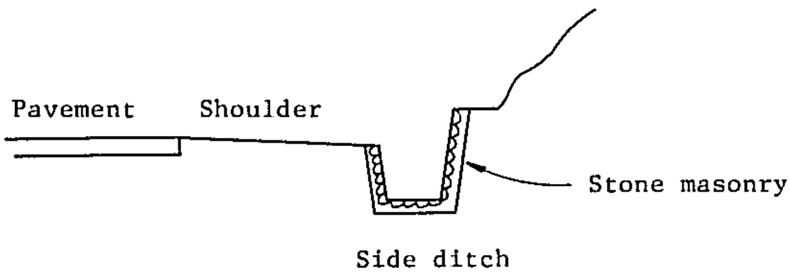


Figure II-1-18 L Type Side Ditch



(Adopted for restoration after
Typhoon Didang)

Figure II-1-19 U Type Side Ditch

(2) Prevention of silting in side ditches

The prevention of silting in the side ditches is necessary. For this purpose, the avoidance of abnormal curving and abnormal changes of longitudinal slope should be required. Additionally the slope protection behind the side ditches also should be considered for the avoidance of sediment inflow. And we recommend the installation of small retaining wall to protect the toe of slope from the scouring by jumping water in ditches and spring water on the slope. (Figure II-1-20)

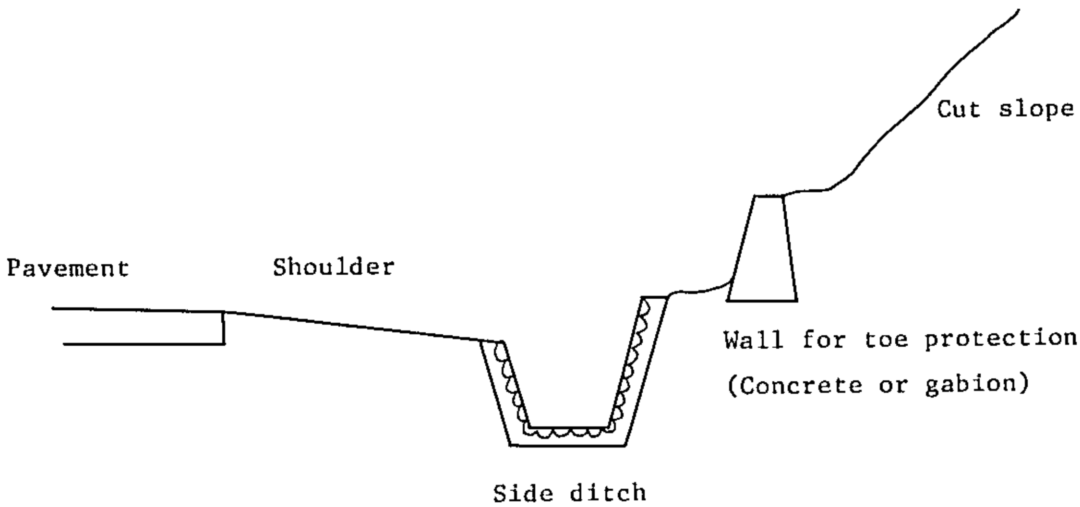


Figure II-1-20 Toe Protection of Cut Slope

Toe scouring of slopes often results the slope failure.
The failures shown on Photo II-1-2, II-1-3 has the possibility to be caused by toe scouring.

Table II-1-1 Roughness of Side Ditches

Material of side ditch		Roughness
Excavated side ditch	Soil	0.02 ∿ 0.025
	Gravel	0.025 ∿ 0.04
	Hard rock	0.025 ∿ 0.035
Constructed in site	Cement mortar	0.01 ∿ 0.013
	Concrete	0.013 ∿ 0.018
	Stone masonry with mortar	0.015 ∿ 0.03
	" without mortar	0.025 ∿ 0.035
Factory production	Reinforced concrete pipe	0.011 ∿ 0.014
	Concrete pipe	0.012 ∿ 0.016
	Colugated pipe	0.016 ∿ 0.025

Table II-1-2 Allowable Average Velocity in Side Ditch

Material of side ditch	Range of average velocity (m/sec)
Concrete	0.6 ∿ 3.0
Asphalt	0.6 ∿ 1.5
Stone or block masonry	0.6 ∿ 1.8
Consolidated gravel or clay	0.6 ∿ 1.0
Rough sand or soil with gravel	0.3 ∿ 0.6
Sand or Sandy soil including much clay	0.2 ∿ 0.3
Fine sandy soil or silt	0.1 ∿ 0.2

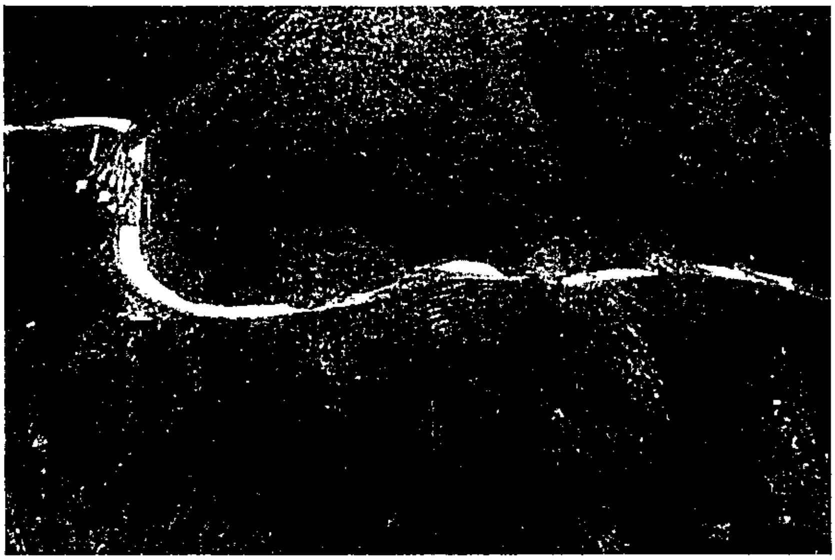


Photo II-1-2

Slope failures on hillside. One of the causes of these failures must be toe scouring. Sta. 204

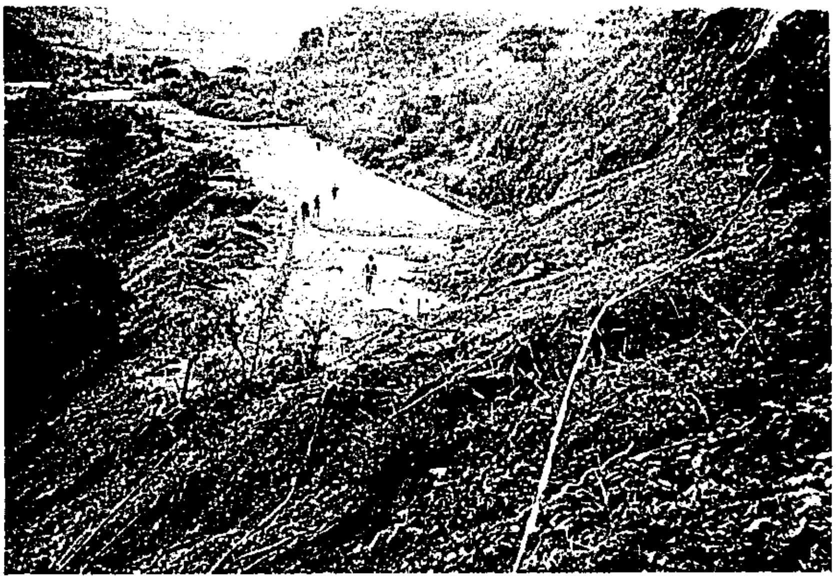


Photo II-1-3

Slope failures on cut slope. Sta. 190 ∿ 191

(3) Prevention of silting of cross drainage inlets

Before Typhoon Didang, comparatively small pipe culverts were used to drain water and damages by silting at the height of Typhoon Didang were found somewhere. (Photo II-1-4, II-1-5) But we are sure that the improvement of many pipe culverts to the large box culverts carried out after Typhoon Didang was highly suitable. We recommend again the improvement of cross drainage as carried out for the restoration works immediately after Typhoon Didang, especially at the channel crossing point. Photo II-1-6 shows an example nothing of damages using box culvert with large cross water way area.

Designed water discharge of cross drainage is gained from equation II-1. Cross sectional area has to have approximately 20% allowance for the sediment inflow and silting.

Following is an example of calculation at Sta. 213

ⓐ Estimates of water discharge at the height of Typhoon Didang

$Qr = 0.2778\ C \cdot r \cdot A$

C = Runoff ratio ---------- 0.8

r = effective rainfall intensity 50 mm/hr

A = Catchment Area -------- 0.25 km^2

$Qr = 0.2778 \times 0.8 \times 50 \times 0.25 =$

$= 2.8\ m^3/sec$

Sediment concentration density = 20%

$Qrt = 2.8 \times 1.2$

$= 3.4\ m^3/sec$

ⓑ Water discharge capacity of 90 cm Ø R.C. pipe culvert

$$Qp = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2} \cdot A$$

n = Roughness of pipe -------- 0.013

R = Radius depth ------------- 0.225 m

I = Gradient of pipe --------- 3%

A = Cross sectional area ----- 0.636 m^2

$$Qp = \frac{1}{0.013} \times (0.225)2/3 \times (0.03)1/2 \times 0.636$$

$= 3.1\ m^3/sec$

$Qrt = 3.4\ m^3/sec > QP = 3.1\ m^3/sec$

Accordingly, 90 cm Ø R.C. pipe culvert is not enough for the discharge of water.

In addition to the considerations about the cross sectional area, the following notices should be discussed to install inlets and cross drainages.

Photo II-1-4

Damage by cross drainage silting and outlet scouring. Sta. 203-204
Debris flow from channel blockaded the inlet and overflew on pavement, also resulted the outlet scouring.

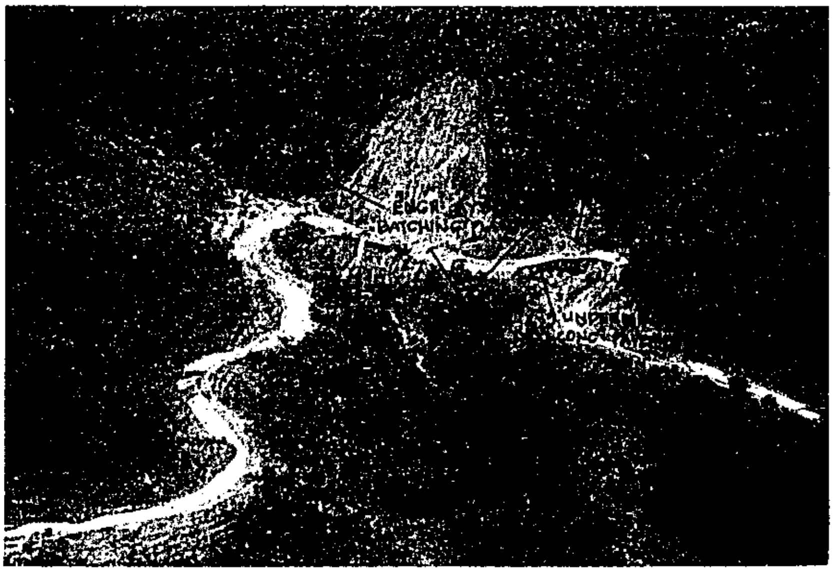


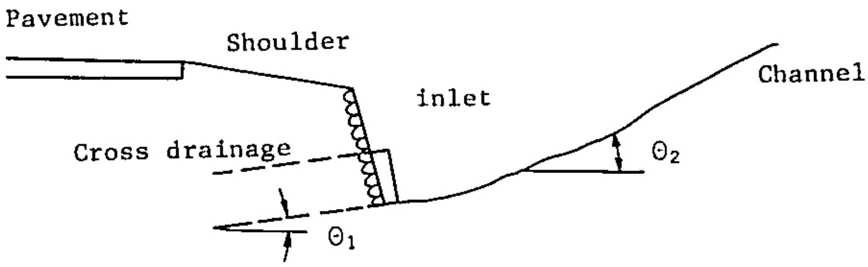
Photo II-1-5

Cross drainage inlet was blockaded by sediment discharge from channel. Sta. 207-208

Photo II-1-6

An example of box culvert. Sta. 208-209
As the cross water way area was sufficient to flow water and sediment and outlet was protected suitably, there were no damages such as blockade, silting and outlet scouring.

ⓐ The bed height of cross drainage should be put together with channel bed. This can avoid the siltation and erosion. (Figure II-1-21)



o $\theta_1 \doteqdot \theta_2$

o The elevation of cross drainage inlet must be approximately same with the original channel bed.

Figure II-1-21 Cross Drainage Inlet

ⓑ The gradient of cross drainage should be approximately equal, if possible, to the original channel gradient. If we inevitably adopt the gradient steeper than the critical gradient yielding the super-critical flow, we have to protect the inlets and outlets of cross drainage against the scouring. (Figure II-1-21)

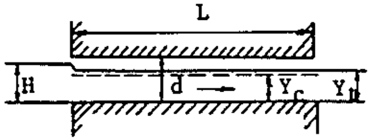
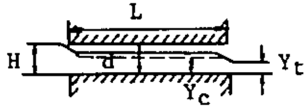
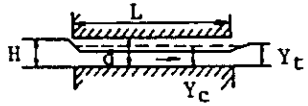
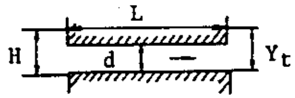
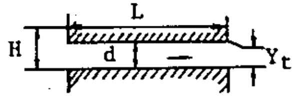
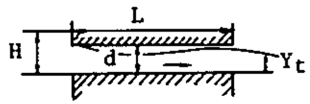
Table II-1-3 shows the hydraulic conditions of cross drainage and the remarkable points.

ⓒ The walls around the inlet should be designed higher than the scouring reach.

ⓓ If the cross sectional area of cross drainage changes narrowly compared to original channel, we have to design the smooth connection.

ⓔ The cross drainage is required to be installed at approximately right angle to the road. But the abnormal change of drainage direction must be avoided.

Table II-1-3 Hydraulic conditions of cross drainage and their remarkable points.

	Hydraulic Condition		Remarkable point
(1)	$H < H^*$ $Y_t > Y_c$		Most desirable
(2)	$H < H^*$ $Y_t < Y_c$ Super-critical flow at outlet		Not desirable. If this type has to be designed, the scouring protection at outlet is required.
(3)	$H < H^*$ $Y_t < Y_c$ Super-critical flow		Not desirable. If this type has to be designed, the scouring protection against jumping water at outlet is required.
(4)	$H > d$ $Y_t > d$		Must not be designed. This type has possibility to be appeared for the abnormal phenomenum.
(5)	$H > H^*$ $Y_t < d$		Must not be designed. This type has possibility to be appeared for the abnormal phenomenum.
(6)	$H > H^*$ $Y_t < d$		Not desirable. The cabitation will be expected at inlet.

H: Water depth at inlet

d: Height of water way area

H*: Critical water depth at inlet

whether the inlet will be under water level or not ($\fallingdotseq 1.2 \sim 1.5d$)

Y_t: Water depth at outlet Y_c : Critical water depth

(4) Scouring protection on the slope around of cross drainage outlets.

After Typhoon Didang there are so many eroded slopes by water flow from cross drainage and they were restored as follows. (Figure II-1-22)

- Expansion of water way area (Photo II-1-7)
- Stone masonry plastering around the outlet (Photo II-1-8)
- Protection of slopes by benching stone masonry wall
- Adjustment of water course

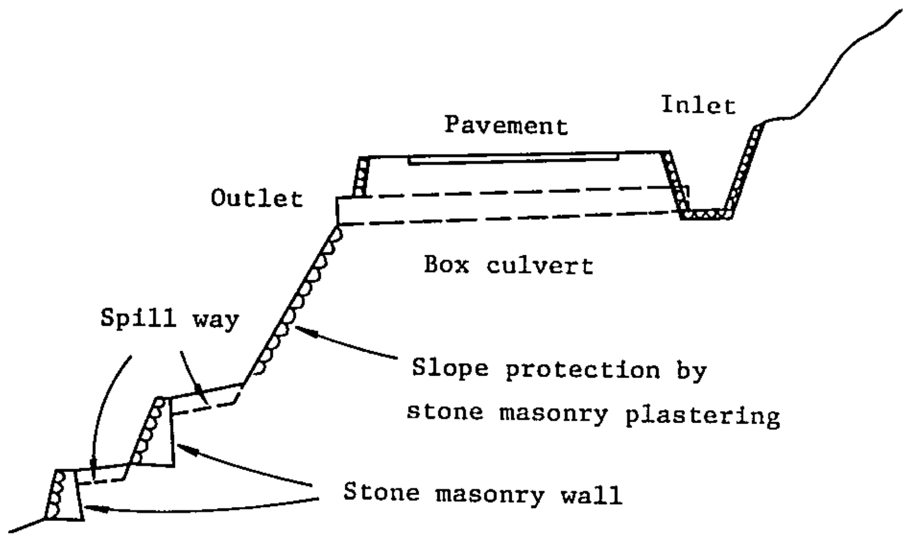


Figure II-1-22 Outlet Protection (Adopted after Typhoon Didang)

These restoration works are highly suitable treatment. We further recommend to use these kind of restoration works or improvement of the slope against the damages in the vicinity of outlets.

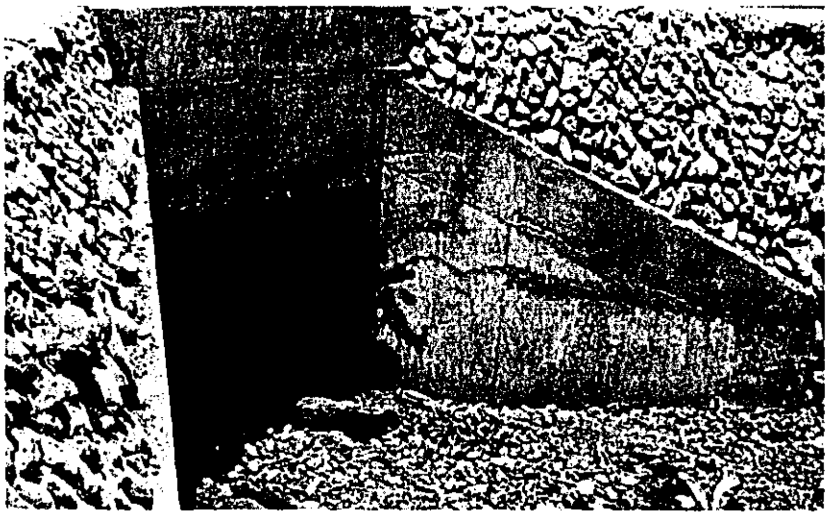


Photo II-1-7 Box Culvert

After Typhoon Didang, some cross drainages are improved from pipe culvert to box culvert having sufficient water way area.

Photo II-1-8

Slope protection around cross drainage outlet using stone masonry plastering.

(5) Improvement of cross drainage

In this section, we recommend following notices in the case of cross drainages installed connecting to the original channels carrying much sediment.

① Counter-measure methods to avoid the damages by sediment discharge

ⓐ If we cannot improve the cross drainage, the road have to cross the channel by bridge. Especially at the channel where debris flow is expected, bridge is highly recommended. At the portion shown on Photo II-1-9, the bridge is highly recommended to avoid the damages, debris flow is often expected where to be reached to the road.

ⓑ If we use the box culverts for cross drainage, the following notices are necessary.

(i) The capacity of inlet should be allowable against silting.

(ii) The gradient change between original channel and box culvert should be minimized as possible as we can. (Figure II-1-21)

(iii) Sometimes, the screen fence on the upstream side of inlet will be effective to deflect sediment. (Figure II-1-23)

Figure II-1-23' shows an example of debris deflector adopted in the United States.

Photo II-1-9

The road is crossing the original channel which debris flow is often expected to be reached to the road.

For avoidance the damages by debris flow, the road is recommended to cross this channel by bridge. Sta. 205 ∿ 206

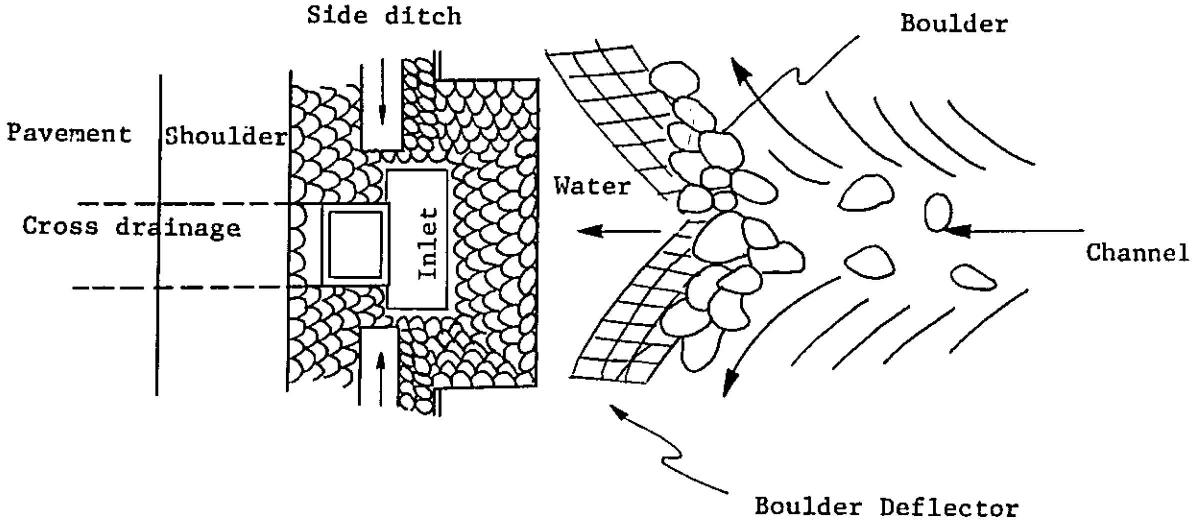


Figure II-1-23 Boulder Deflector

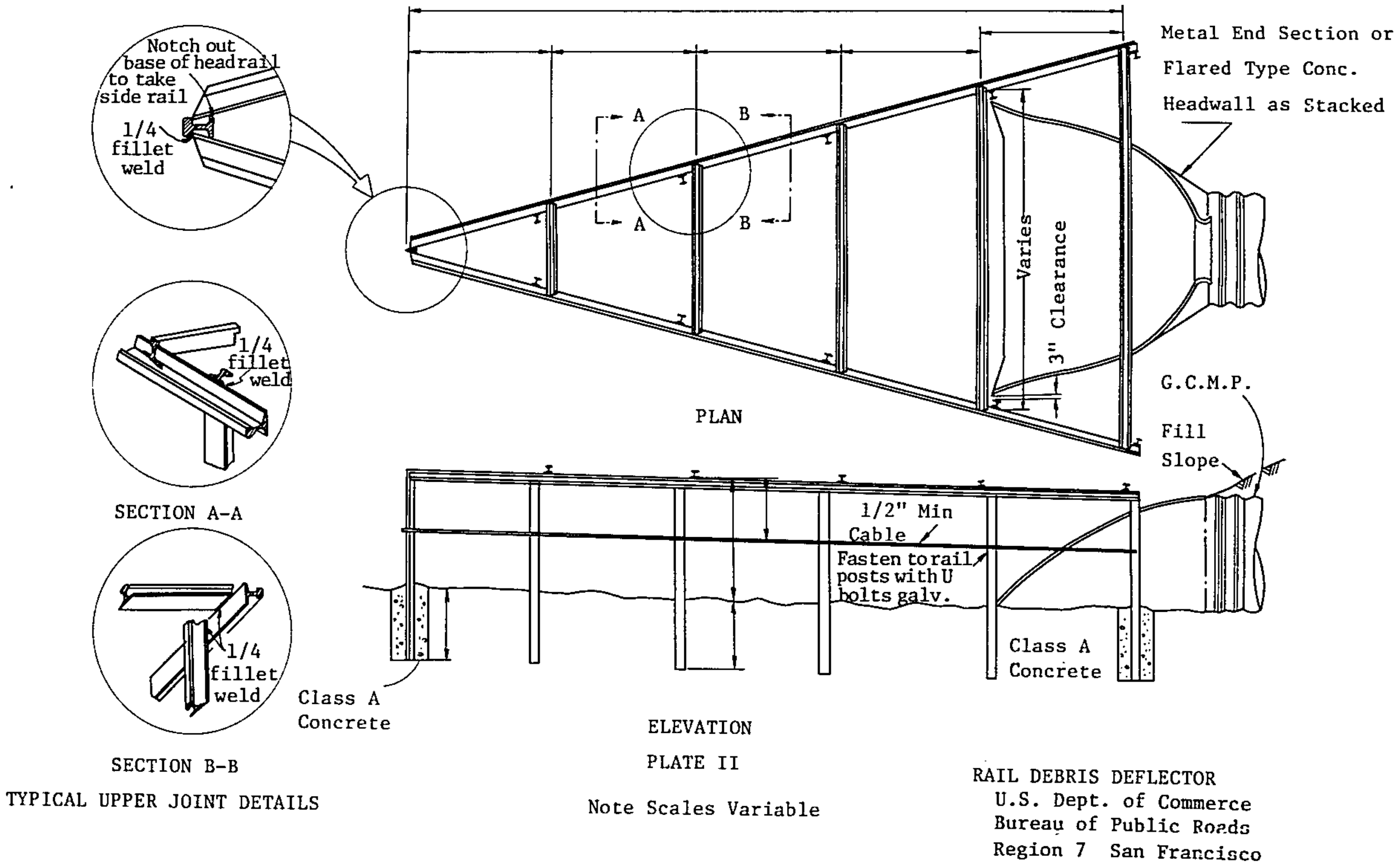


Figure II-1-23' Example of Debris Deflector

② Counter-measure methods to control sediment discharge on the channel bed.

ⓐ Settlement of channel bed

Ground sill will be effective for this purpose (Figure II-1-24).

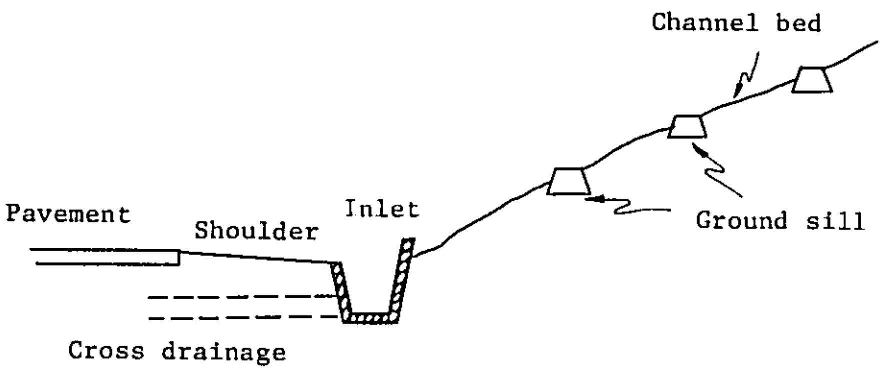


Figure II-1-24 Ground Sill

ⓑ The combination of channel works and ground sills or check dams will be effective for this purpose (Figure II- 1-25).

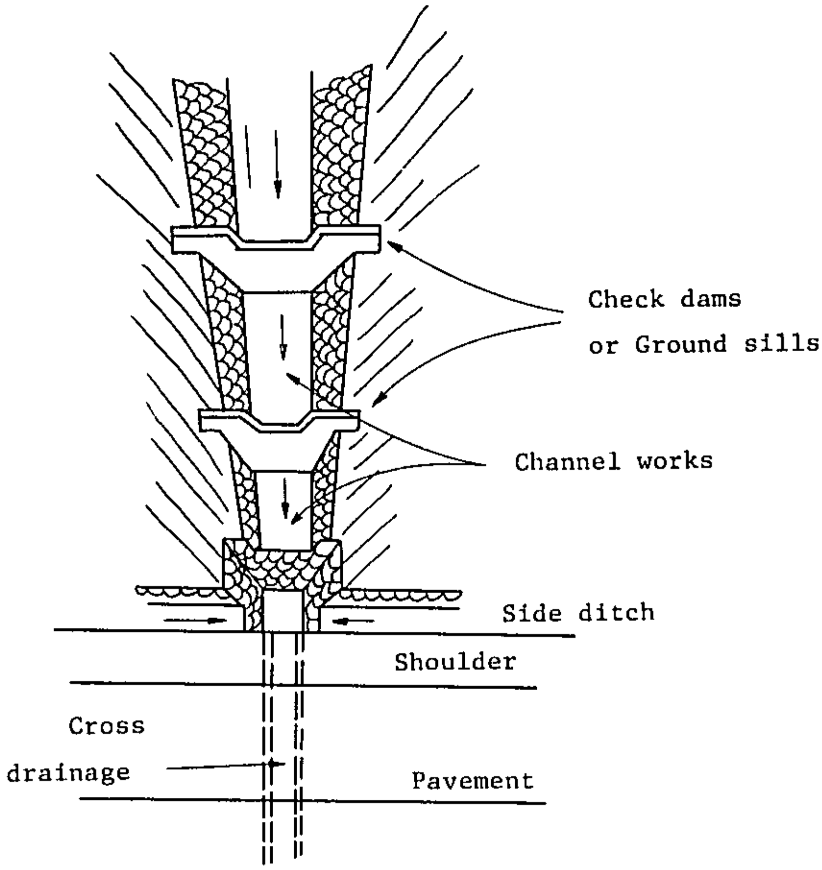


Figure II-1-25 Check Dams and Channel Works

ⓒ Check of sediment

Check dams are useful for this purpose. If boulders or logs are expected to be flown down, the screen type check dams will also be effective (Figure II-1-26).

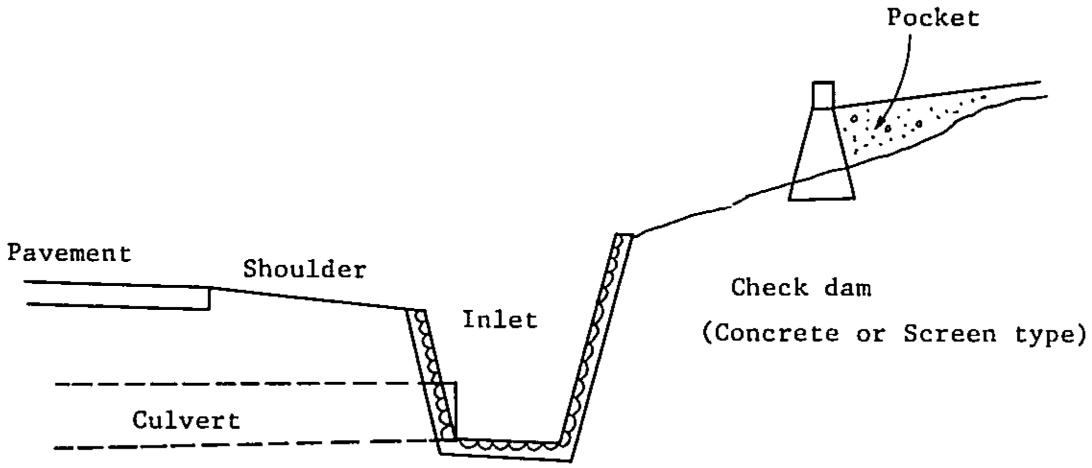


Figure II-1-26 Check Dam

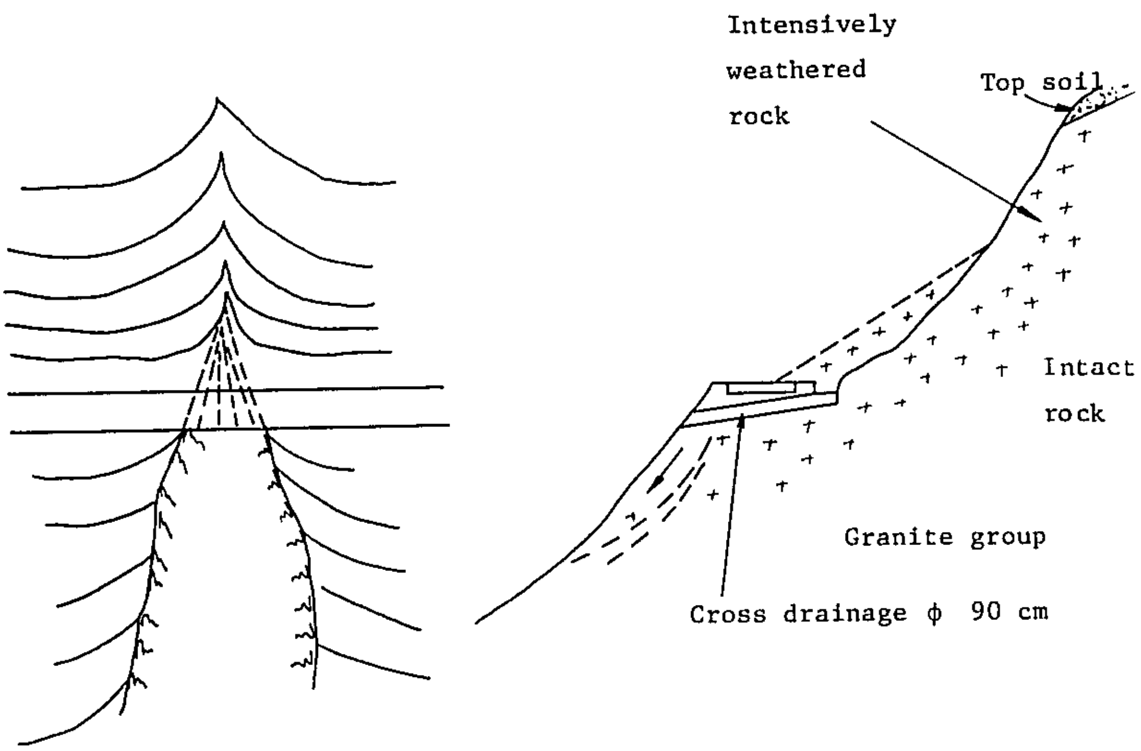
③ Followings are the explanations of counter-measure methods at the vicinity of Sta. 213 section, though the situations of damages was already described on Chapter 4.2.

ⓐ Sta. 213 (1) (Figure II-1-27)

After Typhoon Didang, the small check dams by stone masonry were already constructed. This is very suitable for restoration works. We recommend following additionals.

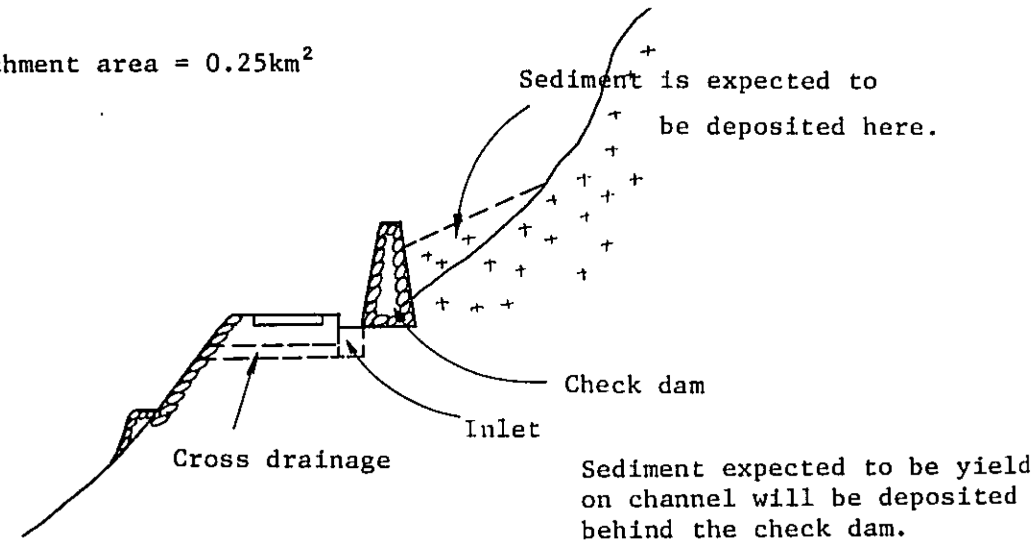
(i) Improvement of inlet and cross drainage capacity.

(ii) For coming heavy rain, the sediment yielded from channel must be checked by check dams to be installed on the channel bed.
The sediment deposited on the road by usual heavy rain must be removed each time.
(Figure II-1-27)



Situations of Damages

Catchment area = 0.25km^2



Restoration Works Recommended

Figure II-1-27 Sta. 213 (1)

ⓑ Sta. 213 (2) (Figure II-1-28, II-1-29)

The protection by stone masonry on fill slope of point A will be suitable. On the other hand, we recommend the installation of ground sills on the stone masonry channel between section A and B restored after Typhoon Didang to mitigate the water velocity and scouring, because the gradient of channel is so steep and the surface of slope consists of weathered granite.

At point B, the side ditches are designed to flow down the surface water to the Santa Fe River. There are some possibilities that surface water will overflow on the road and brings some damages to households on the toe of slope.

We recommend the surface water drain at point B as follows:

(i) Newly installation of drainage channel. This method is good for the stability of channels and slopes but it is so expensive by removing households to install drainage channels.

(ii) Utilization of side ditches

As the velocity of surface flow on the stone masonry channel between A and B will be very fast, it is difficult to collect and drain water completely by side ditches.

We recommend to mitigate the water flow velocity by ground sills or check dams being installed immediately upward of side ditch.
(Figure II-1-28, II-1-29)

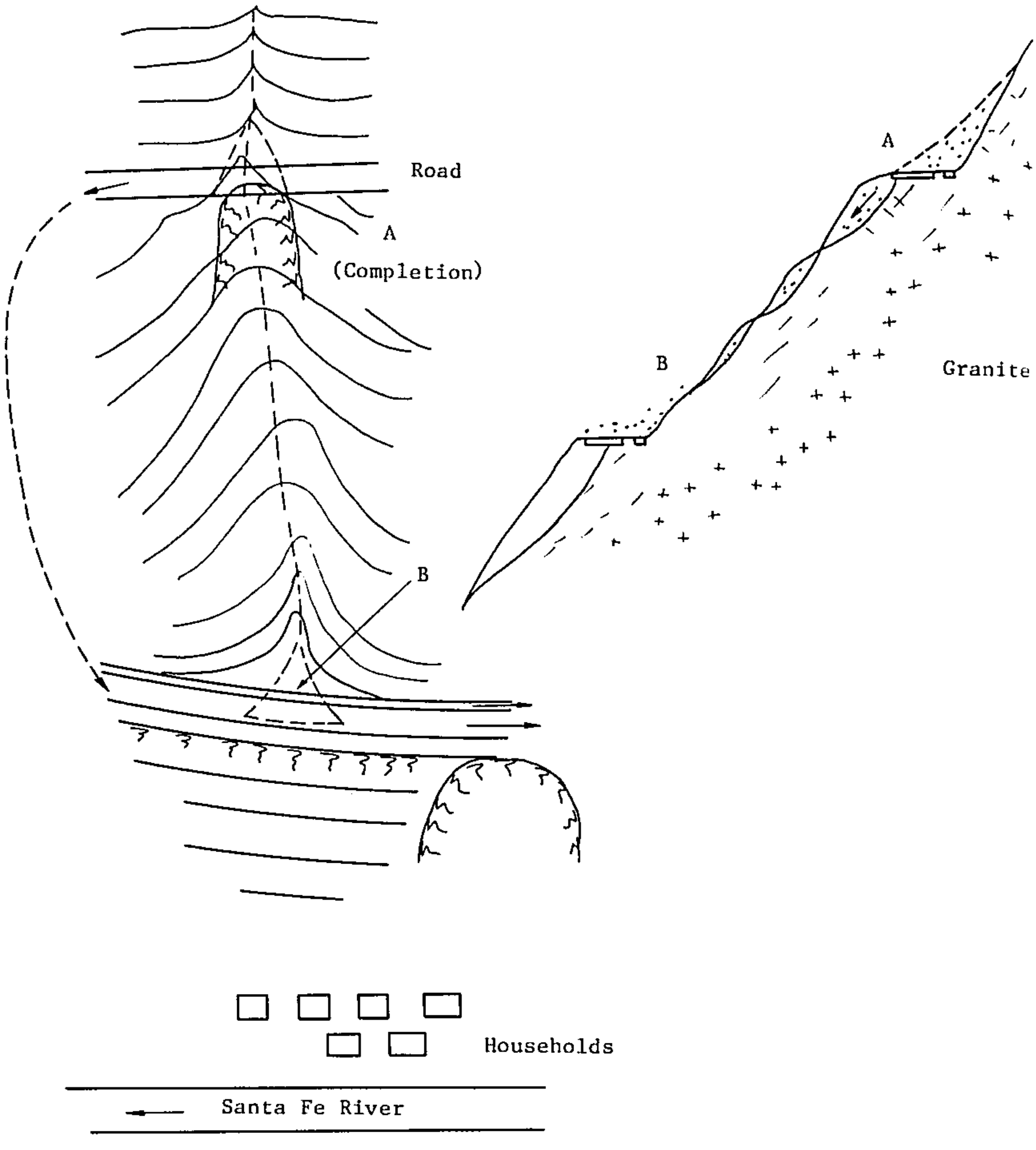


Figure II-1-28 Sta. 213 (2) Damages

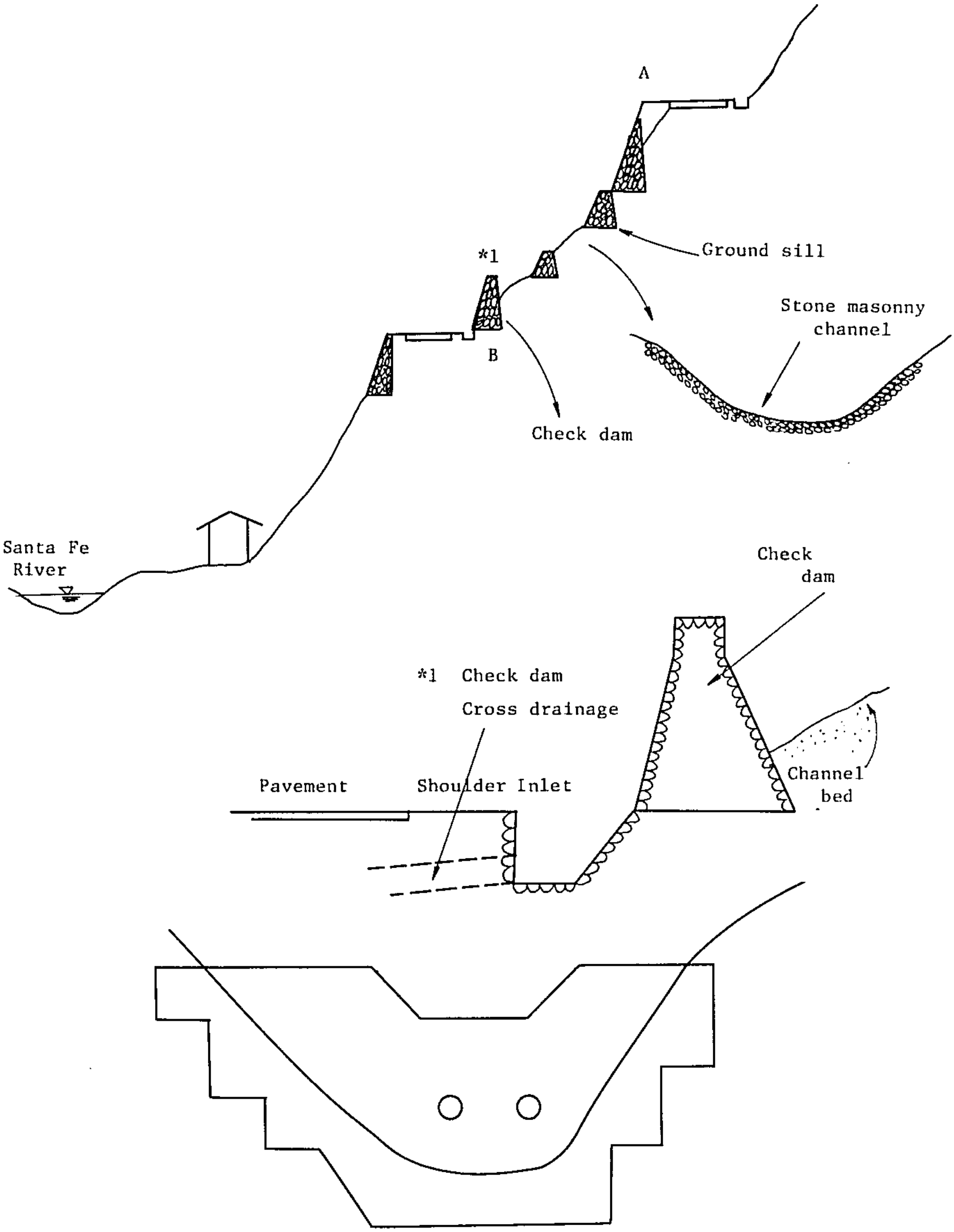


Figure II-1-29 Sta. 213 (2) Restoration Works Recommended

(6) Distance between cross drainages

It is said that the cross drainages are installed normally each 100 meters distance.

It may be enough at the flat section of road between Sta. 174 - Sta. 182. But in mountainous area there are so many complex conditions such as frequent changes of cross sectional gradient and longitudinal slope, continuous curving, many crossing channels and so on. Accordingly, the distance of each cross drainages should be installed closely as possible.

Followings are notices to install cross drainages.

① The water on hillside portion must be drained promptly.

② The depression section of side ditches and the places water concentrates are good for cross drainage distribution.

③ The place where the water discharge exceeds the capacity of side ditches must be a required place for cross drainage distribution.

④ Channel crossing points

⑤ Concentrating place of surface water on pavement

⑥ Reversely changing point of cross sectional gradient of road.

In addition to several points mentioned above, the cross drainage systems should be required to be designed considering topography and road structures. At least in the vicinity of Dalton Pass, the cross drainage should be recommended to be distributed approximately every 50 meters.

1.3 Recommendations on the Improvement of River Bank Protection Works

(1) The revetment and other structures should be designed at the scoured embankment portions and the places having possibility of scouring for the road protection. In the first place, general recommendation as for the river structures will be described. As these portions are apt to be attacked by flood water because of its curving, the protection structures are required to be massive. The protection structures of embankments are classified to revetment works, foot protection works, spur dyke works, ground sills works and so on.

① Revetments

Revetments have utility to protect the embankment from scouring by water flow. As revetments are often destroyed by scouring at their toe, the toe of revements is required to be penetrated enough. Generally, the depth of penetration is 1.0 - 1.5 meters deep under river bed.
Further deep penetration is also required at the place where river bed scouring and undercutting is predicted.

The river bed will be scoured deepest during flood time. But the river bed will recover its height by silting after flood. Accordingly, we should not make mistake the river bed after flood to be a deepest scoured bed. The depth of the toe foundation of revetments must be decided by estimating the deepest maximum depth of scouring in the river bed during flood. (Figure II-1-30)

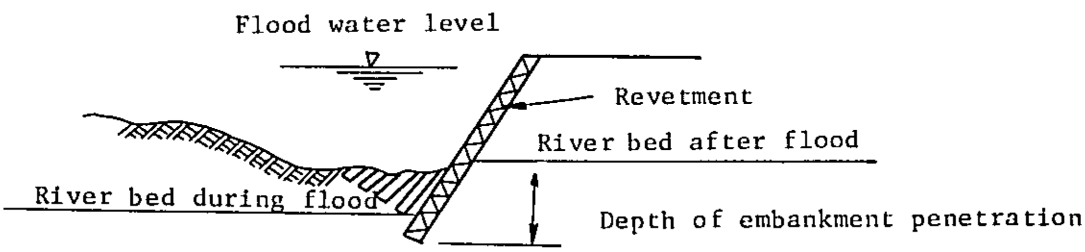


Figure II-1-30 Penetration of Embankment

The suitable structures of revetment were shown on Figure II-1-31. The suitable height of each revetment is under 5 meters. The lowest revetments should be changed to aggregate concrete wall instead of stone masonry.

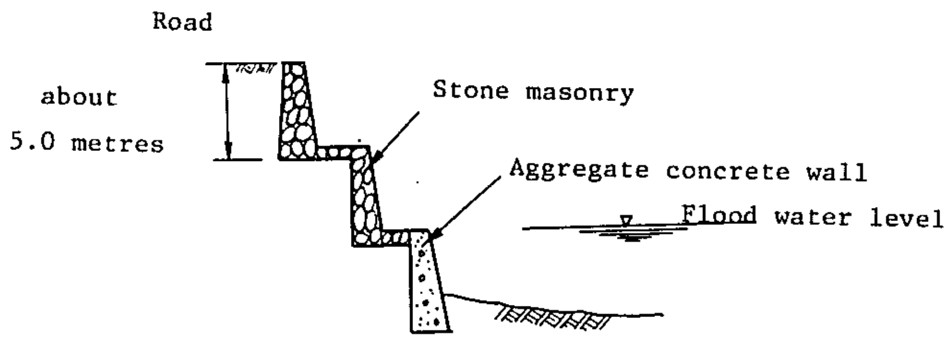


Figure II-1-31 Structure of Embankment

We recommend that gabions are very useful for revetments, because gabions are flexible and are easily installed and materials such as boulders are obtained easily in construction site.

② Foot protection

Construction methods and sizes of foot protections should be decided by considering the grain distribution of river bed materials, velocity and depth of water flow, the river bed evolution and so on. In any cases, as the destruction of revetments progresses from the base, the foot protection is extremely important. As mentioned, the curving portion where is likely to be scoured violently by water flow must be enoughly penetrated its foot under the river bed.

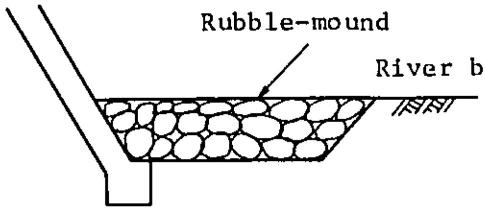
But as deeper penetration is too expensive, we should control the depth of penetration by using foot protection works together. Accordingly, it is general that revetment and foot protection must be combined at the portion of severe scouring. Further, if the lower flow level is considerably high, the height of revetment foundation must be raised up to the height of low water level by using the sheet pile foundation and reinforcement of revetment front by foot protection works must be required.

Generally, though the height of the foot protection works is on the river bed, the rubble-mound by concrete blocks under the low water level is sometimes used in the case of considerably high low water level.

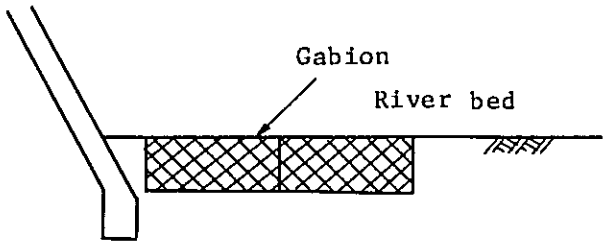
By our observation at damaged portions, no foot protection works are constructed. The foot protection works adding to revetment is highly required to be installed for the protection of embankment from flood water.

Figure II-1-32 show the types of foot protection works available to damaged portions.

① Rubble-mound



② Mattress type gabion



Size :

Width	1.2 ∿ 2.0 m
Length	2.0 ∿ 4.0 m
Thickness	0.4 ∿ 0.6 m
Diameter of wire	3.2, 4.0, 5.0, 6.0 mm

③ Concrete curtain block

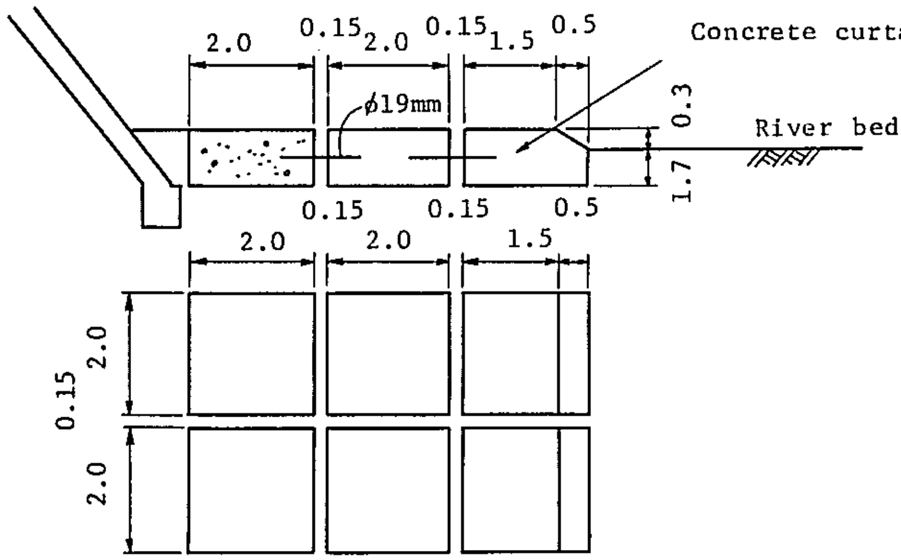
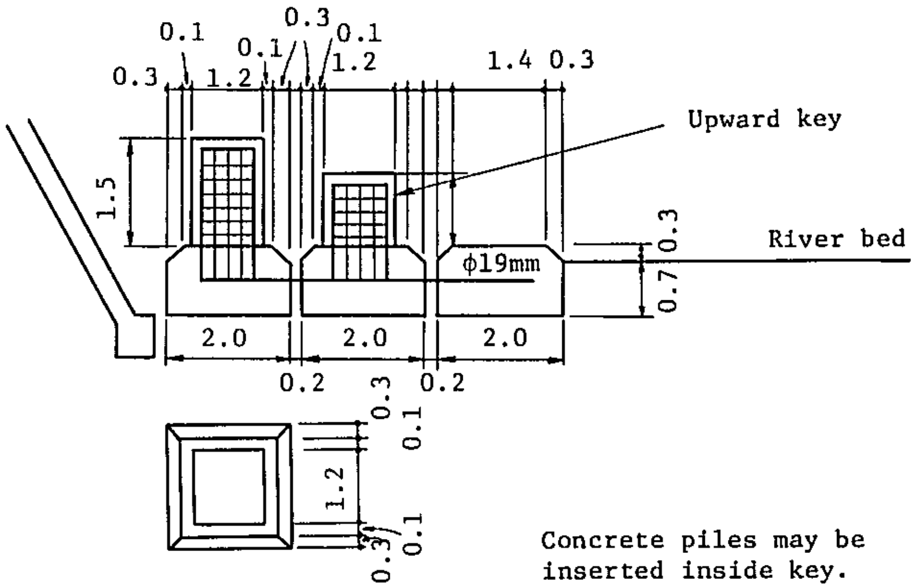


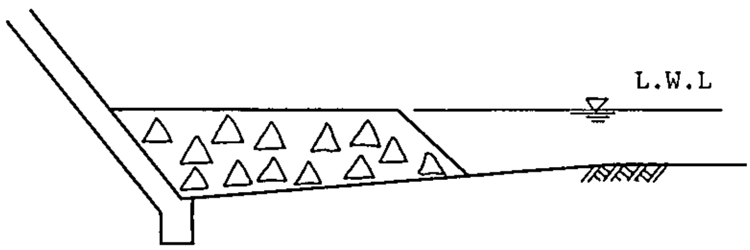
Figure II-1-32 (1) Alternatives of Foot Protection Works

④ Foot penetration having upward keys



Concrete piles may be inserted inside key.

⑤ Concrete block-mound



① Suitable for deep water section

② Concrete block is made on factory or operation yard

③ The shape of concrete blocks
- Cube
- Triangle cone

Figure II-1-32 (2) Alternatives of Foot Protection Works

③ Spur dykes

Spur dykes are installed on the river bed directed to the center of river by approximately right angle in order to protect the revetment from the water scouring by deflecting the water flow direction. Spur dykes must be hard structures, as they are predicted to accept the strong water flow pressure.

The abutment of spur dykes is required to be protected by revetment to prevent from levee scouring by over-flow water on spur dykes. And the tip and downstream side of spur dykes is required to be protected by foot protection works or by enough penetration of spur dyke to prevent from river bed scouring.

ⓐ Height of spur dyke

The height of spur dyke is generally above the medium flood water level or 0.5 ∿ 1.0 meters above of usual water level. The higher spur dyke is likely to be scoured by water flow. The height of spur dyke is required to decrease its height by descending gradient of 1/10 ∿ 1/100 toward the center of river from the stand point of safety.

ⓑ Length and distance of spur dykes

The ratio "ℓ/w", that is the length of spur dyke "ℓ" to the river width "w" is suitable under 0.10. From our judgement at damaged portions, the length of spur dykes is suitable to be existed in the range of 30 ∿ 100 meters, though it depends on the river width.

The suitable distance of spur dykes to be next to each other is 1.4 ∿ 1.8 times of spur dykes length at concave portion and 1.7 ∿ 2.3 times, 2.8 ∿ 3.6 times, at straight portion and convex portion respectively.

ⓒ Direction of spur dyke

The direction of spur dyke is divided into three types such as right angle, declining to upstream, declining to downstream toward the levee direction.

Spur dyke declining to upstream has utility deflecting water flow course toward the center of river and results the advantage of levee protection, on the other hand tip portion of spur dyke will be deeply scoured and downstream abutment portion will be silted. The standard declining angle is 10 ∿ 15 degrees, 5 ∿ 10 degrees, 0 ∿ 10 degrees at straight, concave, convex portions respectively.

Spur dyke declining to downstream is likely to be scoured on the downstream abutment portion and is disadvantageous for the protection of levee though the resistance against the water flow is low.

Right angle spur dyke is acceptable having medium characteristics between upstream and downstream declining spur dykes. But scouring of the tip portion can not be avoided. (Figure II-1-33)

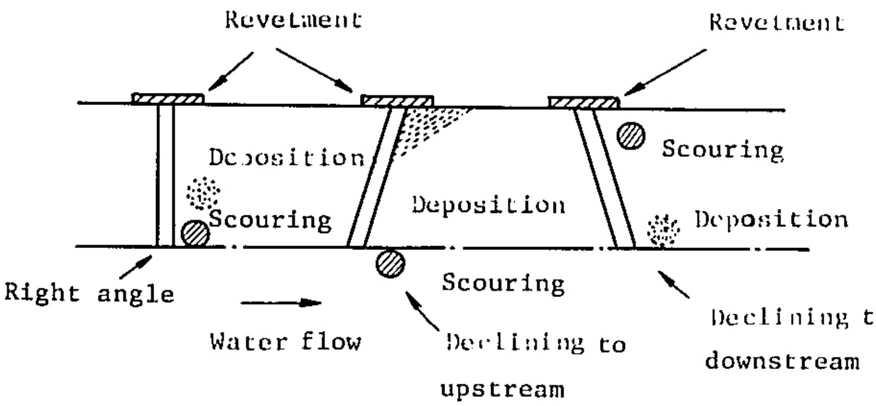
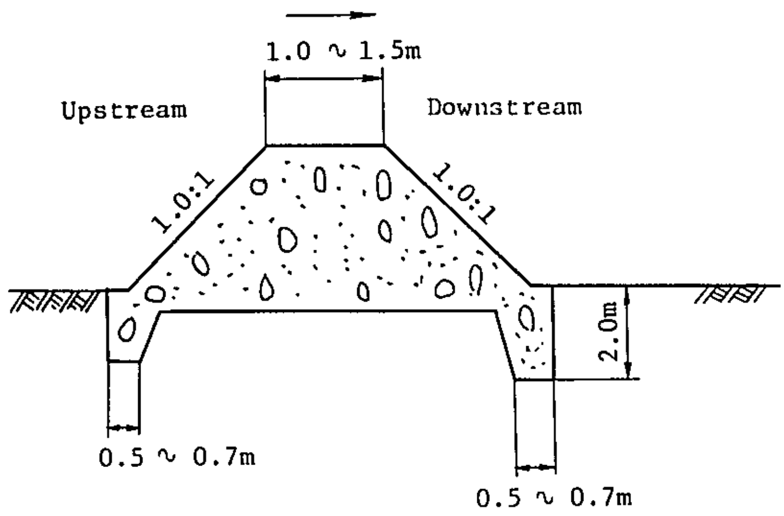


Figure II-1-33 Directions of Spur Dyke

Figure II-1-34 shows applicable spur dyke types at the damaged portions.

Anyway, installed spur dykes at damaged portions will be predicted the lack of strength against the flood water, because these are only covered by stone plastering.

Aggregate concrete



Foot penetration on the tip of spur dyke

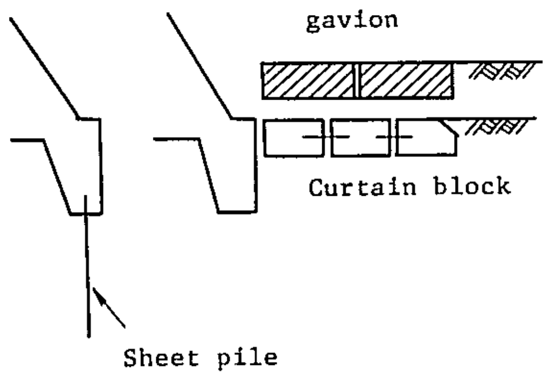


Figure II-1-34 (1) Alternatives of Spur Dykes

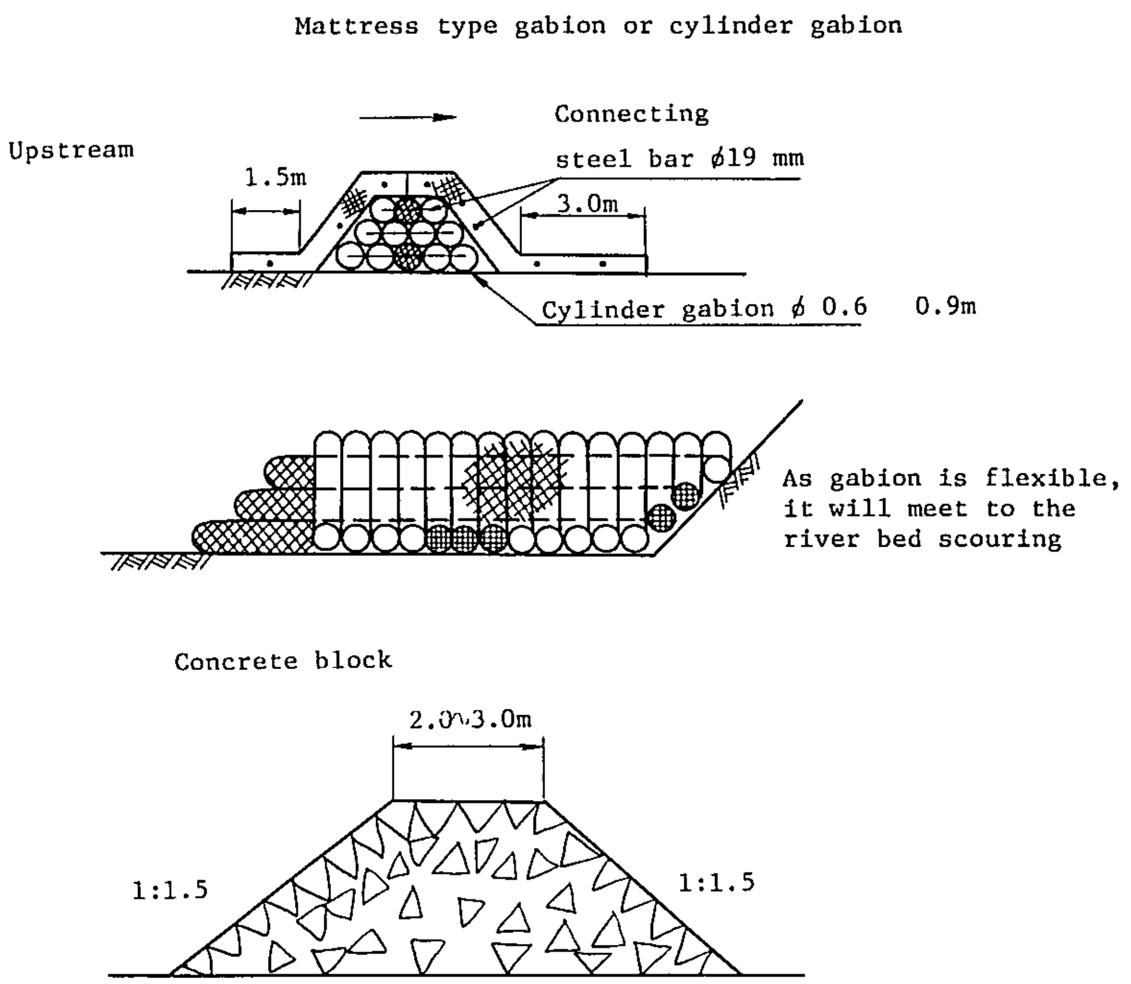
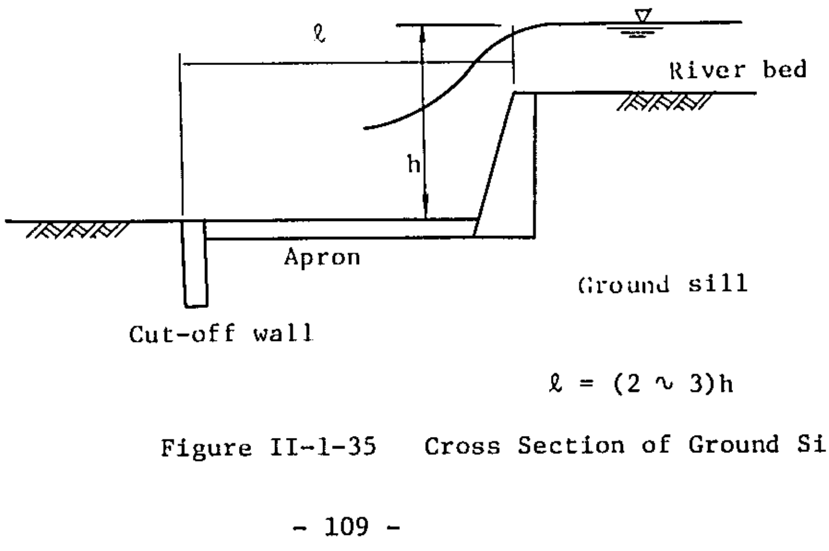


Figure II-1-34 (2)   Alternatives of Spur Dykes



$\ell = (2 \sim 3)h$

Figure II-1-35   Cross Section of Ground Sill

④ Ground sill

Ground sills will be installed across the river for the purpose of minimizing the river bed evolution.

The main purpose of this structures in the torrential rivers is mitigation of river bed gradient and adjustment of river course. And the main purpose of this structures in gentle rivers is mitigation of river bed undercutting, minimizing the local scouring by concentrating water flow.

(2) The restoration works of damaged points by flood water scouring were already completed almost 80%. The typical restoration works are the shift of road toward hillside and embankment protection, but stability problem of cut slopes will be remained

Next are the concrete recommendations for counter-measure methods of each damaged portions.

① Sta. 166 + 400

ⓐ Situations (Figure II-1-36)

The river-side slope at this point of road is the natural steep slope having 15 meters height and adjoins to the gentle concave portion of the Talavera River.

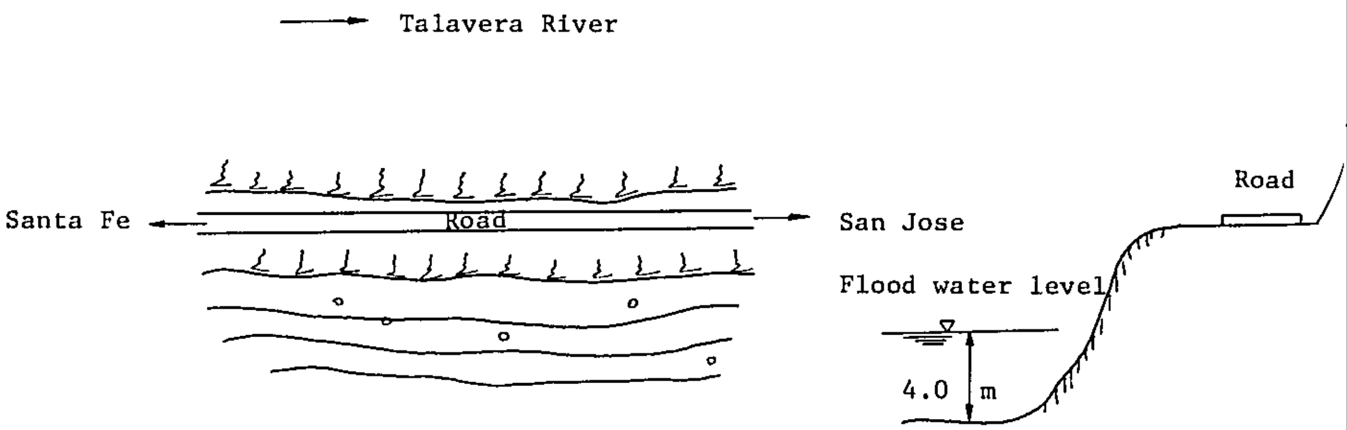


Figure II-1-36 Sta. 166 + 400 Situations

ⓑ Damages

Scouring by flood water is considerably progressing, and does not bring any influence to the road now. But scouring of road will be predicted at coming flood.

ⓒ Counter-measure methods (Figure II-1-37)

As the allowance between road and levee is enough now, also the river is remarkably wide here, spur dyke which can deflect the water flow toward river center will be more effective than levee protection by revetment. The proposed distribution of spur dykes is shown on Figure II-1-37.

At this point, it is not necessary to complete all spur dykes shown on Figure at the same time.
At the first step, the nearest point of levee to the road should be completed the spur dykes installation, after that, other spur dykes will be completed step by step judging the scouring.

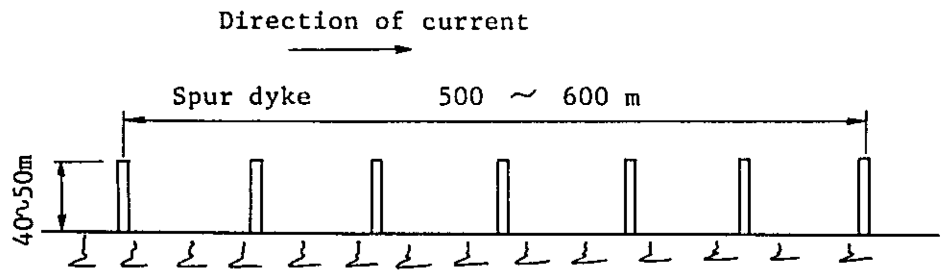
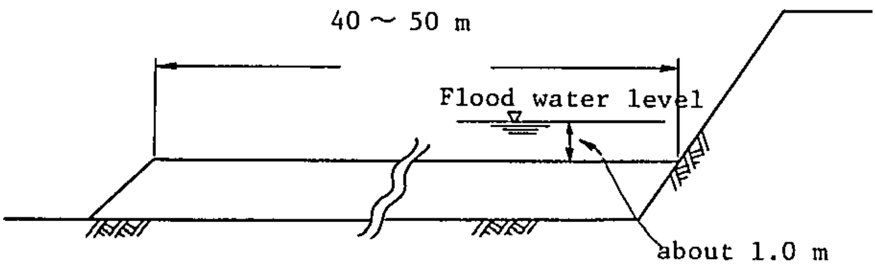


Figure II-1-37 Sta. 166 + 400 Counter-measure Methods



i It will be better to lower the height of spur dyke about 1.0 meters under flood water level, as the flood water level is comparatively high.

ii There are some kinds of spur dyke such as stone masonry, aggregate concrete works, cylinder gabion, mattress type gabion and so on.

Figure II-1-38

2 Sta. 170 + 600 (Figure II-1-39)

ⓐ Situations

This section was scoured most violently through our investigation area. The river curves approximately right angle toward road. The levee is very steep and 15 ∿ 20 meter high to the road.

ⓑ Damages

Violent scouring of embankment destroyed completely the fill section of road.

ⓒ Counter-measure methods (Figure II-1-40)

After Typhoon "Didang", the road was shifted to cut slope side and was protected by revetment at down-stream where the geologic condition is considerably bad.

The

strength but approximately 1.0 meter depth of penetration will not be able to bear against scouring.

We recommend to install the foot protection works to protect the revetment foundation and to complete until coming flood.

For the upstream road portion attacked by water flow by right angle, firstly the mitigation of water flow attack to the levee and correction of river curving must be carried out.

We recommend here to construct spur dykes promptly.

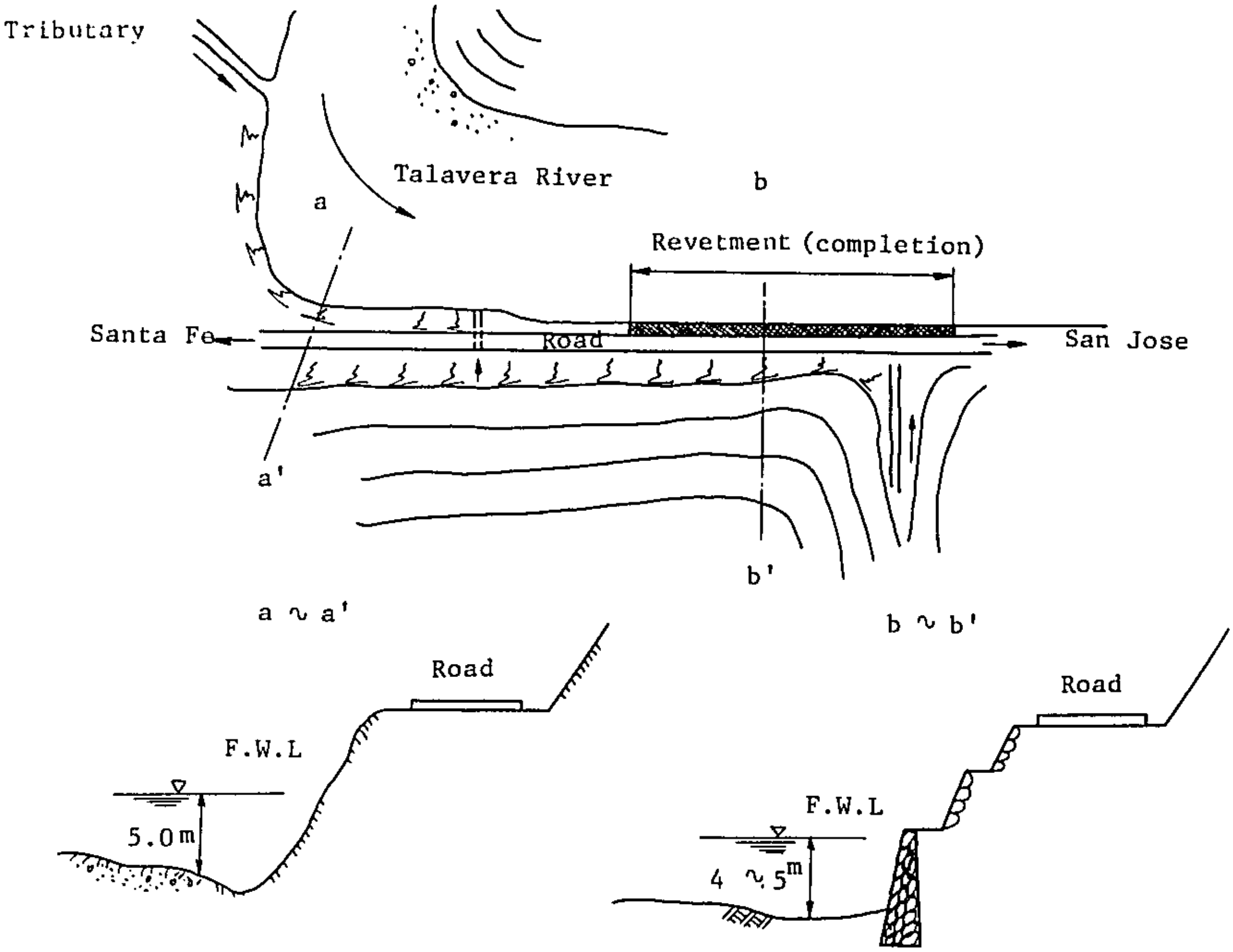
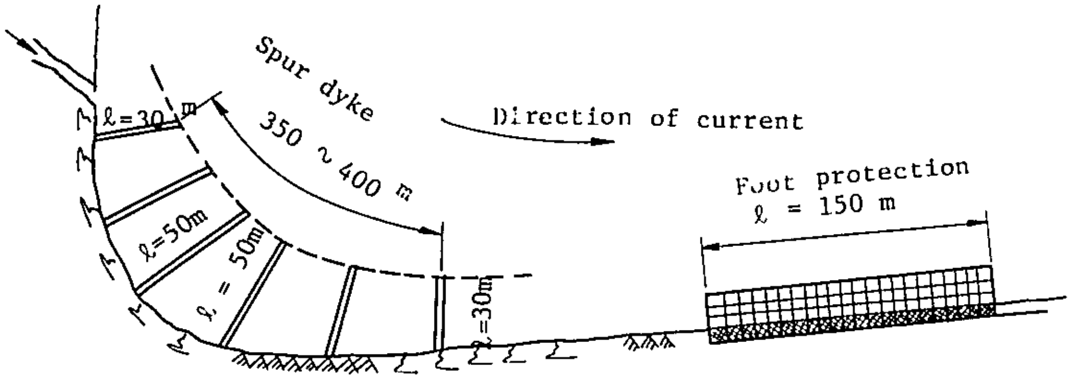
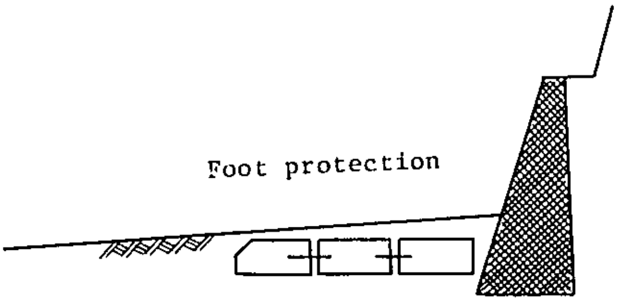


Figure II-1-39 Sta. 170 + 600 Situations





i To modify the river curve, the middle part of spur dykes should be longer than others.

ii Aggregate concrete, cylinder gabion or mattress type gabion are available for spur dykes.

iii Cutrain block or mattress type gabion is recommended to be used for foot protection.

Figure II-1-40 Sta. 170 + 600 Counter-measure Method

③ Sta. 187 + 425 (Figure II-1-41)

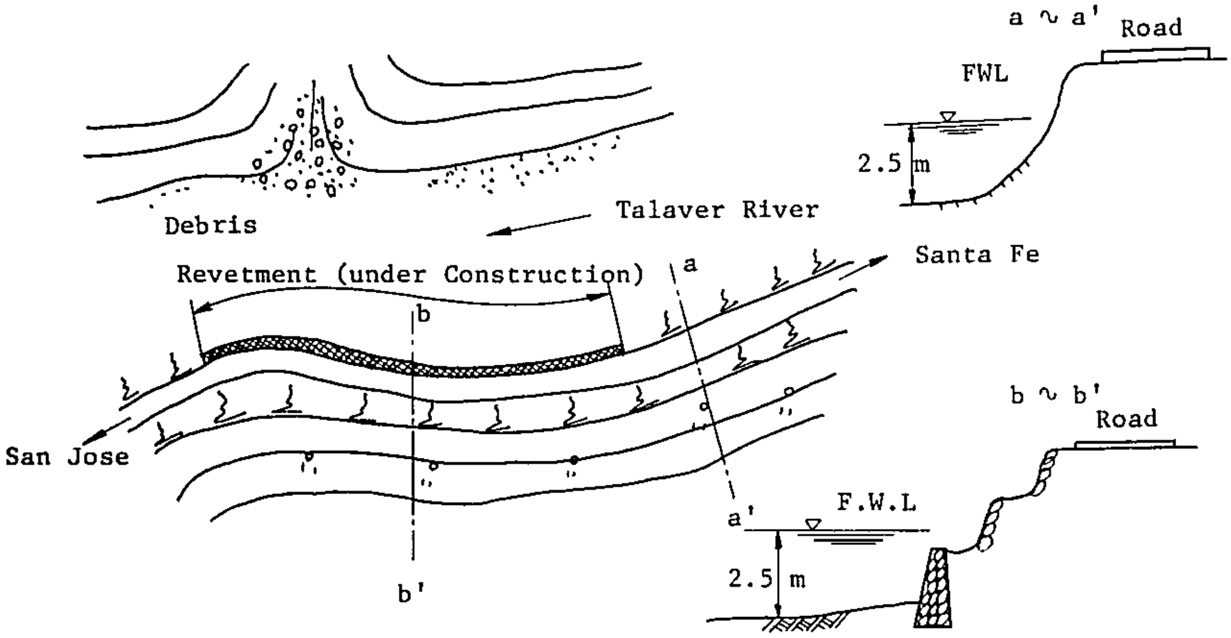


Figure II-1-41 Sta. 187 + 425 Situations

ⓐ Situations

The Talavera River curves here toward to the road and a channel from the opposite side of the river flows into by right angle to the road.

ⓑ Damages

The flood water scoured fill section of road completely and undermined the pavement of road.

ⓒ Counter-measure methods (Figure II-1-42)

After Typhoon Didang, the road was shifted to cut slope side and revetment is under construction. As the toe of levee will be extremely scoured in future, foot protection works on the toe of revetment must be promptly installed. We recommend to use the foot protection having upward keys as shown on Figure II-1-42 to deflect the water flow, as the river curves continuously.

We also recommend to protect by revetment the natural levee about 100 meters upstream of construction site, because there will be predicted scouring by coming flood.

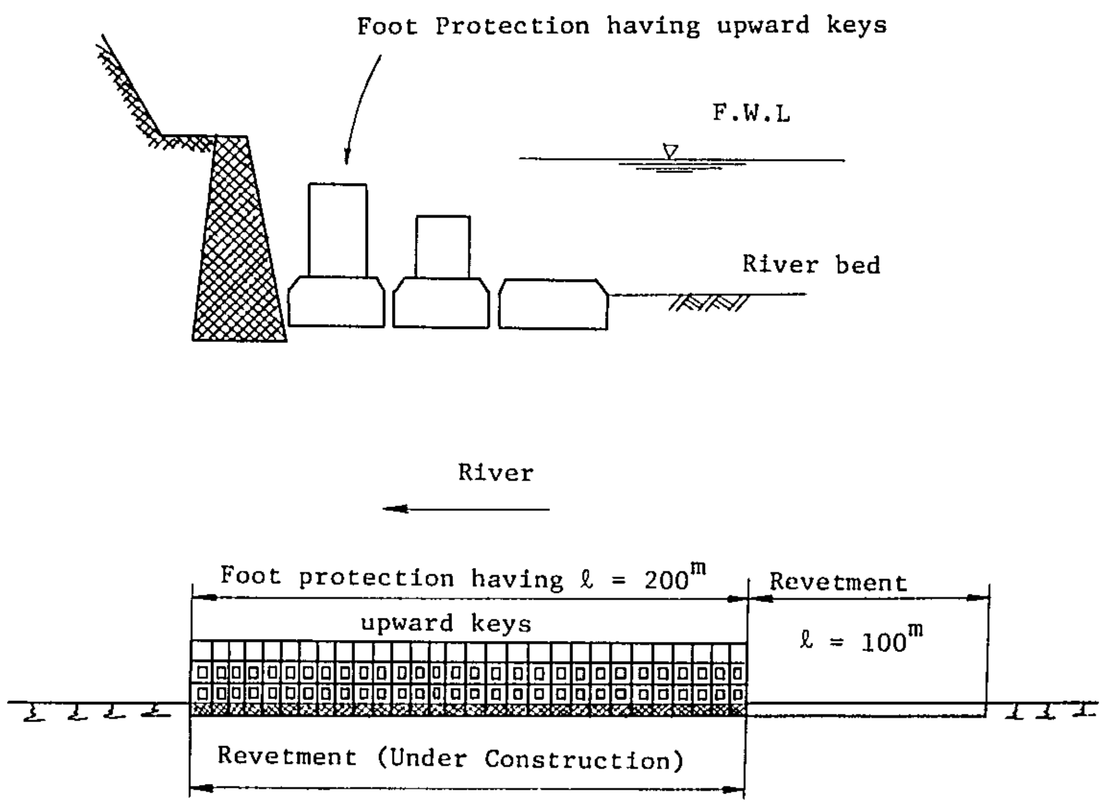


Figure II-1-42 Sta. 187 + 425 Counter-measure Methods

④ Sta. 189 + 900 (Figure II-1-43)

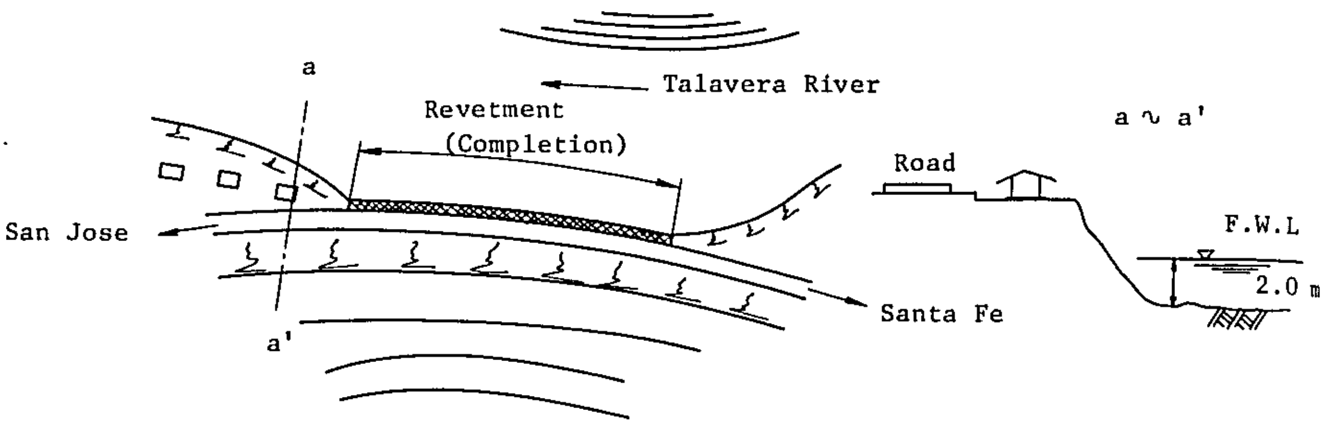


Figure II-1-43 Sta. 189 + 900 Situations

ⓐ Situations

The road embankment is apt to be scoured by flood water, as the Talavera River curves toward road.

This section of the Talavera River has steep gradient more than 1/200 and approximately 60 m width.

ⓑ Damages

The shoulder of the road was lost by flood water.

Ⓒ Counter-measure methods (Figure II-1-44)

The revetment was already completed at the section which will be affected by levee scouring. The penetration of revetment is more than 1.5 meter deep. Also, levee scouring is not expected heavily judging from river conditions. Accordingly, this restoration is considered to be suitable. Additionally, we would like to recommend the protection of downstream levee of this section, because several households are behind the river and the road is close to the river.

The revetment extending about 30 meters continuing to the completed revetment will be enough to protect the levee, because the base rock crops out on the foot of levee.

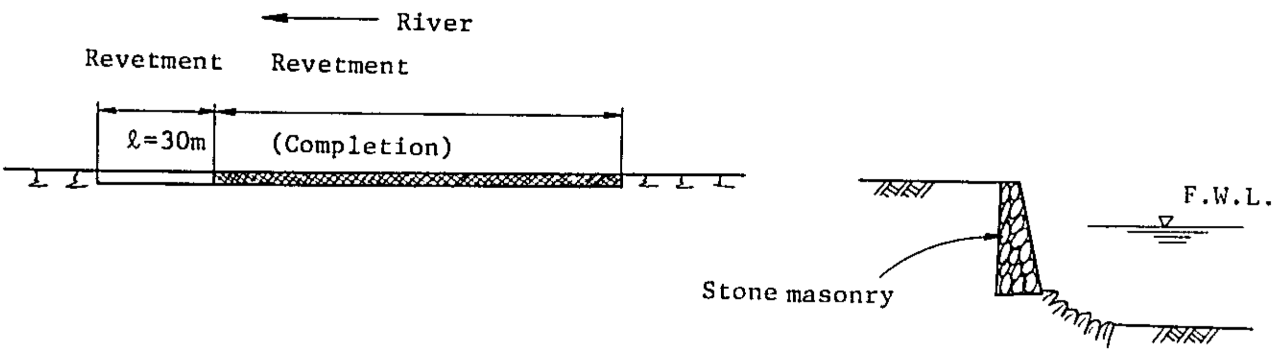


Figure II-1-44 Sta. 189 + 900 Counter-measure Methods

⑤ Sta. 192 + 600 (Figure II-1-45)

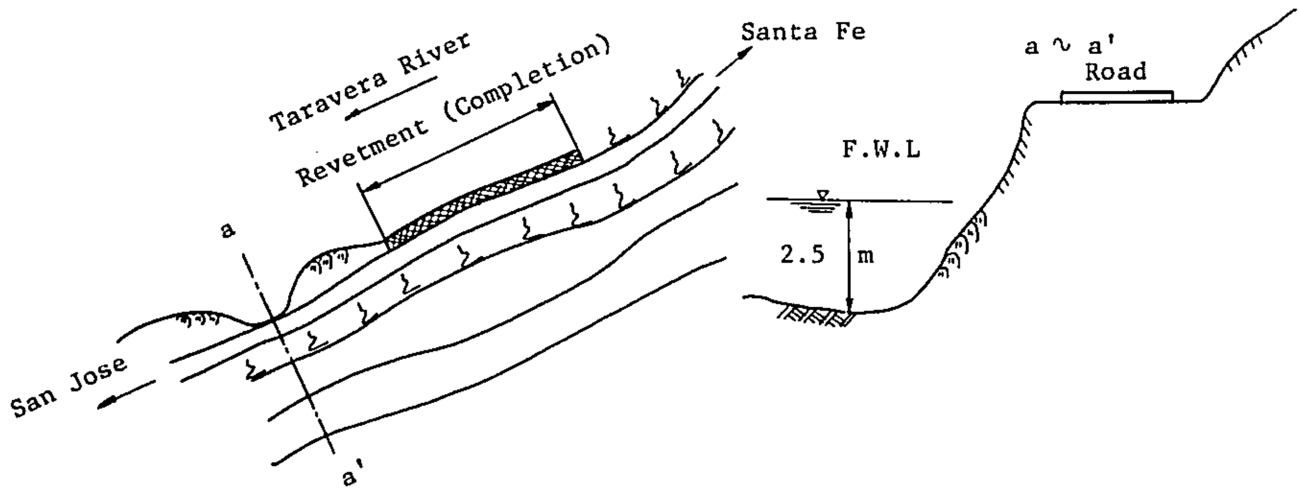


Figure II-1-45 Sta. 192 + 600 Situations

ⓐ Situations

The river curves toward the road. The height of levee is approximately 15 meters and crop out of rock exists somewhere.

ⓑ Damages

The fill section of road was lost by water scouring.

ⓒ Counter-measure methods (Figure II-1-46)

The installation of revetment was already completed at the most severely damaged section. As the both side of this section are dangerous and will be predicted the damages of road by coming flood. We recommend to protect the levee by revetment at both sections. For sometimes although the scouring of levee is not so important, foot protection works or spur dykes will be required in the future to reduce the river bed evolution.

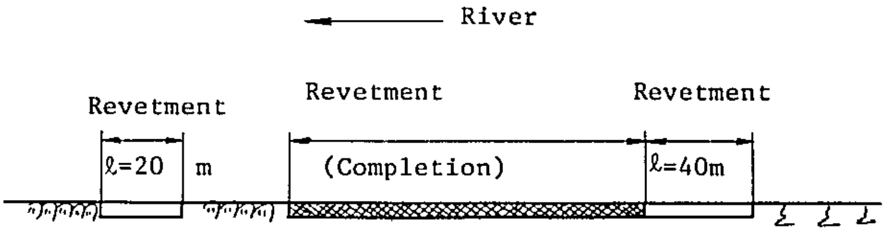


Figure II-1-46 Sta. 192 + 600 Counter-measure Methods

⑥ Sta. 217 (Figure II-1-47)

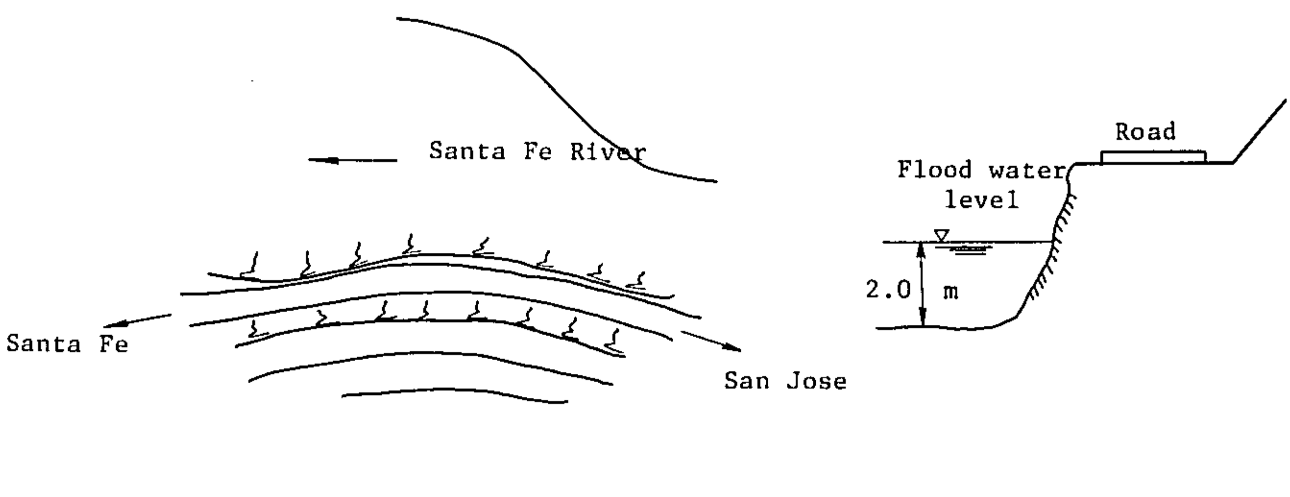


Figure II-1-47 Sta. 217 Situations

ⓐ Situations

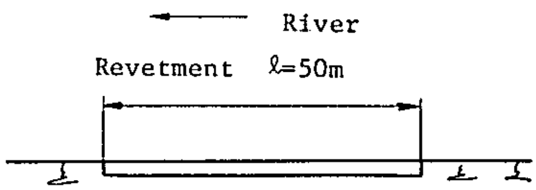
Damaged portion is the gentle curving section of the Santa Fe River. In immediately downstream, spur dykes are installed.

ⓑ Damages

The levee was scoured remaining about 2 meters to the road. The present situation permits the vehicle traffic. By coming flood the destruction of road is predicted.

ⓒ Counter-measure methods (Figure II-1-48)

We recommend the installation of revetment promptly. The 1.5 meters deep penetration of revetment foundation will be enough for the protection of revetment toe.



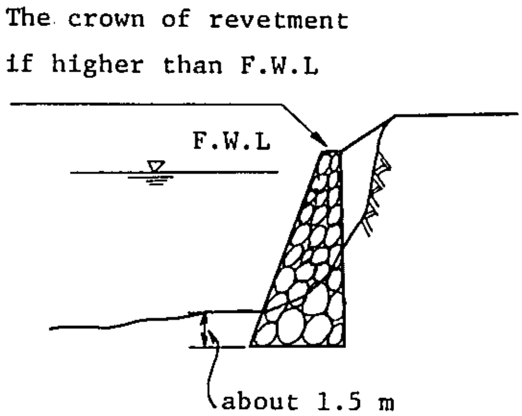


Figure II-1-48 Sta. 217 Counter-measure Methods

⑦ Sta. 220 + 500 (Figure II-1-49)

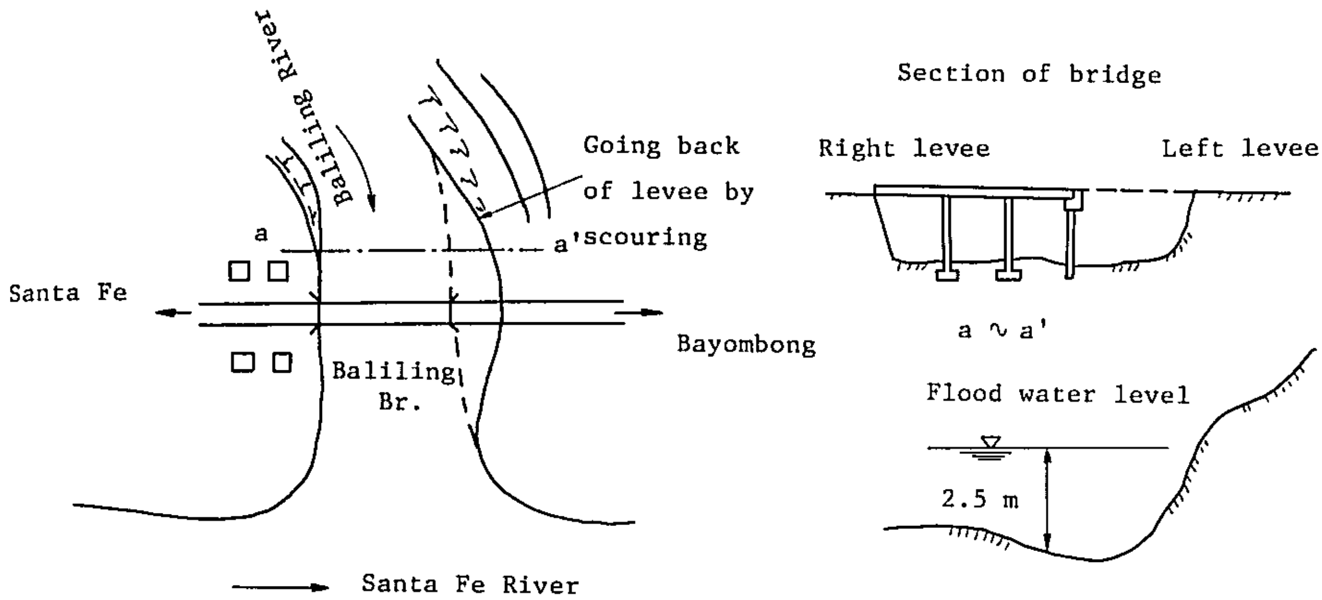


Figure II-1-49 Sta. 220 + 500 Situations

ⓐ Situations

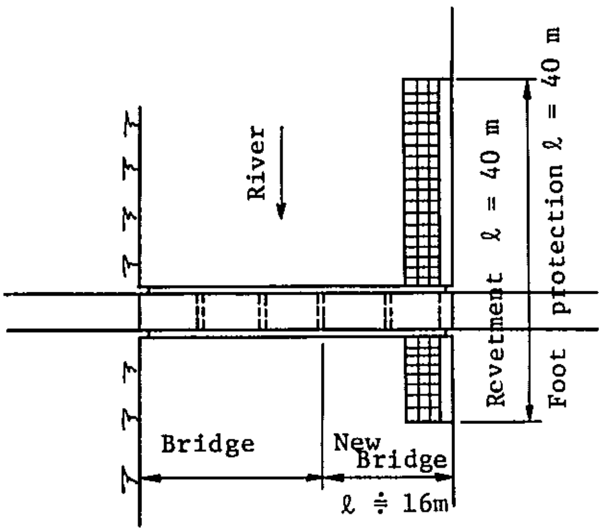
Damaged section locates just upstream of confluence of the Santa Fe River and the Baliling River. The left levee of the Baliling River curves toward road.

ⓑ Damages

The flood water scoured the left levee of the Baliling River and destroyed the road behind of bridge abutment.

ⓒ Counter-measure methods (Figure II-1-50)

After Typhoon Didang, the temporary bridge was constructed and opened to the traffic. We recommend to build bridge on damaged road portion scoured by water flow and to make flood flow down promptly. Also, the levees of both sides of bridge are recommended to be protected by revetments. Additionally, it will be desirable to protect the toe of revetments by foot protection works.



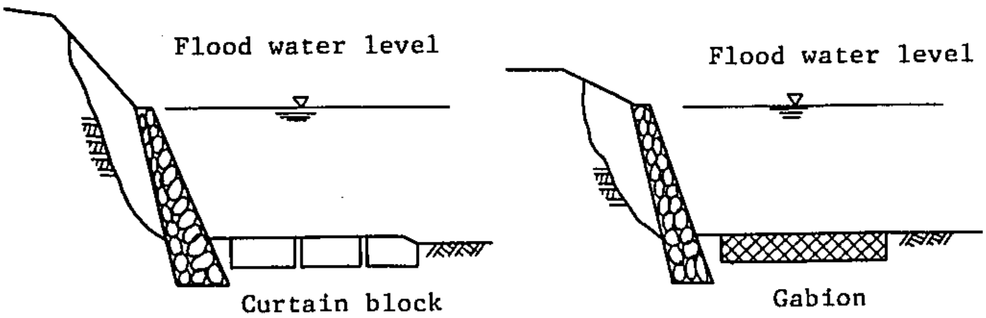


Figure II-1-50 Sta. 220 + 500 Counter-measure Methods

⑧ Sta. 225 + 640 (Figure II-1-51)

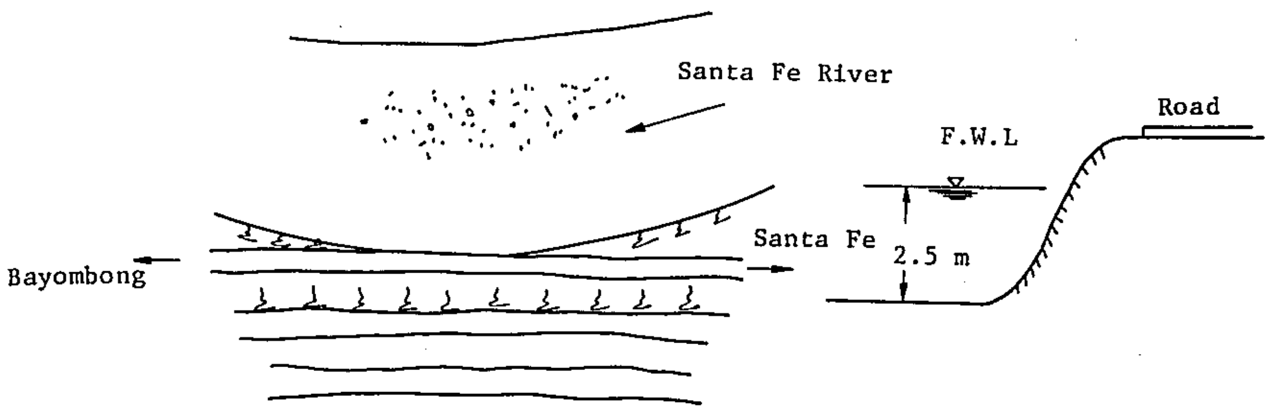


Figure II-1-51 Sta. 225 + 640 Situations

ⓐ Situations

This section is also likely to be scoured by curving water flow. The height of road is 5 meters above river bed.

ⓑ Damages

The levee was scoured about 2 ∿ 3 meters toward road by flood water. It will be desirable to be restored until next coming flood.

ⓒ Counter-measure methods (Figure II-1-52)

We recommend for the restoration works to install revetment and foot protection works.

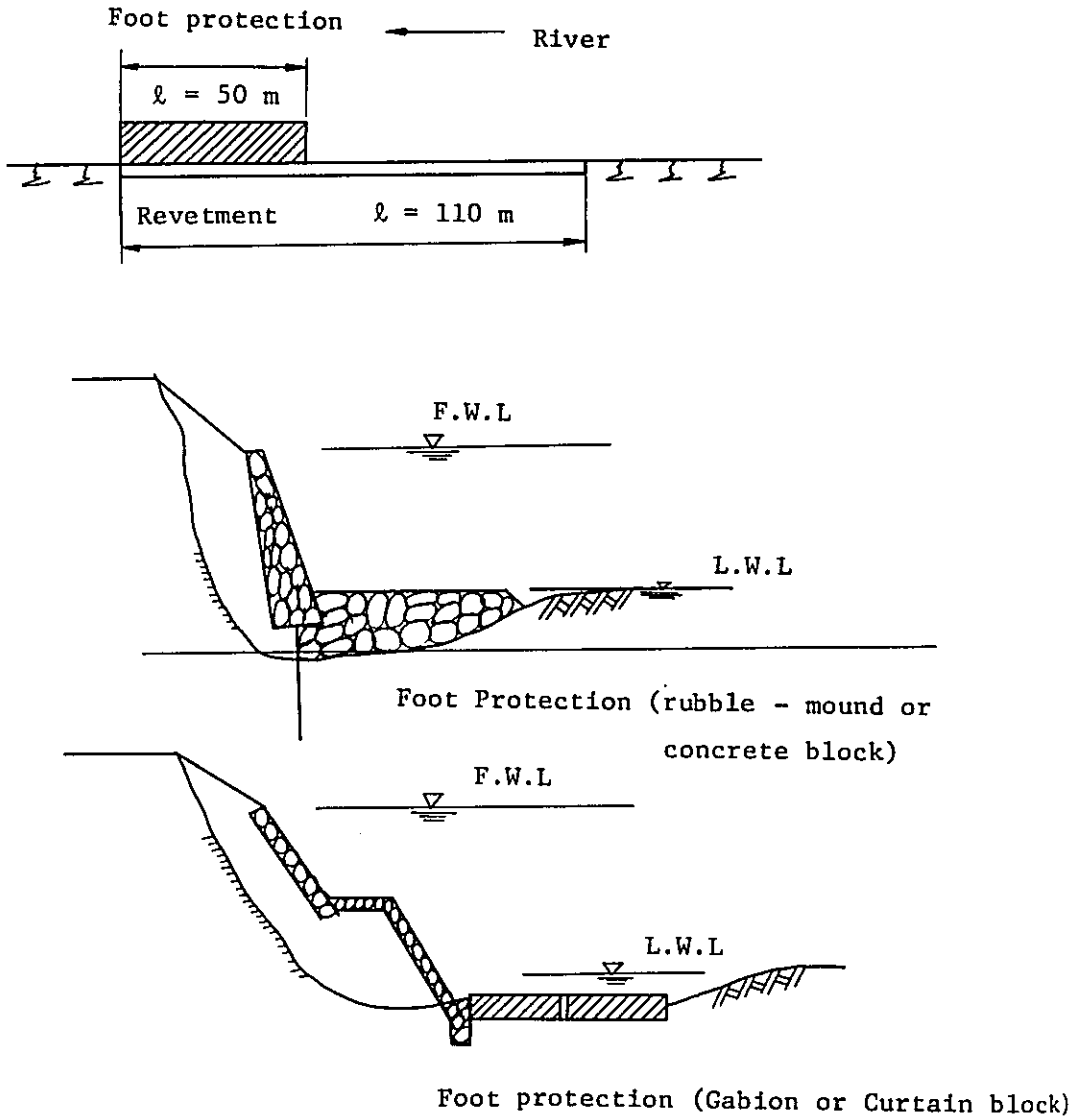


Figure II-1-52 Sta. 225 + 640 Counter-measure Methods

⑨ Sta. 242 + 243 (Figure II-1-53)

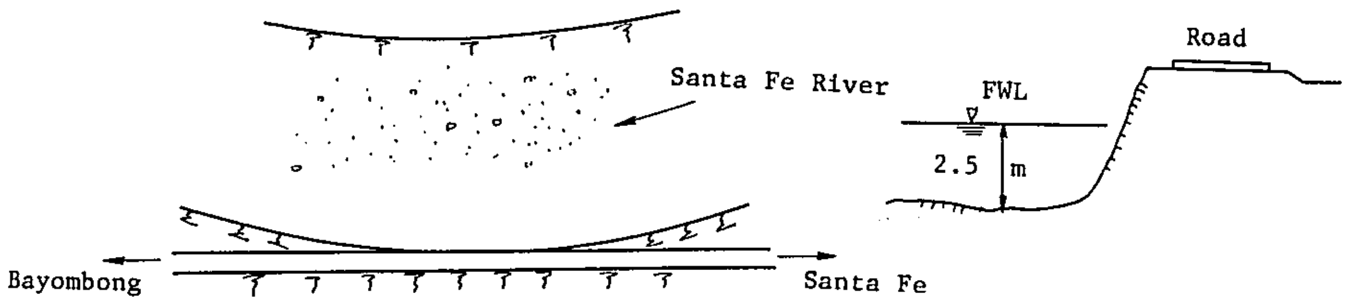


Figure II-1-53 Sta. 242 + 243 Situations

ⓐ Situations

This section is also likely to be scoured by flood water.

ⓑ Damages

The levee was scoured extending to the length of 100 meters. The enough allowance between levee and road permits the traffic vehicles. Coming flood will reach its scouring to the road.

ⓒ Counter-measure methods (Figure II-1-54)

At the first step, we recommend to deflect the water flow to the center of river by spur dykes. At the second step, if you judge through the observation of river bank conditions that only spur dykes can not avoid the scouring of a levee toe, the revetment will be required to be installed.

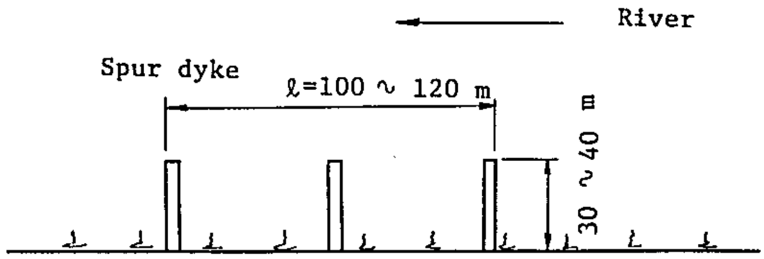


Figure II-1-54 Sta. 242 + 243 Counter-measure Methods

⑩ Sta. 253 + 255 (Figure II-1-55)

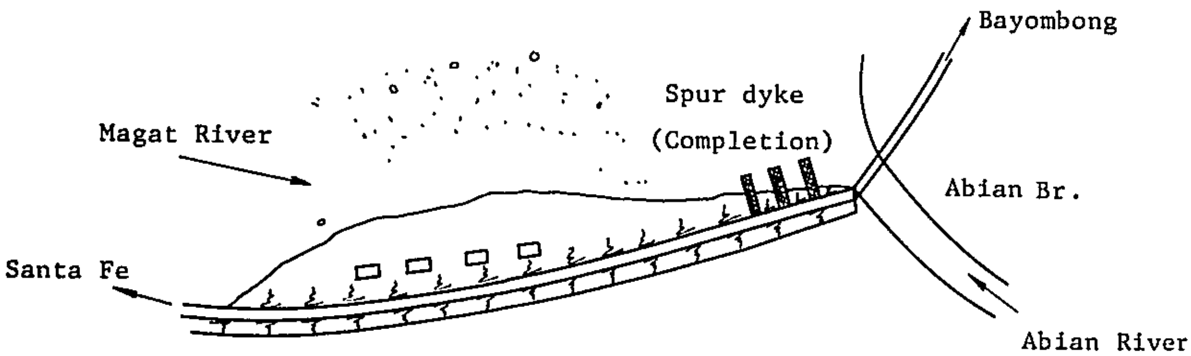


Figure II-1-55 Sta. 253 + 255 Situations

ⓐ Situations

This point locates on the downstream of the confluence of the Santa Fe River and the Matnud River. The shape of the confluence affects to the unstable river course. The water flow concentrates to the right levee of the Magat River. The width of river is 400 ∿ 500 meters and the gradient of river is gentle.

ⓑ Damages

In spite of the high progress of scouring, the road will not be scoured easily, because the river has major bed.

ⓒ Counter-measure methods (Figure II-1-56)

For the purposes of scouring control, river adjustment, spur dykes are designed to be installed and three of them are completed. After this the installation of spur dykes should be continued. As the damaged portion is too long, designed spur dykes should be installed gradually judging the length and distance of them based on the observation of effectiveness of completed spur dykes rather than completion of all spur dykes at the same time. Further, as this section is extremely important place for the flood control, more careful discussion including correction of the confluence shape will be highly required.

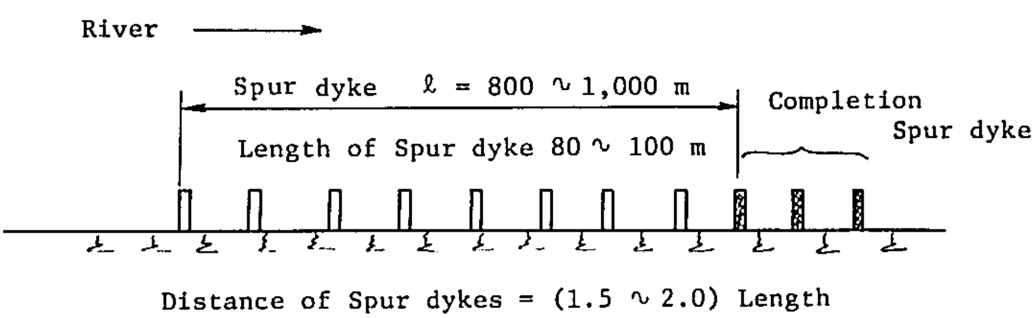


Figure II-1-56 Sta. 253 + 255 Couner-measure Methods

2. RECOMMENDATIONS ON THE GENERAL COUNTER-MEASURES METHODS FOR THE CAGAYAN VALLEY ROAD

2.1 Scope of the Counter-measures

In the Cagayan Valley Road, most seriously damaged portion is fifty kilometers long road stretch before and behind the Dalton Pass. This portion is most vulnerable to disaster caused by rainfall in Cagayan Valley Road because of its steep topography and fragile geology. As already described before, there are some reasons causing desaster to the road, of which most important are the collapse of slopes on the mountain side of the road and the scouring of shoulders of the road either by water running on the road or by flood in the river. Although emergency restoration works necessary for ensuring the traffic has been almost completed, it is recommended that further improvement of its facilities and additional disaster prevention works are necessary to meet with such a heavy rainfall as was brought about by Thphoon Didang.

The first thing to be considered when we make a plan of disaster prevention is the level to which the facilities are protected against disaster. It is noted that the amount and kinds of disaster prevention works should be well balanced with the importance endowed to the road. Therefore, taking into account that this road is the only one connecting Cagayan Valley and City of Manila, the capital of the country, and traffic is considered to increase along with the progress of Cagayan Valley development projects in future. It is difficult at present to make a clean dicision on the level of disaster prevention works because it requires further analysis about the financial situation which is related with the cost of works, the technology of construction etc. To say more concretely, the level is widely ranged from the lower one which is admitting a disaster every few years unless they cause serious damage to the traffic, to the higher one which is aimed at no more damages in future, requiring big amount of investiment for the works.

The outline of disaster prevention works is summarized in two cases for the sake of simple conclusion, neither of which would not admit serious damage to the road by respective rainfall; the Case I is necessary to eliminate such damages, and the Case II is also expected to minimize the damages.

Damaged portions descrived on the Chapter II.1, "Recommendations on the Counter-measures for Selected Damaged Road Portions" have high priority of counter-measures to minimize or to eliminate the damages because of their dangerous conditions. Among those dangerous portions, the further detailed priority should be discussed from the view points of the situations of slopes, embankments, topographic and geologic conditions and the construction cost for counter-measures.

On Table II-2-1, the counter-measures of Case II at selected damaged portions are given the highest priority, and the counter-measures of Case II at other stretch other than selected portions is given next high priority followed by Case I.

2.2 Outline and Summary of Counter-measures Required for Minimizing or Eliminating the Damages Caused by Disasters

Since it is difficult to obtain clear relationship between the intensity of rainfall and disaster, the standard design is applicable for fairly long portion in the road, the detailed planning would require further investigations and surveys.

Cost of the project is estimated, according to the table "Outline of Counter-measures", to be 151.0 Million pesos in Case 1 and 68.7 Million pesos in Case 2 respectively.

As far to foreign money, for Case I, the expenditure required to get the foreign material and construction equipment is estimated about 15% of the total cost of Case I.

Table II-2-1 Outline of Counter-measures

(1) STA 167 km ∿ STA 174 km (Distance : 7 km)

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Slope Protection	① STA 170km	① Check dams 2 L=30m and 50m H=10m ② Shelter L=1 points χ 100m	① Check dams 2 L=30m and 50m H=10m -
	② STA 170km + 600	① Excavation of cut slope L=150m $V=22,500m^3$ ② Grating crib works (2 steps) L=150m H=10m + 10m $A=3,000m^2$ ③ Turfing or sodding (2 steps on top) L=150m, H=20m $A=3,000m^2$	① Excavation of cut slope L=150m $V=22,500m^3$ ② Grating crib works (1 step at toe) L=150m H=10m $A=1,500m^2$ -
	③ Stretch other than ① and ②	① Excavation of cut slopes *60% of all stretch* L=6,750m χ 0.6 =4,100m H=30m $V=405,000m^3$ ($1,000m \times 150m^3/m = 150,000m^3$ $2,000m \times 100m^3/m = 200,000m^3$ $1,100m \times 50m^3/m = 55,000m^3$)	① Excavation of cut slopes 20% of all stretch(6,750m) L=1,300m H=30m $V=155,000m^3$ ($500m \times 150m^3/m = 75,000m^3$ $800m \times 100m^3/m = 80,000m^3$)

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Slope Protec-tion	③ Stretch other than ① and ②	② Drainage on cut slopes L=4,100m χ 3 steps =12,300m ③ Retaining wall with guard fence. 60% of all stretch L=6,750m χ 0.6 =4,100m H=5.0m	② Drainage on cut slopes L=1,300m χ 3 steps =3,900m ③ Retaining wall with guard fence. 20% of all stretch(6,750m) L=1,350m H=5.0m
Embank-ment Protec-tion	① STA 166km + 400	① Spur dykes L=50m χ 7	① Spur dykes L=50m χ 7
	② STA 170km + 600	① Foot protection L=150m ② Spur dykes L=50m χ 6	① Foot protection L=150m ② Spur dykes L=50m χ 6
Drainage system	All stretch	① Side ditches Cut slope side: all stretch 7,000m Fill slope side: 50% of all stretch 3,500m Total: L=10,500m ② Cross drainages 1 drainage per 100m stretch L=70 points χ 15m	① Side ditches Cut clope side: all stretch 7,000m Fill slope side: 50% of all stretch 3,500m Total: L=10,500m ② Cross drainages 1 drainage per 100m stretch L=70 points χ 15m
Vehicle safety facili-ties	All stretch	① Guard rail 70% of all stretch L=4.9 km	-

(2) STA 182 km + 500 ∿ STA 209 km + 700 (Dalton Pass) (Distance : 27 km)

Items	Location	Kind of Structures and Number: Counter-measures to eliminate the damages (Case I)	Kind of Structures and Number: Counter-measures to be carried out promptly to minimize the damages (Case II)
Slope Protection	① STA 193km + 200∿300	① Removal of unstable soil L=100m, H=30m W=50m $V=150,000m^3$	① Removal of unstable soil L=100m, H=30m W=50m $V=150,000m^3$
	② STA 201km + 850	① Retaining wall (4 steps of gabion) L=60m ② Drainage on slope L=60m χ 3 steps =180m ③ Horizontal drainage boring 50m/1 boring χ 8 boring = 400m	① Retaining wall (4 steps of gabion) L=60m - -
	③ STA 205km + 959	① Retaining wall (in fill section) L=50m, H=5.0m ② Retaining wall (in cut section) L=50m, H=5.0m	① Retaining wall (in fill section) L=50m, H=5.0m ② Retaining wall (in cut section) L=50m, H=5.0m
	④ STA 206km + 606	① Shelter L=1 points χ 200m	-
	⑤ Stretch other than ① ∿ ④	① Excavation of cut slopes 60% of all stretch L=27,000m χ 0.6 =16,200m H=30m $V=1,310,000m^3$ ($2,000m \chi 150m^3/m = 300,000m^3$ $6,000m \chi 100m^3/m = 600,000m^3$ $8,200m \chi 50m^3/m = 410,000m^3$)	① Excavation of cut slopes 20% of all stretch L=5,400m H=30m $V=470,000m^3$ ($1,000m \chi 150m^3/m = 150,000m^3$ $2,000m \chi 100m^3/m = 200,000m^3$ $2,400m \chi 50m^3/m = 120,000m^3$)

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Slope Protection	⑤ Stretch other than ①∿④	② Drainage on cut slopes 70% of cut slope stretch 16,200m χ 0.7 =11,300m L=11,300m χ 3steps =33,900m ③ Retaining wall with guard fence 50% of all stretch L=27,000m χ 0.5 =13,500m H=5.0m ④ Shelter L=2 points χ 150m =300m	② Drainage on cut slopes 20% of cut slope stretch L=5,400m χ 3 steps =16,200m ③ Retaining wall with guard fence 20% of all stretch L=27,000m χ 0.2 =5,400m H=5.0m -
Embankment Protection	① STA 187km + 425	① Revetment L=100m H=6m χ 3 steps ② Foot protection L=200m	① Revetment L=100m H=6m χ 3 steps ② Foot protection L=200m
	② STA 189km + 900	① Revetment L=30m, H=4.0m	① Revetment L=30m, H=4.0m
	③ STA 192km + 600	① Revetment L=60m H=6m χ 3 steps	① Revetment L=60m H=6m χ 3 steps
Drainage System	① All stretch	① Side ditches Cut slope side: all stretch 27km Fill slope side: 50% of all stretch 13.5km Total: L=40,500m	① Side ditches Cut slope side: all stretch 27km Fill slope side: 50% of all stretch 13.5km Total: L=40,500m

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Drainage System	① All stretch	② Cross drainages 1 drainage per 50m stretch L=540 points χ 150m	② Cross drainages 1 drainage per 50m stretch L=540 points χ 150m
	② Protection of channels	① Channel works 8 points ② Bridges L=3 points χ 50m	① Channel works 3 points -
Vehicle Safety Facili-ties	All stretch	① Guard rail 70% of all stretch L=27,000m χ 0.7 =18,900m	-

(3) STA 209km + 700 (Dalton Pass) ∿ STA 253km + 255 (Distance : 43km)

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Slope Protection	① Mountainous portion (STA 210 ∿ 216km 6km stretch)	① Excavation of cut slopes 60% of all stretch L=6,000m × 0.6 =3,600m H=20m V=3,600m × 50m^3/m =180,000m^3 ② Concrete spraying (1 step on toe) L=3,600m, H=10m A=3,600m^2 ③ Turfing or sodding (1 step on top) L=3,600m, H=10m A=36,000m^2 ④ Drainage on cut slopes L=3,600m × 2 steps =7,200m	① Excavation of cut slopes 20% of all stretch L=6,000m × 0.2 =1,200m H=20m V=3,600m × 50m^3/m =180,000m^3 ② Concrete spraying (1 step on toe) L=1,200m, H=10m A=12,000m^2 ③ Turfing or sodding (1 step on top) L=1,200m, H=10m A=12,000m^2 ④ Drainage on cut slopes L=1,200m × 2 steps =2,400m
	② STA 215km	① Removal of unstable soil L=120m, H=50m W=100m V=600,000m^3 ② Turfing or sodding L=120m, H=50m A=60,000m^2 ③ Retaining wall (4 steps of gabion) L=120m	① Removal of unstable soil L=120m, H=50m W=100m V=600,000m^3 ② Turfing or sodding L=120m, H=50m A=60,000m^2 ③ Retaining wall (4 steps of gabion) L=120m
	③ STA 221km	① Check dam 2	-

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Embankment Protection	① STA 217km	① Revetment L=50m, H=6.0m	① Revetment L=50m, H=6.0m
	② STA 220km + 500	① Revetment L=40m, H=6.0m ② Foot protection L=40m ③ Bridge L=16m	① Revetment L=40m, H=6.0m ② Foot protection L=40m ③ Bridge L=16m
	③ STA 225km + 640	① Revetment L=110m, H=6.0m ② Foot protection L=110m	① Revetment L=110m, H=6.0m ② Foot protection L=50m
	④ STA 242km + 243	① Spur dykes L=40m χ 3	① Spur dykes L=40m χ 3
	⑤ STA 253km	① Spur dykes L=100m χ 8	-
Drainage System	① Mountainous portion (L=6.0km)	① Side ditches Cut slope side: all stretch 6,000m Fill slope side: 50% of all stretch 3,000m Total: 9,000m ② Cross drainages 1 drainage per 50m stretch L=120 points χ 15m	① Side ditches Cut slope side: all stretch 6,000m Fill slope side: 50% of all stretch 3,000m Total: 9,000m ② Cross drainages 1 drainage per 50m stretch L=120 points χ 15m

Items	Location	Kind of Structures and Number	
		Counter-measures to eliminate the damages (Case I)	Counter-measures to be carried out promptly to minimize the damages (Case II)
Drainage System	② STA 213km (Protection of channel)	① Retaining wall L=30m, H=4.0m ② Check dam 1 ③ Ground sills 2	① Retaining wall L=30m, H=4.0m ② Check dam 1 ③ Ground sills 2
Vehicle Safety Facilities	All stretch	① Guard rail 40% of all stretch L=43,000m χ 0.4 =17,200m	-

3. INTRODUCTIONS OF INFORMATION SYSTEM FOR TRAFFIC VEHICLES ON THE UNUSUAL WEATHER

It can be said that the portion of the road around Dalton Pass between San Jose City and Santa Fe City is easy to be suffered from the damages caused by typhoon and heavy rainfall, because of very wrong conditions on the topography and geology.

Of course, it will be possible to minimize, if not eliminate, such damages by the construction of counter-measures such as slope protection works, drainage system and river protection works against scouring. But it will cost much expenditure and require much time to fully construct the complete counter-measures for the damages due to heavy rainfall. Therefore, judging from the present financial situation in this country, it might be said impossible to complete those counter-measures in short terms.

Then, setting information system on the road conditions under the unusual weathers around Dalton Pass might be very effective not only to minimize the damages, but also to offer the actual conditions of the road and damages more accurate and quick to the administraters and the drivers of vehicles, as complementary counter-measure until the protection works for damages will have completed.

This system consists of the following parts:

(1)	Sensor part	Rain guage Extensometer (landslide meter) I.T.V.
(2)	Transit part	Cable Wireless system
(3)	Observation part	Analysis of data Record
(4)	Information part	Administrator User (drivers of vehicles)

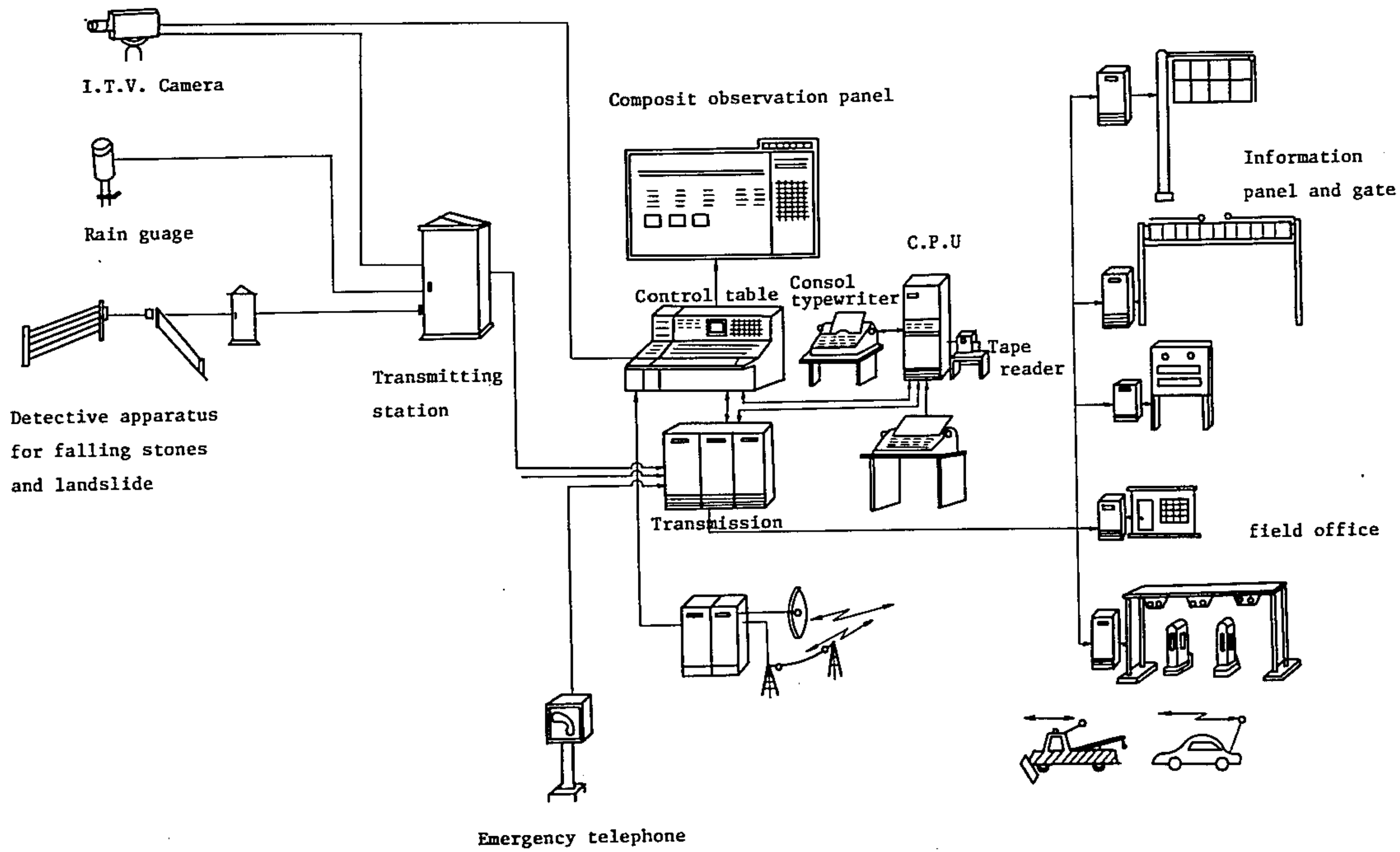


Figure II-2-1 Mechanism of Information System for Road Conditions under the Unsual Weather

PART-B MANILA SOUTH ROAD

1. RECOMMENDATION ON THE ATIMONAN-PAGBILAO DIVERSION ROAD

(1) Preface

(2) Geological Description

(3) Factors Affecting the Road Alignment

(4) Cut Slope Stabilization

(5) Summary

PART-B MANILA SOUTH ROAD

1. Recommendations on the Atimonan-Pagbilao Diversion Road

(1) Preface

ATIMONAN-PAGBILLAO section, which belongs to DIVERSION ROAD, also known as the Manila South Road, has been in stage of execution.

Of the major thoroughfares, the large percentage of the earthwork in this area already has been completed. Therefore, this cut slope section has been selected for immediate implementation considering reasons below:

ⓐ The existing road situation, especially the road alignment, is not so good as to cause various kind of traffic accidents, such as the traffic congestions and the traffic obstructions by the reason why the heavy trucks are able to creep up the steep slope only with slow speed.

ⓑ DIVERSION ROAD has been selected for immediate implementation because the existing road is so bad in its road surface and alignment that it will be unable to stand for long use.

And also, the existing road is to serve for use of the emergency in future. For this purpose, the pavement repairing work is continuously to execute hereafter, parallel to the execution of DIVERSION ROAD, because of the reasons below:

(i) The existing road seems to be available for the alternative route of DIVERSION ROAD in the situation of traffic congestions.

(ii) Being layed out passing through beautiful area, the existing road seems to use for serve as the sightseeing route, even after completion of DIVERSION ROAD.

There are many difficult ploblems in the execution of work of DIVERSION ROAD. Above all, the cut slope protection work in the section located between Sta. 165 + 687.27 and Sta. 169 + 940.00 is the most important thing to be examinned sufficiently, because the existing plan of which the cut slope gradient is 0.25 : 1 is in danger of stone-fall and land-slide along the steep cut slope.
In addition to this, it increases the difficulty of the cut slope stabilization that the height to cut amounts to about 80m high.

(2) Geological Description

ATIMONAN-PAGBILLAO section running along the whole southern DIVERSION ROAD are composed of limestone. The hilly land is a limestone table, which is covered with one to two meters depth of clayey volcanic ash and underlain by a deep lime stratum.

Many bedding planes on the site of this section have been observed from the crack on limestone and opened in fissures inclined to N-50°W and 40°-N direction. The cut slope right hand is in danger of land-slide along the inclined bedding planes.
On the other hand, the cut slope left hand is in no danger of land-slide, but only in danger of top soil falling overlied the lime strata.

Therefore, the appropriate cut slope protecting work should be selected for immediate implementation considering the special geological situations.

(3) Factors Affecting the Road Alignment

Generally speaking, the road plan about mountenous area like this section is in the face of the problem that it should be selected attaching importance whether to the geometrical alignment in order the vehicles to pass through rapidly or to the earth cutting volume, as little as possible.

Now that 7% of the vertical alignment have been selected for the most steep slope in this section, much more earth cutting volume would be produced, according to the existing plan. Therefore, the relation between the selection of vertical alignment and the cut slope stabilization should be scrutinized carefully, during the final engineering.

The details of the problems mentioned above include the followings:

ⓐ The method depends upon the attaching to the feasibility of the project.

This method is that the vertical alignment is to be 7% of the existing slope gradient up to 10% of the maximum.

In this case, the heavy truck will be decreased own capacity to creep up along the steep slope. And then, the traffic congestion will be brought as a natural consequence. In order to cancel the traffic congestion, the road width composed of three lanes, to which the creeper lane for heavy trucks is added, is to be considered.

The most important problem is to be scrutinized about advantages and disadvantages in the standpoint of the relation between the change of the alignment with a creeper lane and the earth cutting volume.

ⓑ The method depends upon the attaching to the smooth passage in this section.

This method is that the tunnel structure, which means the closed conduit in this section, is to be adopted as the way of protecting traffic vehicles against the land-slide and the stone-fall.

In this case, even a heavy truck will be able to pass through, easier than in the former. And then, the road width composed of two lanes without the creeper one will be allowed to be planned, because the traffic congestion is expected to be relieved.

The most important problem in this work is to be scrutinized in the points of advantages and disadvantages of the stage construction and its application zone about the closed conduit work.

For the part of the stage construction, two steps of the execution of work are considered:

(i) The 1st step is the temporary execution of cut slope protection work in which only retaining walls are to be constructed both sides for the purpose of the protection against the stone-fall.

(ii) The 2nd step is the execution of closed conduit work which stands for long use of the traffic system.
For the part of the application of zone about the closed conduit work this section, the structure is to be fit to the zone where the hill is so high that no cut slope protection work might be in safety of slope failures.

All of mentioned above are considered from the view point of the reconnaissance at this time, therefore, the term of application and the cost about the respective work are to be scrutinized carefully in the final engineering in future.

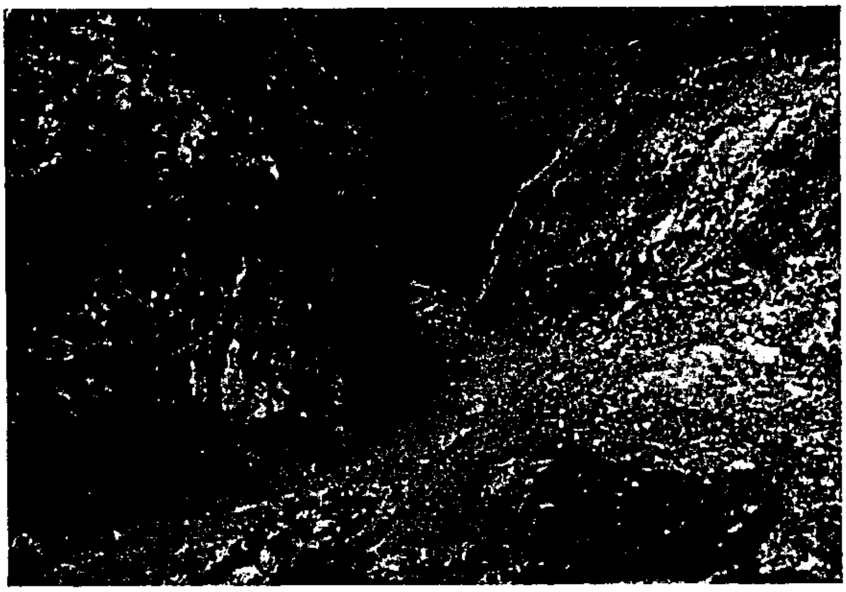


Photo - 1 - 1

Photo - 1 - 2

(4) Cut Slope Stabilization

Excavation in this road section is remarkably progressing. So, suitable cut slope stabilization method is required to be adopted for the safety of traffic vehicles.

As the present road can still accommodate the traffic vehicles during the Diversion Road is closed, the cut slope stabilization methods should be discussed from the standpoint of economy rather than slope stability.

Disaster prevention methods are divided into two types, those are slope protection and traffic vehicle protection.

We recommend here the guard fence, stone fall prevention steel wire net, concrete spraying and concrete grating crib works for the slope protection methods and concrete shelter for the traffic vehicle.

Table 1-1 shows the alternatives of combinations of prevention works mentioned above. On this table, we discussed the prevention works on cut slope at left side toward Manila, because this cut slope is predicted to have large scale failures as described in the Geologic Conditions.

① No protection except for excavation where is the possibility of slope failures along joints or cracks during dry weather even if the slope gradient is less than 45 degress.

② Among ⓐ & ⓕ of the left rank of Table 1-1, ⓒ, ⓔ, ⓕ are highly recommended because they are considerably inexpensive, easily constructed, also very effective in preventing rock falls during usual rainfall.

③ During heavy rains when relatively large scale failures or rock falls occur as predicted, methods ⓐ & ⓕ on Table 1-1 will not be sufficient.

The Diversion Road shall be closed to traffic and the present road shall be used as a detour. The relationship between rainfall intensity and failures must be observed, investigated and studied further.

④ The methods of ⓖ & ⓘ on Table 1-1 will be suitable for cut slope stabilization, but the construction will be more difficult and construction cost will be more expensive.

⑤ For traffic vehicular safety, the shelter will be most suitable among the methods presented in Table 1-1 and it requires no slope protections works. In this case, we recommend the stage construction procedure.

First, the retaining walls with guard fence would be constructed on both sides of the road that may later on serve as the side walls of the shelter. The second stage involves the construction of the concrete slab for the roof (Fig. 1-12) and sand cushion to absorb the impact load of falling rocks (Fig. 1-12).

However, if the first stage can control the slope failures without endagering the safety of motorists, there will be no more need the second stage as this will create further problems such as air pollution and undoubtedly additional expenses that will include the lighting facilities.

In adopting the shelter for this stretch, a thorough study should therefore be undertaken with the considerations on economical aspects and traffic vehicle safety.

(5) SUMMARY:

With the different methods of slope protection and stabilization presented above, the most important consideration to be taken is what degree or level of slope protection works should be done on the Diversion Road.

For economy, the less expensive methods could be adopted to protect the road from minor slope failures. If during storms or typhoons, extensive slope failures occur, the Diversion Road can be closed and the old road shall be used as detour.

The more expensive but permanent slope protection works could be adopted later when traffic volume has considerably increased and the importance of the road has become evident. Possibly, a Cost-Benefit Ratio Analysis is necessary for this with Traffic Safety as one of the factors to be considered.

Table 1-1 Alternatives of Slope Stabilization Methods

Protection Methods	Construction Cost	Slope Stability (Safety of Traffic)			Difficulties of Construction	Judgement
		Ordinary	Usual Rain	Heavy Rain		
Excavation (no protection)	-	x	xx	xx	-	xx
ⓐ ①	Cheaper a little	◎	x	xx	◎	x
ⓑ ②	Expensive	◎	x	xx	◎	x
ⓒ ① + ②	"	◎	o	x	◎	o
ⓓ 1 step at toe ② + 3 steps on top ①	"	◎	x	xx	◎	x
ⓔ 1 step at toe ③ + 3 steps on top ①	"	◎	o	x	o	o
ⓕ 1 step at toe ④ + 3 steps on top ①	"	◎	o	x	o	o
ⓖ ③	more expensive	◎	◎	o	x	x
ⓗ ④	"	◎	◎	o	xx	x
ⓙ 1 step at toe ④ + 3 steps on top ③	"	◎	◎	o	x	x
ⓙ ⑤	most expensive	◎	◎	◎	o	o

① Guard Fence for Rock Fall ② Rock Fall Prevention Steel Wire Net
③ Concrete Spraying ④ Concrete Grating Crib Works ⑤ Shelter

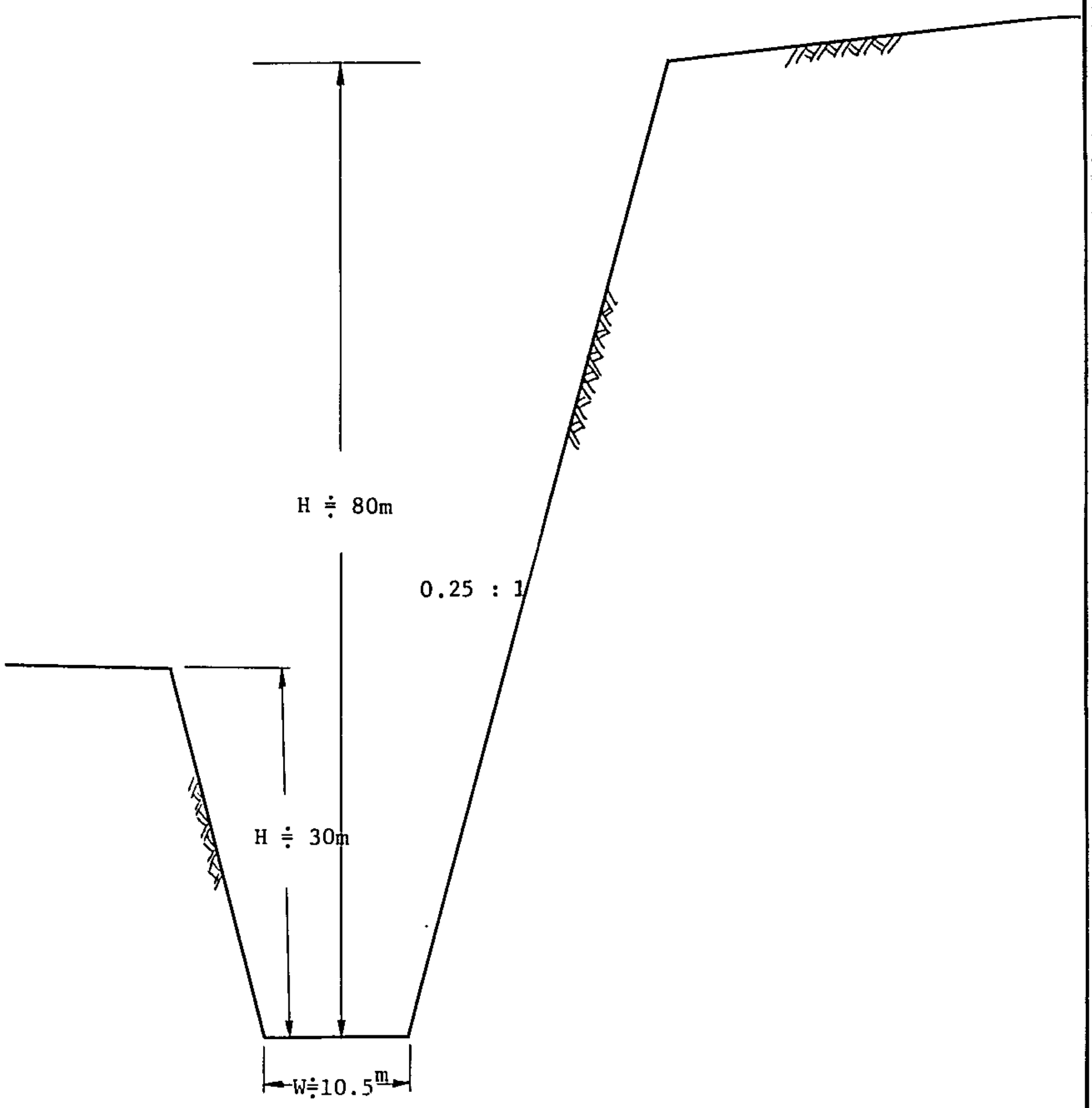


Figure 1-1 Present Profile of Slopes

Guard Fence

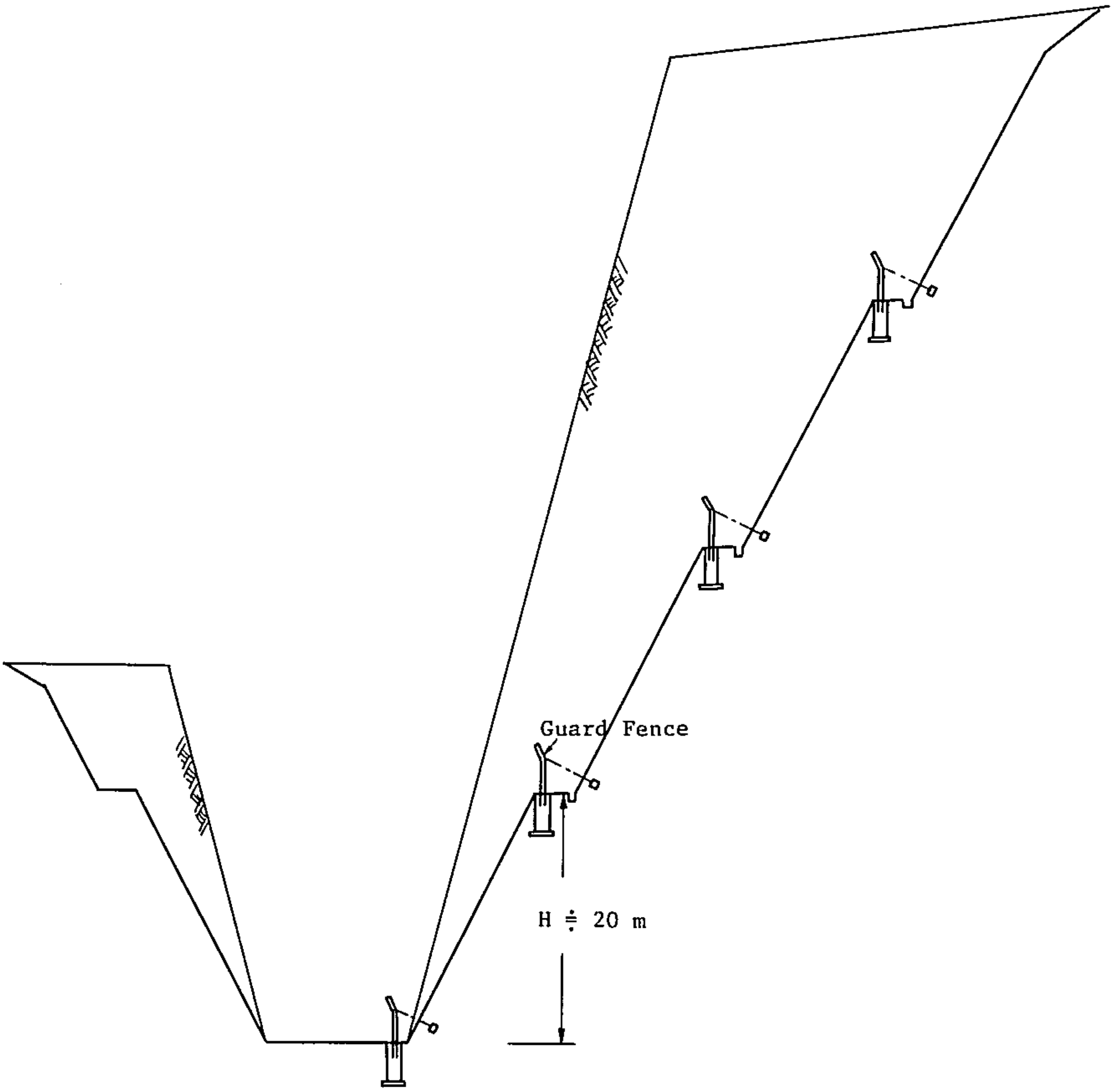


Figure 1-2 Case - ⓐ

Rock Fall Prevention Steel Wire Net

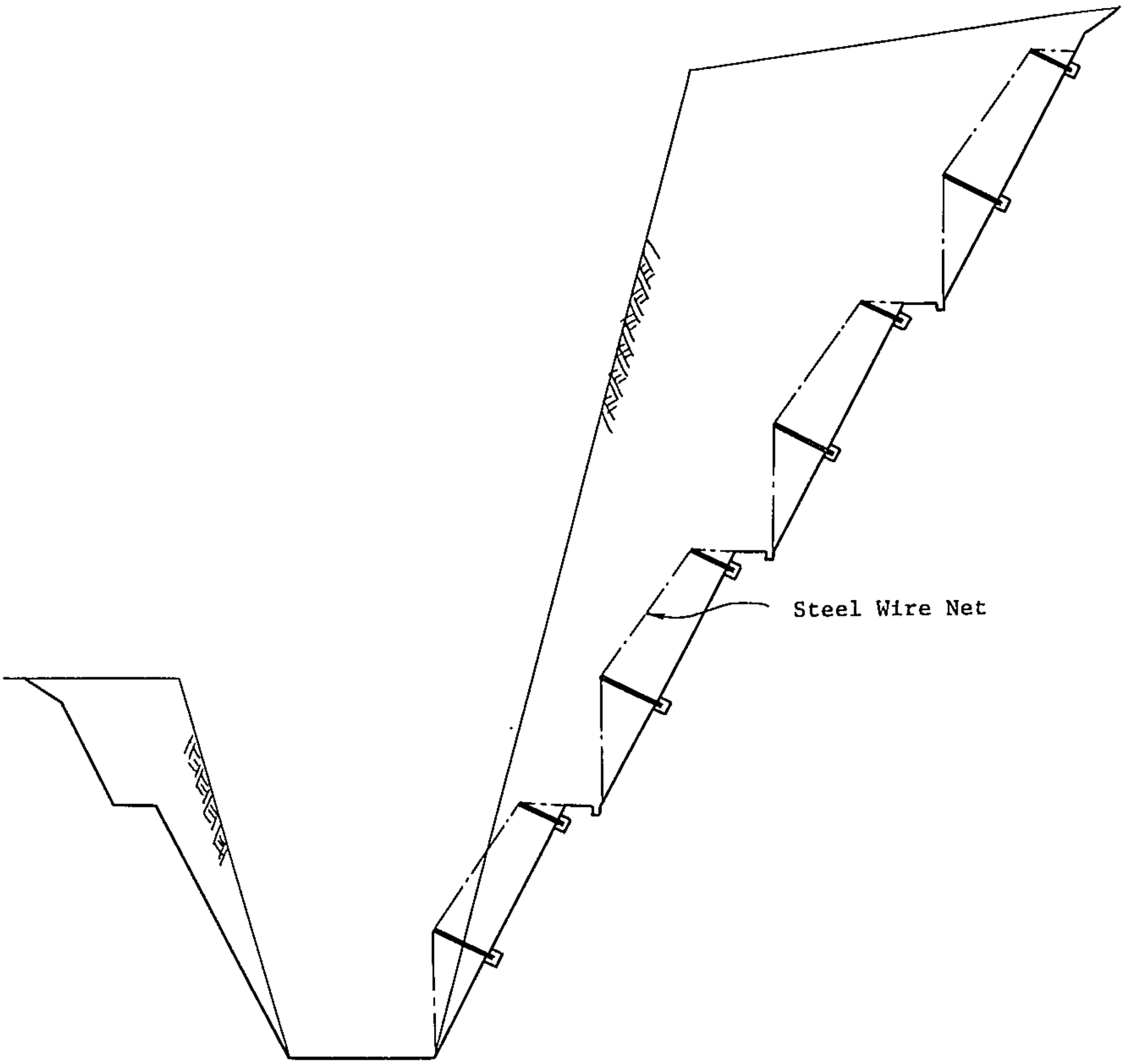


Figure 1-3 Case - ⓑ

Case ⓒ = Case ⓐ + ⓑ

Guard Fence + Rock Fall Prevention Steel Wire Net

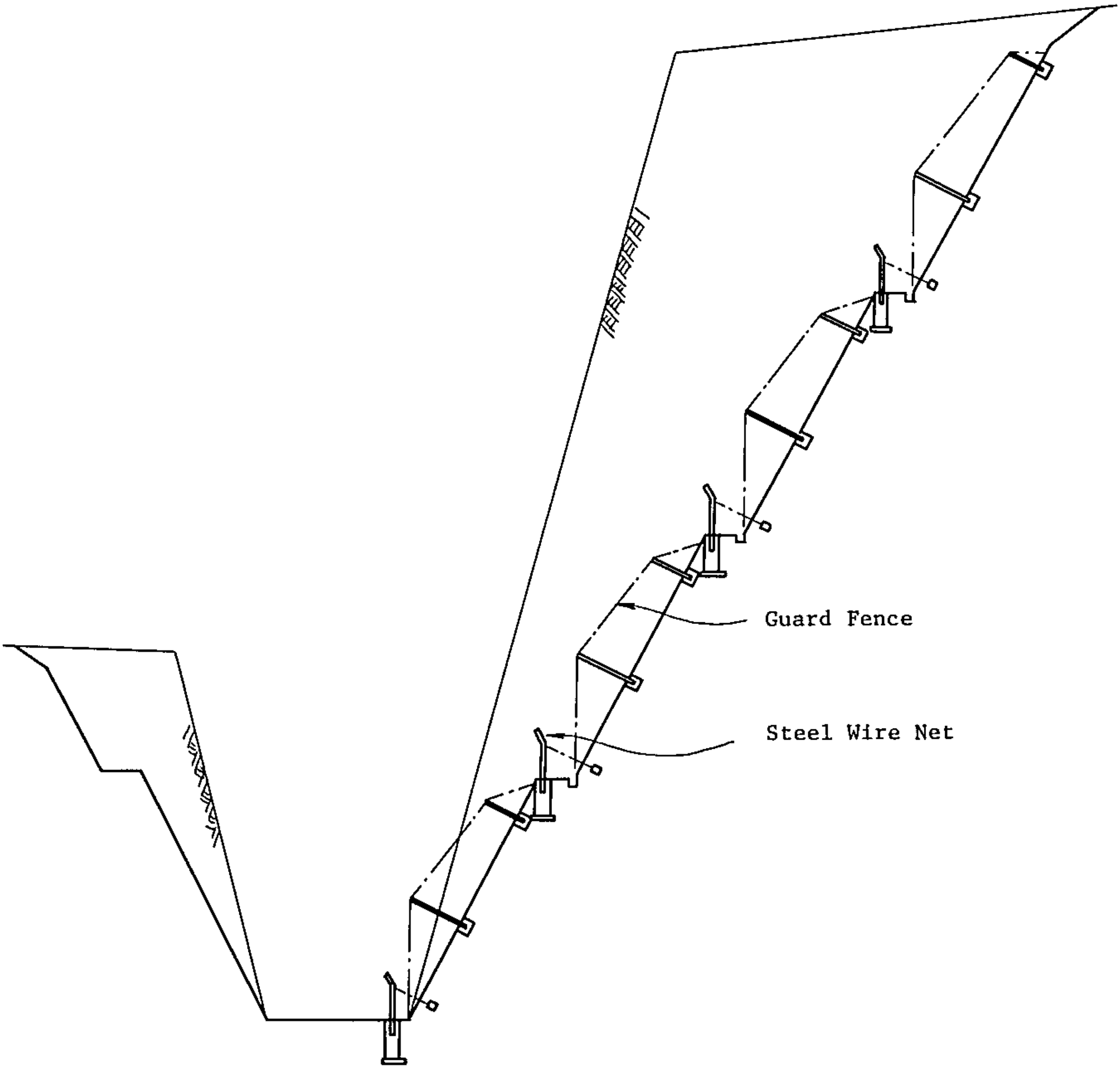


Figure 1-4 Case ⓒ

1 step at toe ..... Rock Fall Prevention Steel Wire Net

3 steps on top .... Guard Fence

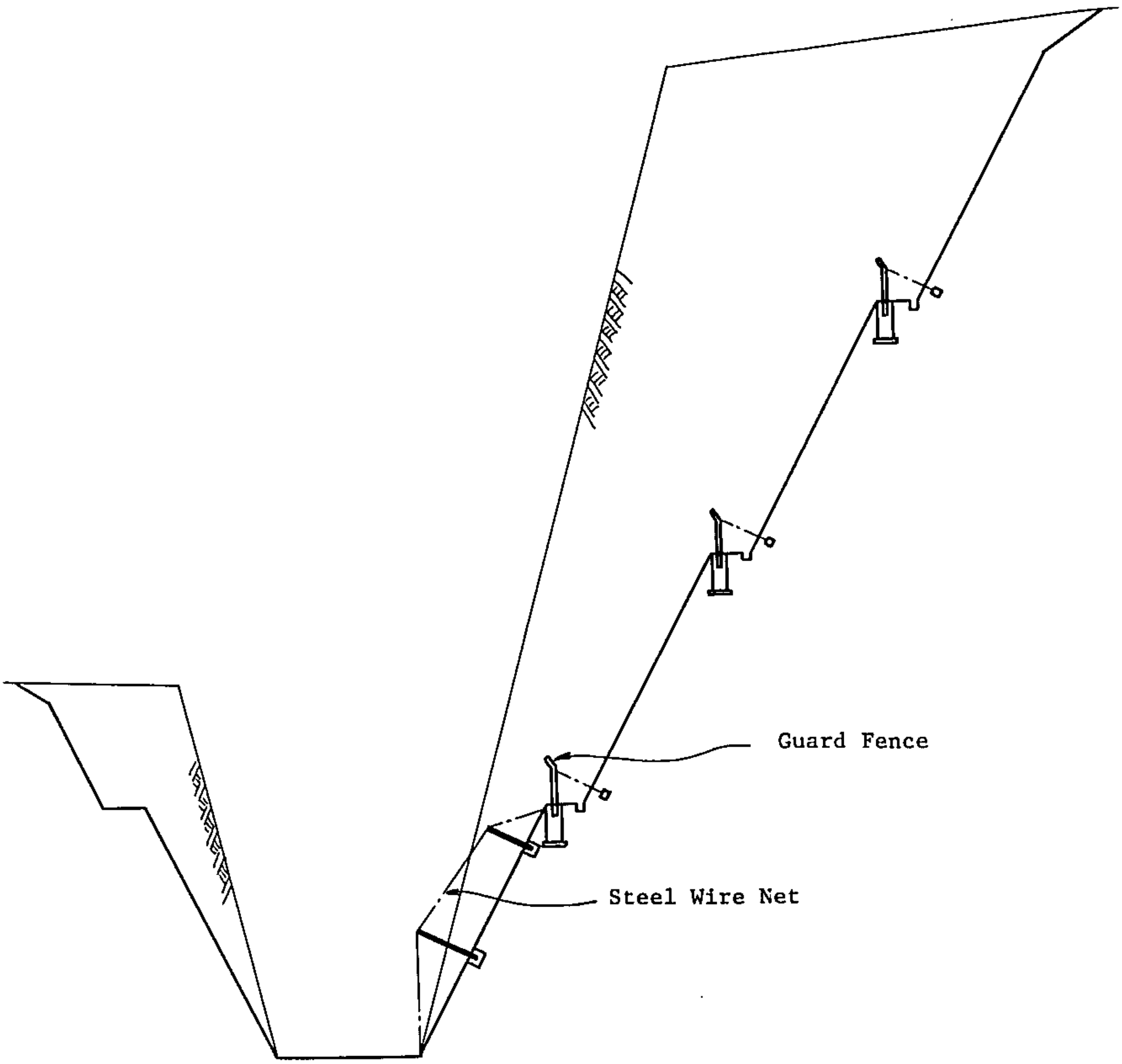


Figure 1-5 Case ⓓ

1 step at toe ..... Concrete Spraying

3 steps on top .... Guard Fence

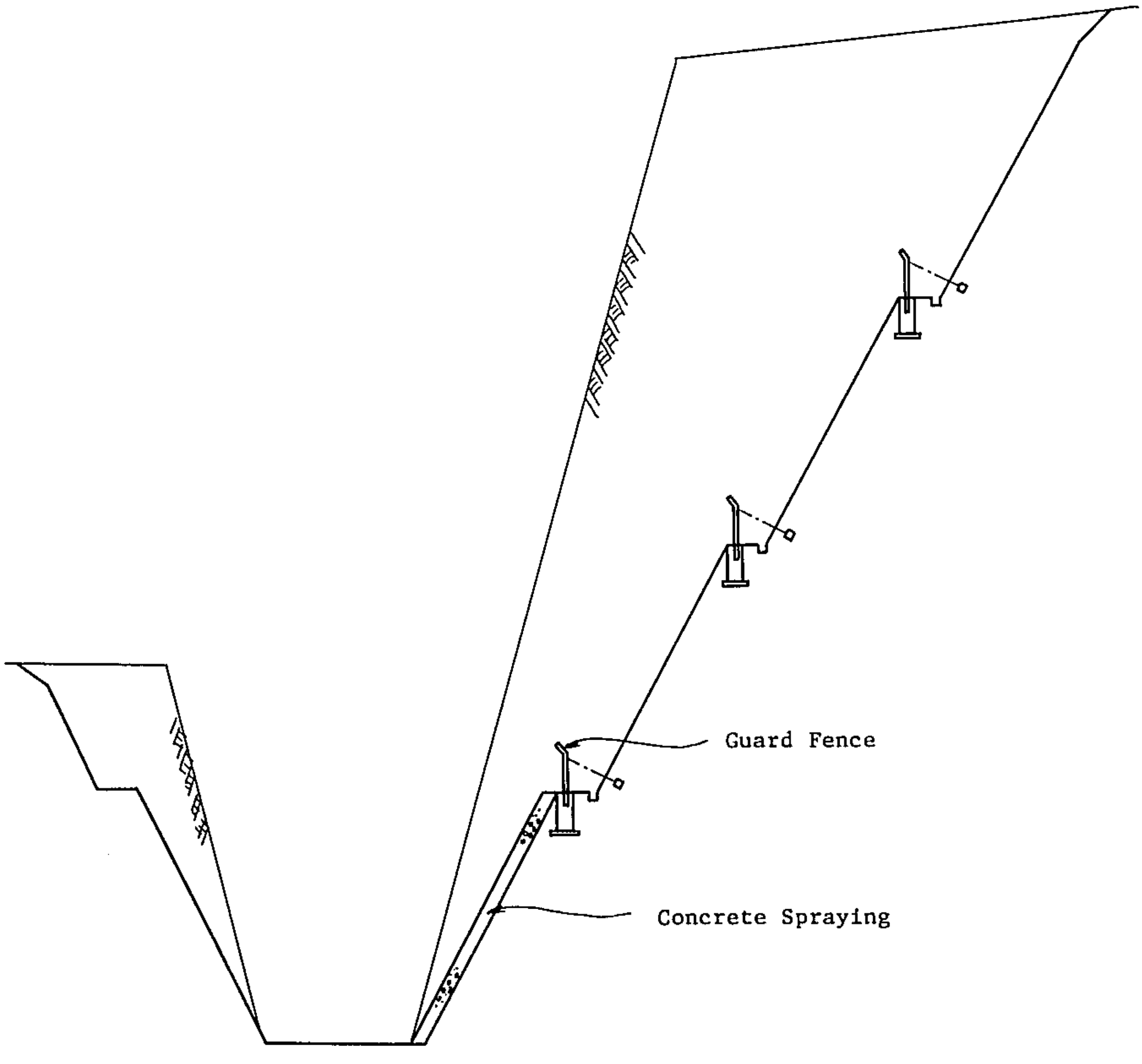


Figure 1-6 Case ⓔ

1 step at toe ..... Concrete Grating Crib Works

3 steps on top .... Guard Fence

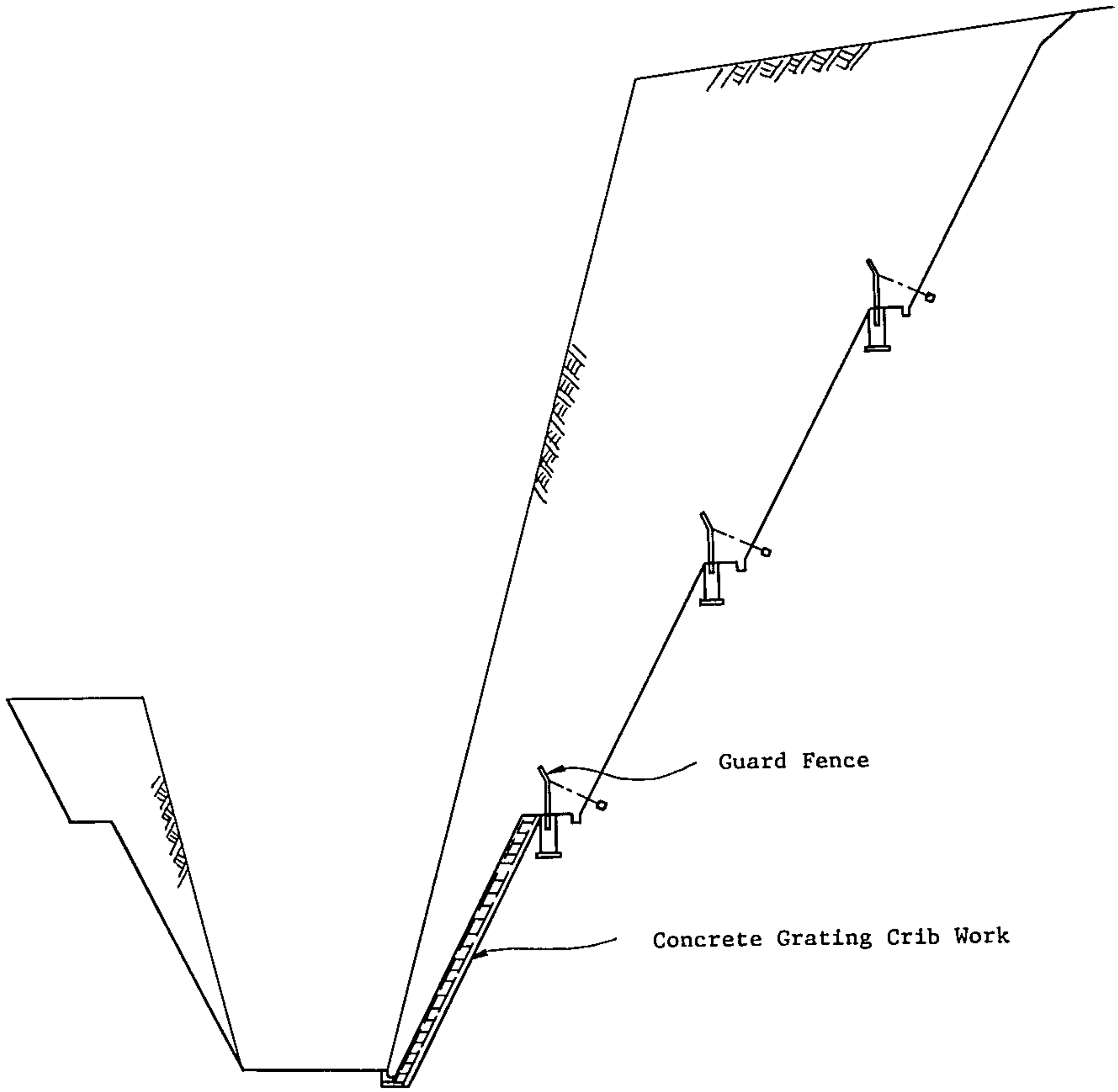


Figure 1-7 Case (f)

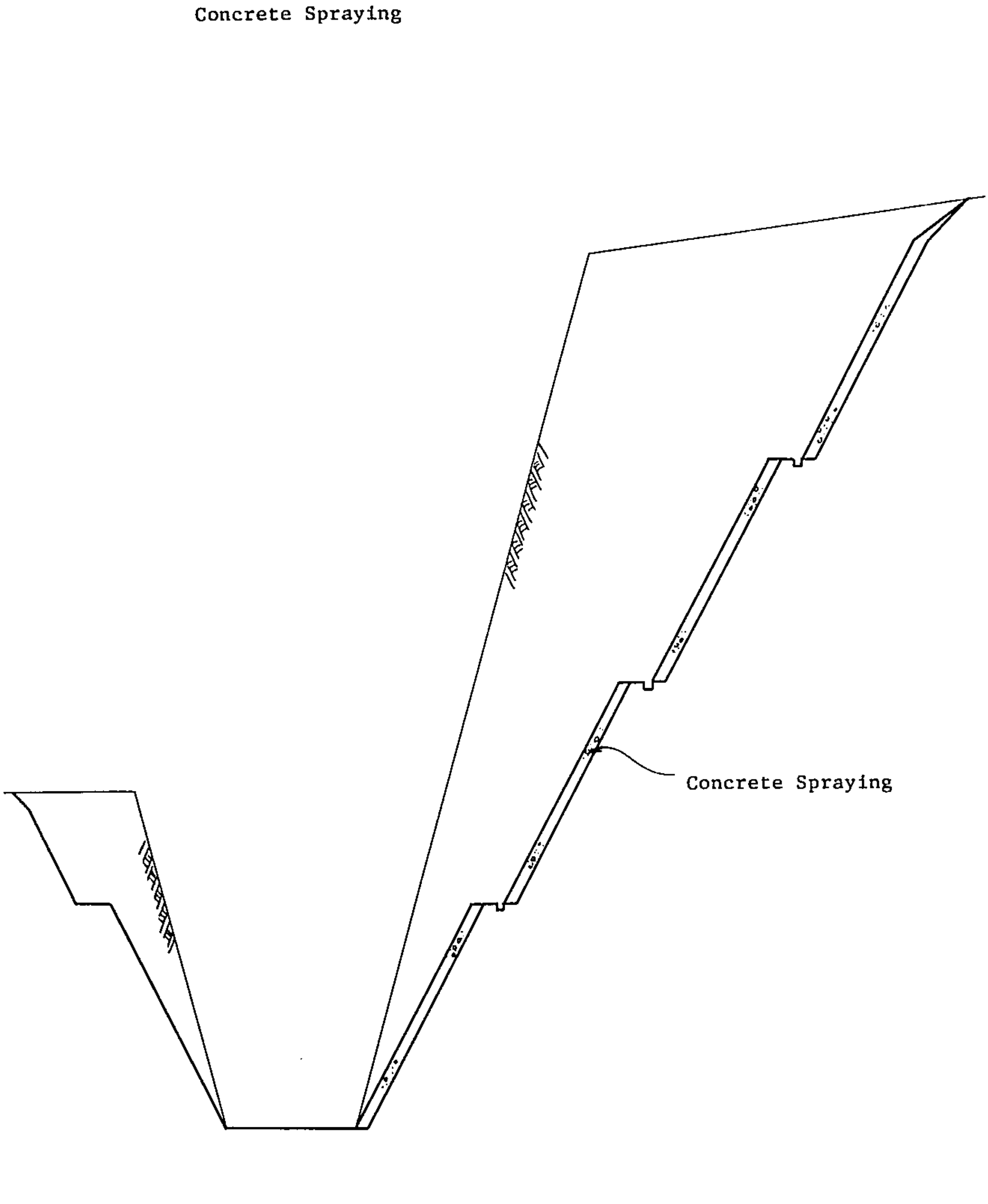


Figure 1-8 Case (g)

Concrete Grating Crib Works

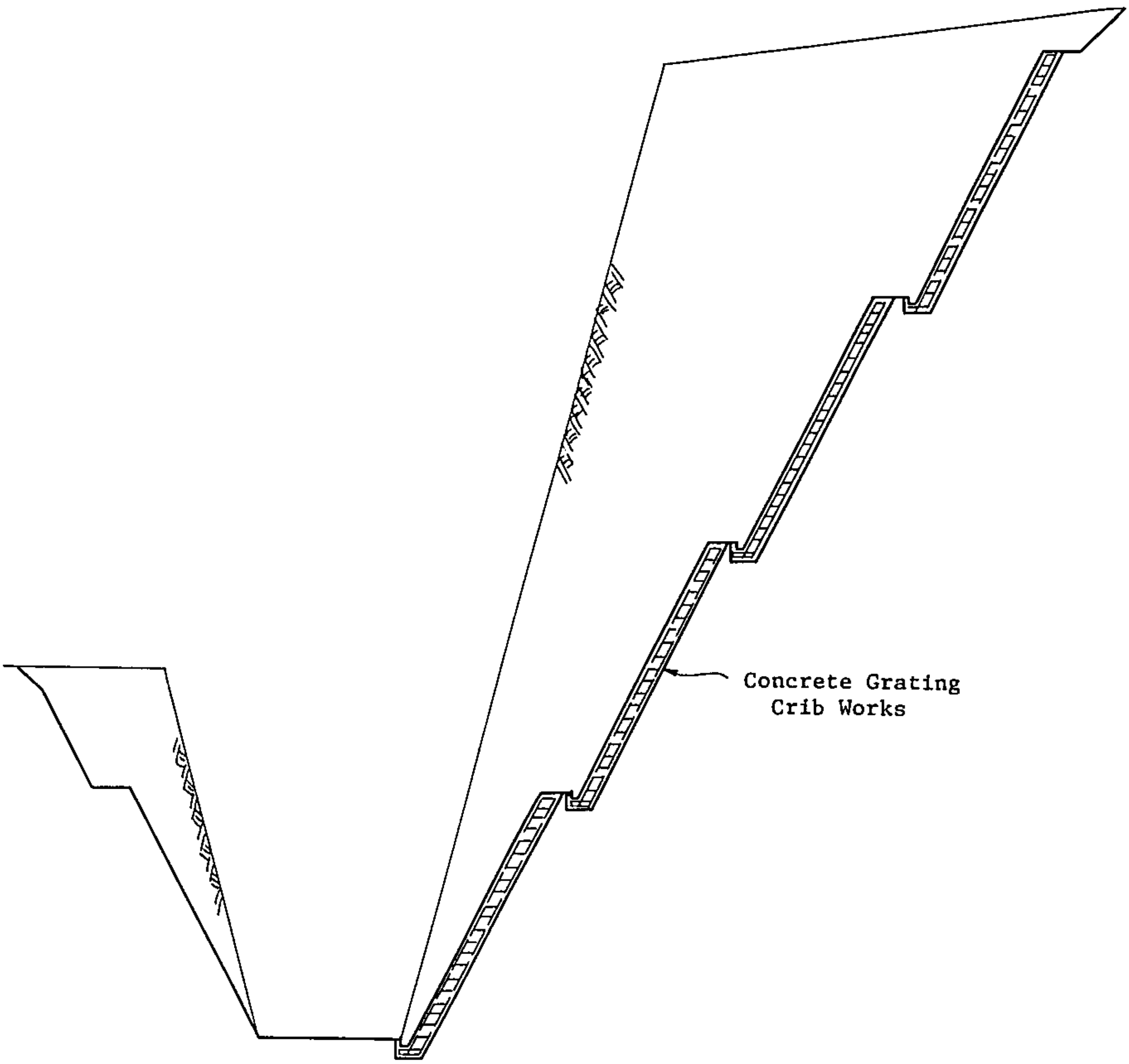


Figure 1-9 Case ⓗ

1 step at toe ..... Concrete Grating Crib Works

3 steps on top .... Concrete Spraying

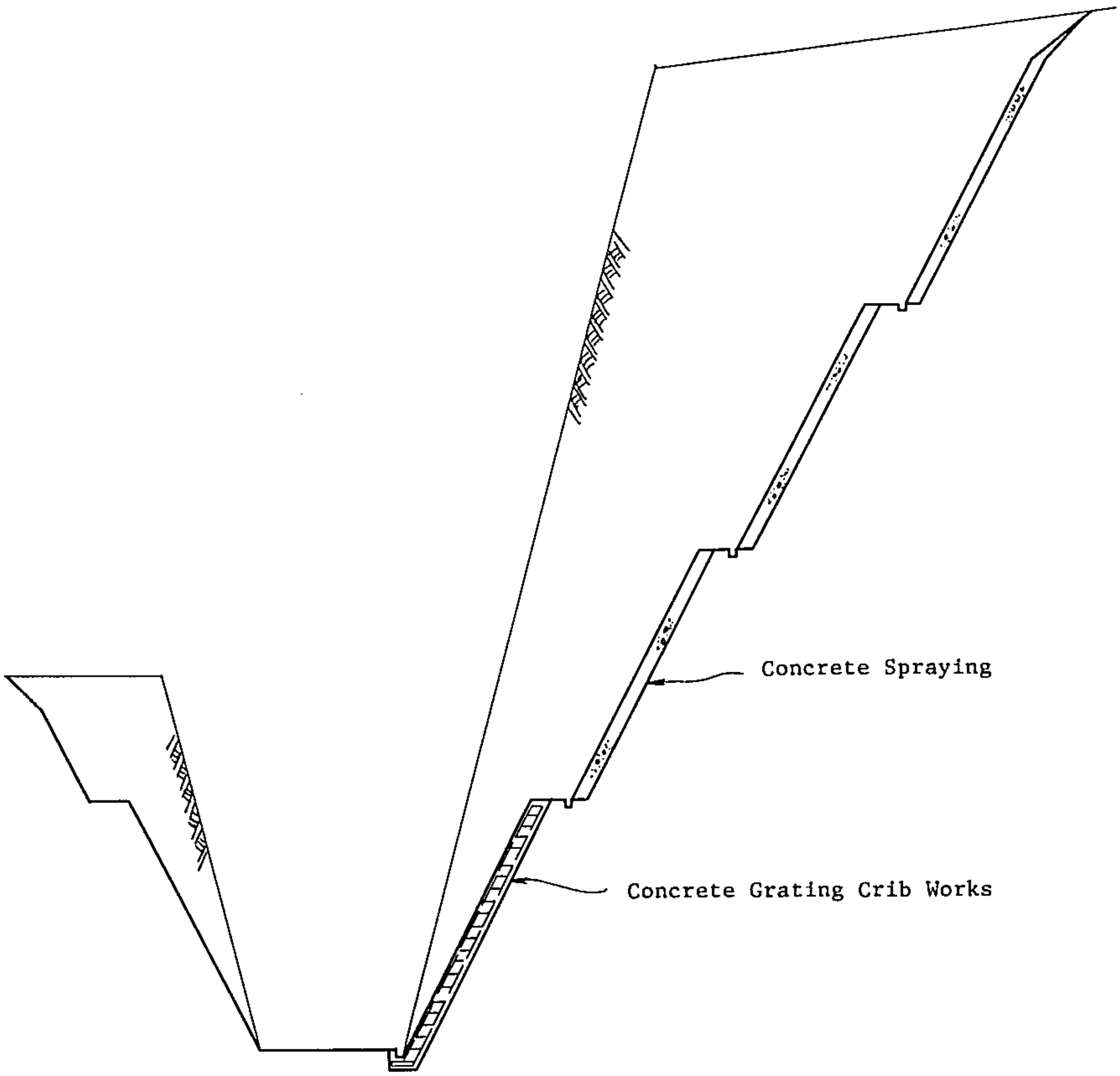


Figure 1-10 Case (i)

Shelter

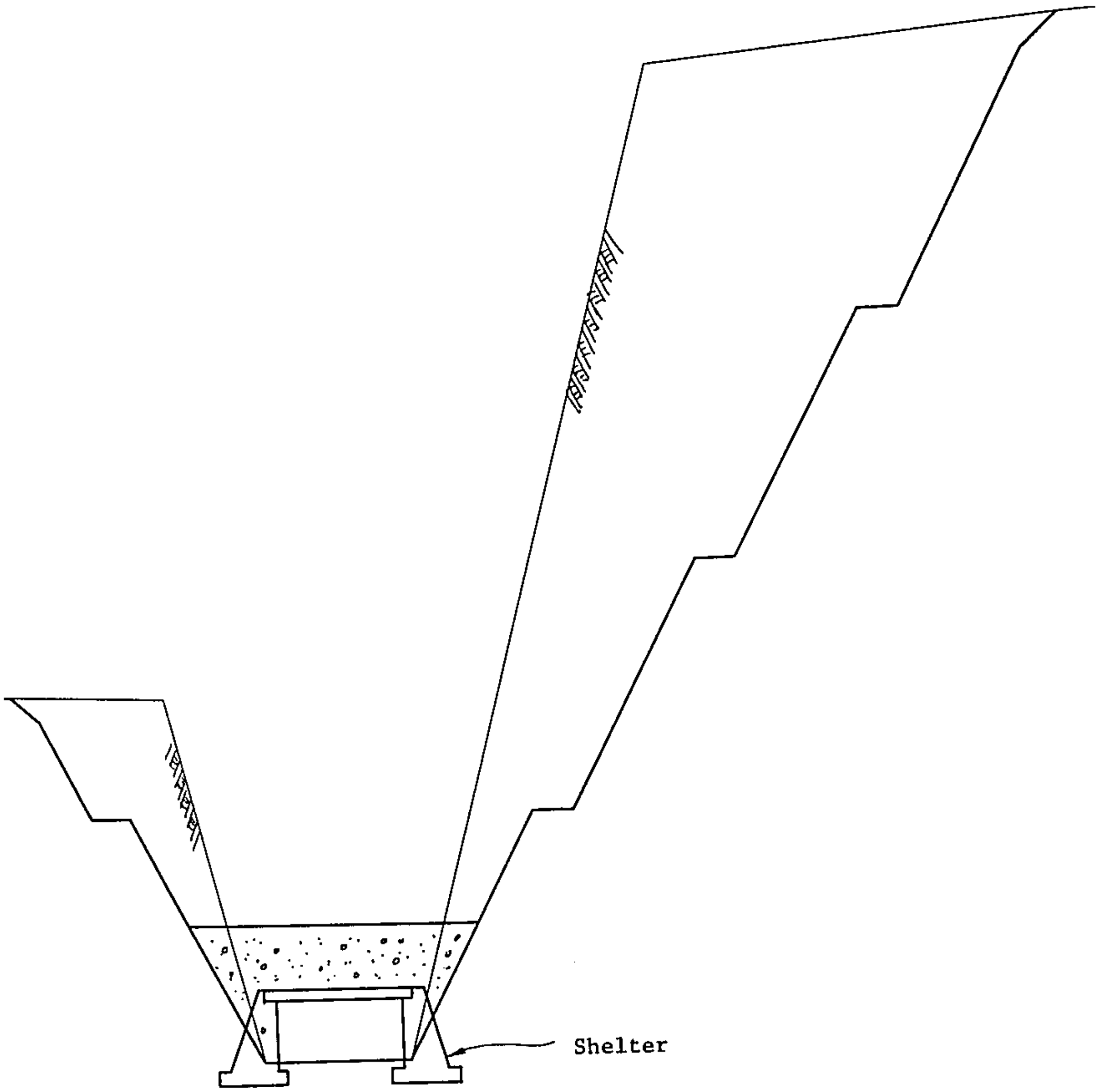
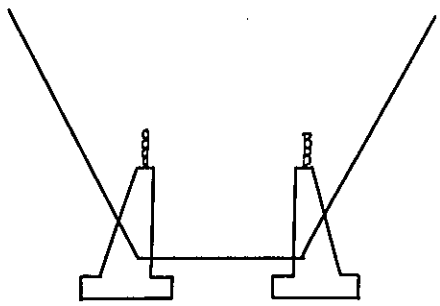


Figure 1-11 Case ⓙ

① Construction of Retaining Wall



② Construction of Shelter

ⓐ Slap

ⓑ Sand Cushion

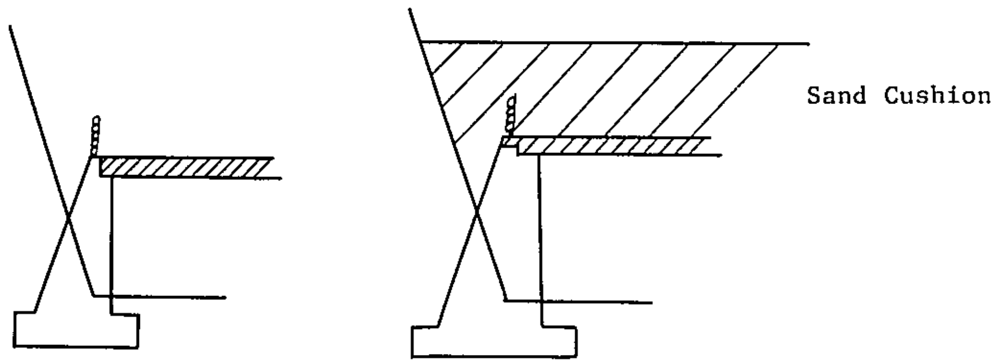


Figure 1-12 Stage Construction of Shelter

2. Recommendations on the Counter-measures for Damaged Embankment of the Kawayan Bridge

(1) Present situations of the site

The Kawayan river was about 120 meters in width at the site of the bridge before typhoon Didang, but after that, the river was widened to about 150 meters due to severe scouring of river bed and bank and the access road to the bridge was also washed out. As a result, the bridge presently under construction has to be expanded another span of 30 meters.

But if the present conditions of the southern river bank adjacent to the bridge will be kept without any bank protection it is expected the river bank and the road will be damaged further by coming typhoon like Didang.

The characteristics of the Kawayan River are presented as follows:

① The river bed is being scoured year by year. In 1934, the river bed was on the plain terrace remaining at the upstream side of the river. Accordingly, for 42 years from 1934 until 1976, the river bed has been scoured down about 4 meters.

As a result of the scouring of the river bed, it is considered that the stream course changed with in the present river. The velocity of stream is calculated to be from 3.2 to 4.7 m/sec., according to the equation of Manning, where the gradient of river is about 1/50 ∿ 1/100, the hydraulic mean depth is about 1.8 meters.

As far as the observed data on discharge during floods are concerned, there are no available data, so we just tried to estimate the maximum discharge during floods with the above results. Maximum water dischage is estimated to be approximately 800 m^3/sec.

Estimated velocity and volume of discharge are expected to be referred to the consideration of protection works for river. Concerning the width required for the Kawayan River in order to allow the safe flood water discharge, we referred to the standard width of river depending on the designed discharge in The Japan Association of Civil Engineering. (Table 2-1)

According to the above table, the adequate width for the Kawayan River at the site of bridge ranges from 110 to 120 meters due to the maximum discharge of more than 800 m^3/sec. So, the length of the bridge (same with the width of river) under construction may be accepted completely.

(2) Recommendation on counter-measures for the road and bridge protection

For this case, two major problems must be discussed, as follows:

The first point is the protection works against scouring of the southward river bank at up-stream of the bridge and road.

The second point is the prevention works against scouring of the river bed adjacent to the bridge and the road.

Then, the recommendations for these two points are as follows:

① For the first point;

Judging from the severe condition of scouring and the range of the portion required to be protected, it is recommended that bank protection works and foot consolidation works will be suitable for river control rather than the spur dykes.

② For the second point, it is recommended that the consolidation works must be designed at the distance of about 15 m to 30 m downstream of the bridge.

③ In addition, for the future proposal it is recommended that the flood control plan including river improvement and sediment control works must be considered throughout the critical sections of the river.

(3) The problems in the case adopting spur dykes

① Under the condition that the river is more or less than 100 meters in width, presumably we adopt the spur dyke works for prevention of scouring of left bank, the stream changed by the spur effects will run towards the opposite side of pier or abutment of the bridge. Then it is expected that the area adjacent to the spur dyke site will suffer the worse result even if the protected portion can be kept well.

② It is easily considered that the durability of spur dyke works in the proposed site will not last long, becuase of rather high velocity of stream current as already experienced.

③ The spur dyke is not enough to fully protect the river bank and prevention scouring. It is informed that the spur dyke is effective only in connection with river bank protection.

④ The spur dyke parallel to the stream which you have already proposed might be effective in this site. But even if you adopt this works, the foot consolidation works should also be considered to prevent further scouring of the river bed.

Eventually, the point of discussion concerning about advantage of each works will be depended on which work is more economical and effective.

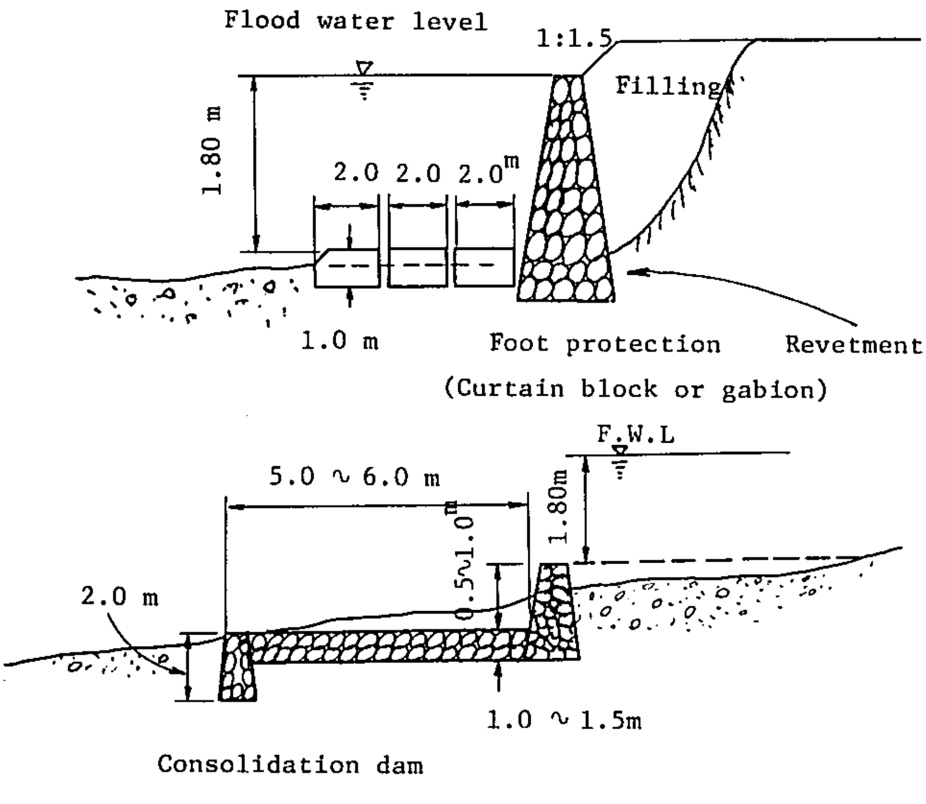


Figure 2-1 Planned Cross Section Adjacent to Kawayan Bridge

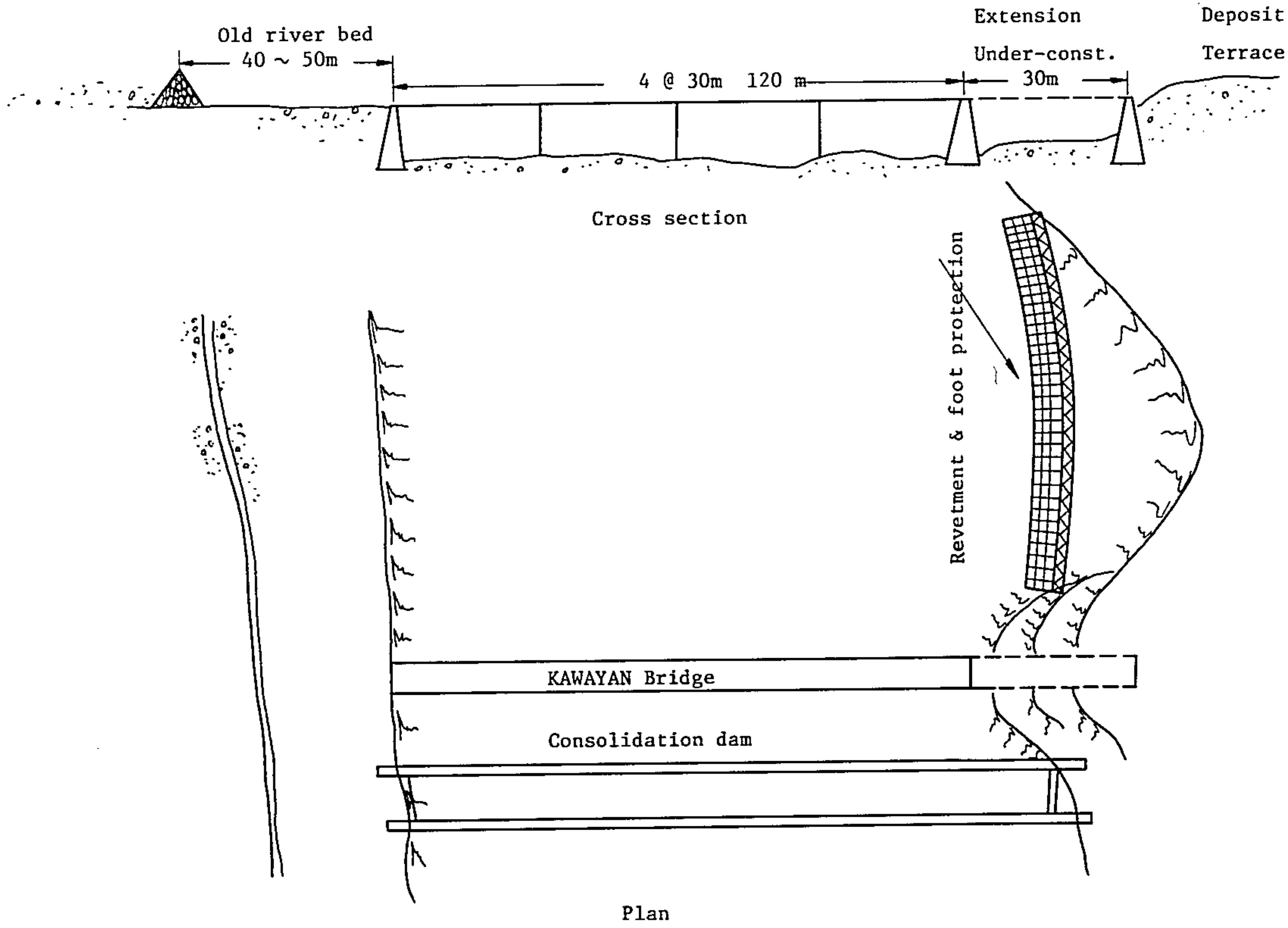


Figure 2-2 Sketch of Recommendation works

Table 2-1 Standard Width of River Depending on the Designed Discharge

Designed discharge (m^3/sec)	Proposed width (m)
300	40 ∿ 60
500	60 ∿ 80
800	80 ∿ 110
1,000	90 ∿ 120
1,500	120 ∿ 170
2,000	160 ∿ 220
3,000	220 ∿ 300
5,000	350 ∿ 450

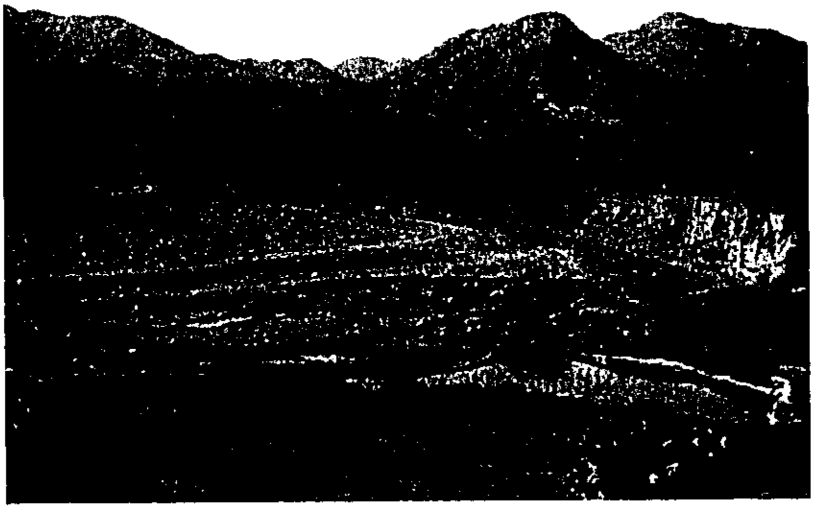


Photo - 2 - 1

Photo - 2 - 2

3. Recommendations for the Channel Adjustment of the Sariaya River

(1) Location

In this section, about 200 km south from Metro Manila, the reconstructed road is running through the foot of the Sanpablo mountain (E.L 7176 feet) where there are beautiful coconut forest. The longitudinal slope of the road is very gentle, but there are a number of rivers crossing at the right angles to the road.

(2) The characteristics of this river

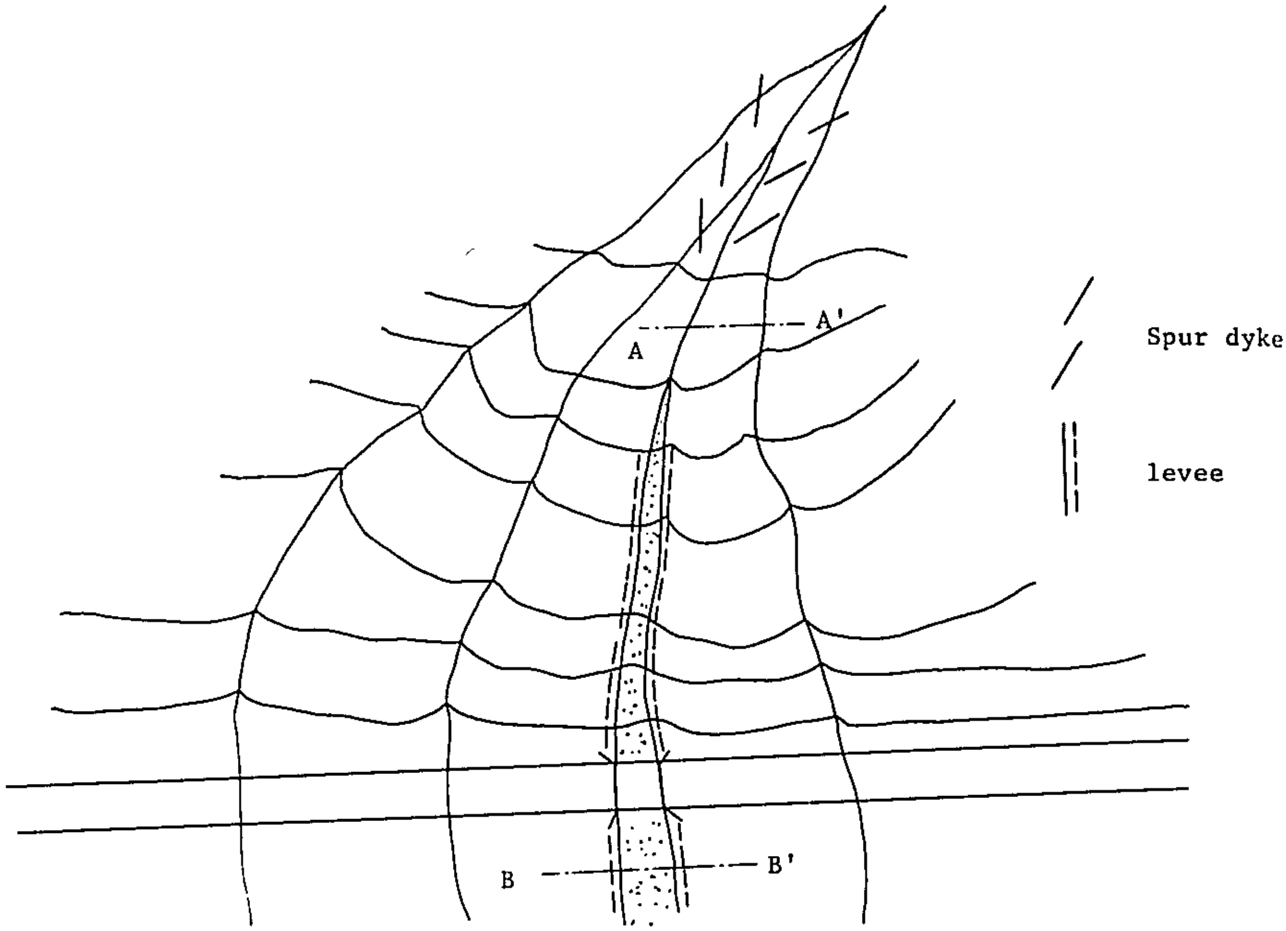
Every time of the heavy rains, these rivers very often were changed their streams and resulted to destruct the newly reconstructed road. In another words, the new river channel will be formed by the flood.

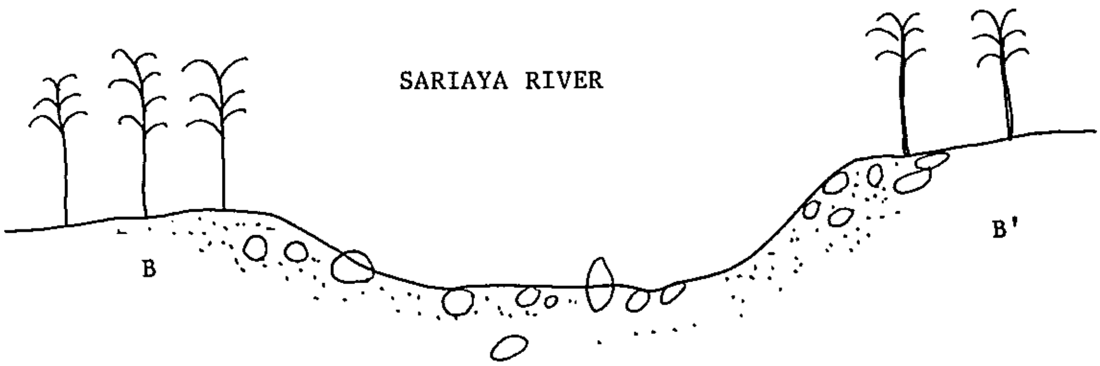
The geology of this portion belongs to terrace deposit consisting of the river bed material with large cobles, 2 meters in maximum diameter. The longitudinal gradient of the river is more or less than 2.00 $^{o/o}$ at the portion crossing the road. But, at the upstream, the gradient is more steeper. Judging from the topographical point of view, there is well developed fan exisisting at the point of changing gradient of the river.

(3) Counter-measure

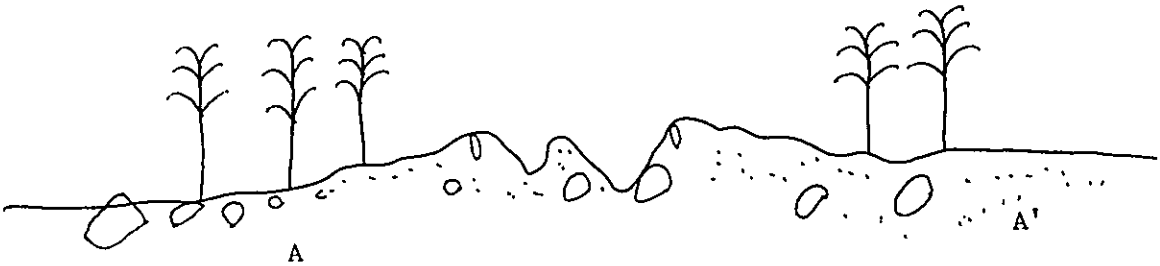
① The spur-dyke might be adopted to fix the river channel as shown in Fig. 3-1.

② When the river bed is lower enough to maintain the stream, the bank protection works and river bed consolidation works must be adopted.





River bed at downstream



River bed at upstream

Figure 3-1

4. Recommendations for Restorations of Damages of Embankment Protection of Sappan Bridge Approach

The present site condition shows that the side face of the road alongside the river is affected directly by collision force of the river flow, because the curvature bend of the Sapaan River is in close approach to the road. Under such condition, the base grade of the river embankment was scoured with resultant collapse of the slope for total length of about 50 m.

The possible method of restoration from damage is to protect the slope with the revetment. Since the damaged grade receive direct impact from the river flow, a thoroughgoing consideration must be given to reinforcement of the revetment and consolidation of the foundation. It is, therefore, proposed that the foundation should be strengthened by combined use of masonry and sheet pile.

It is, no doubt, possible that the river bed will be scoured after completion of revetment construction. If so, it is further proposed that foot protection should be provided if any anxiety arises as to security of the revetment after full investigation of the scoured condition.

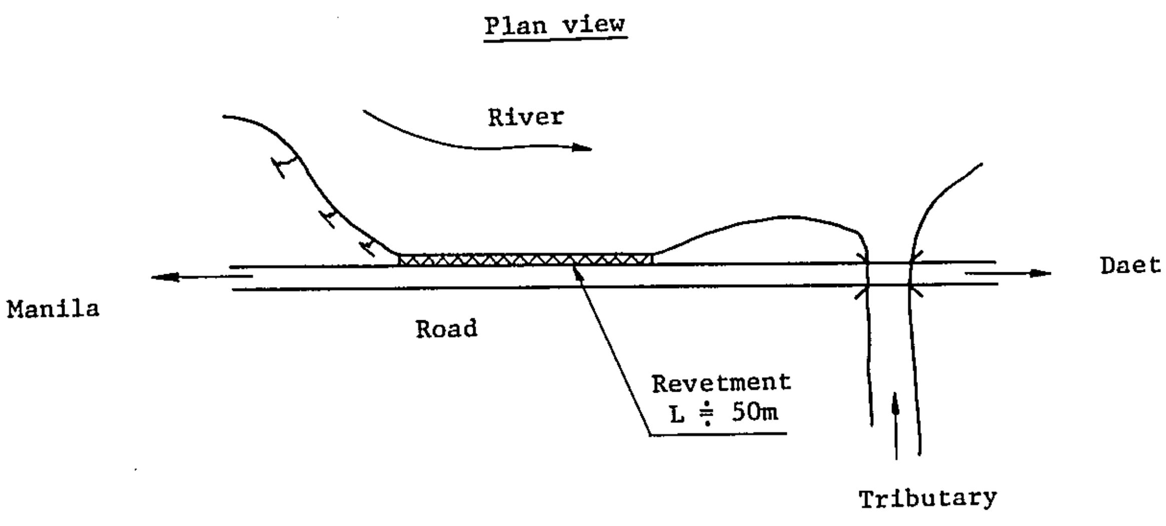


Figure 4-1

Cross-sectional view

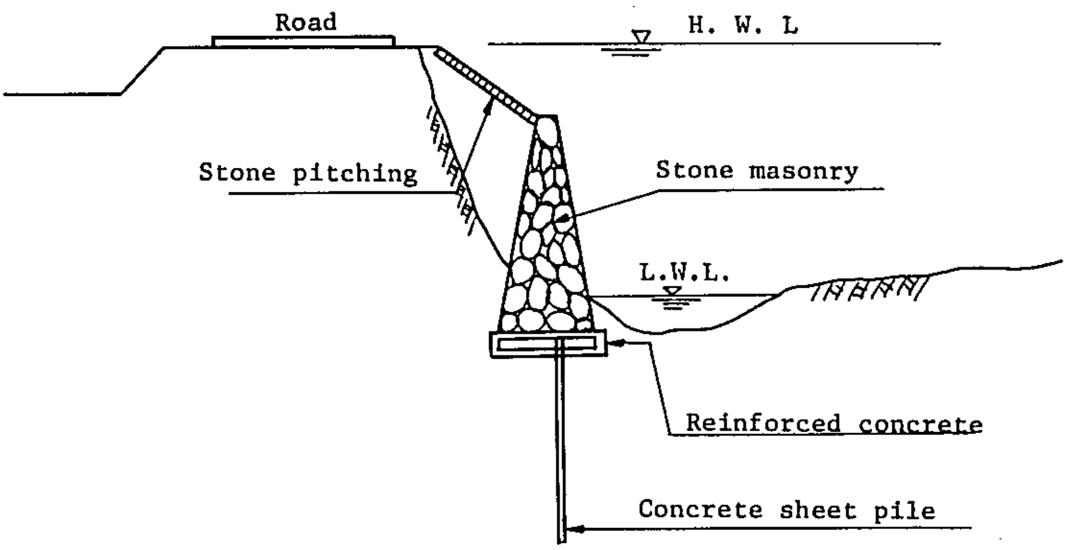


Figure 4-2

Photo - 4 - 1

5. Recommendations for Restorations of Other Places

(1) Sta 229 + 100

The damaged grade is located where the curvature bend of the Caluag River running down at a gentle gradient draws near the road. There, the slope face of the road appears to permit scouring easily from the discharge at the time of flood.

The damage is observed on the embankment (river side) of the road in collapse for total length of about 30 m. The major cause for damage to be considered may be due to scouring of the slope face of the road by impact from surface water over the mountain side and river discharge. The method of restoration from the damage is to provide protection over the damaged slope face. In this regard, the work now nearing its completion by use of stone masonry is considered as an appropriate measure to be taken for this purpose.

The geological condition of the foundation for masonry work constitutes the hard soil layer. Being distanced apart from the river, the foundation seems to be stabilized for the time being.

However, when viewed from stability in a long run, necessary provision should be considered for protection of the embankment base, for instance, by use of the foot protection or groin method, since the foundation will be hit by direct force of discharge at flood of the river even though gently sloped.

When the revetment serves concurrently for maintenance of the river, the drip holes must be arranged very carefully because a drip hole of the masonry may permit intake of river flow, thus causing silt to be drawn out.

Plan view

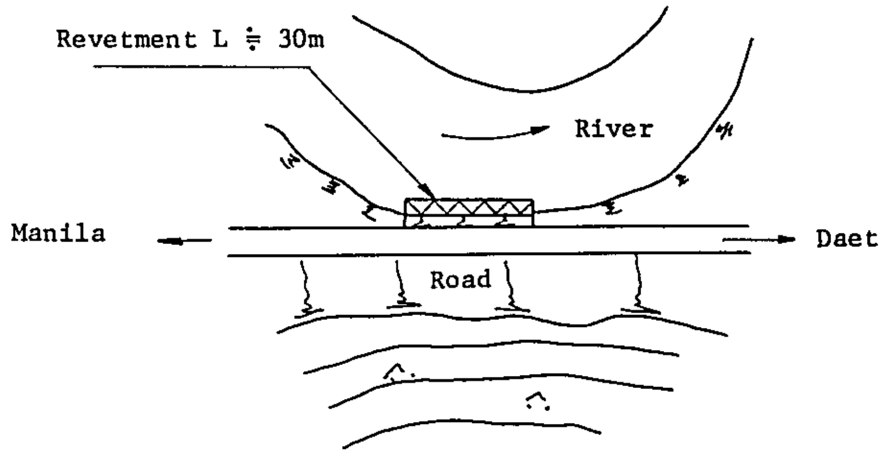


Figure 5-1

Cross-sectional view

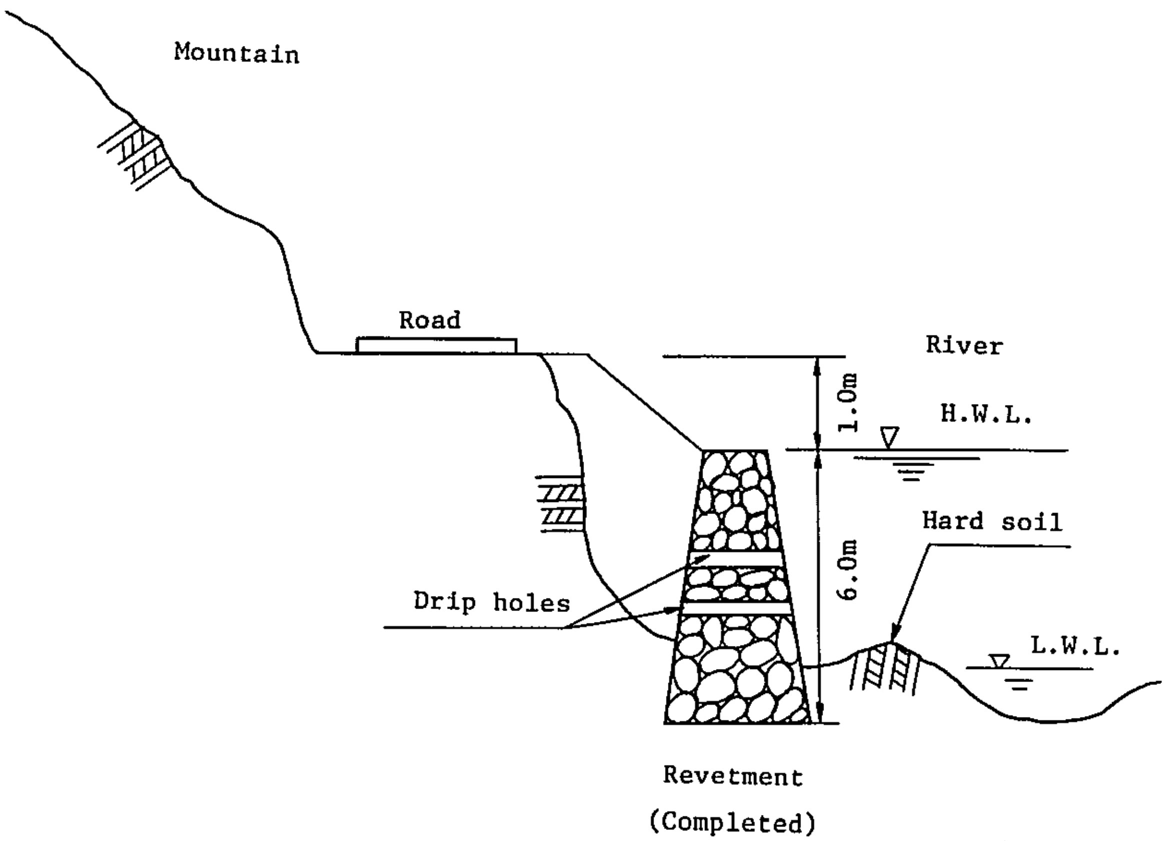


Figure 5-2

(2) Road damages in mountainous zone

Damages of the road in the mountainous zone are observed at about seven parts of the total extension. In all instances, such damage appears to have arisen from softening of the fill-up base of road due mainly to precipitation over the slope face of the road and surface water from the road. Thus, the pattern of damage seems to be almost common and identical to all of seven parts.

Restoration work from damage is already finished up with built-up of stone masonry. Appropriate measures are taken, wherever deemed necessary, to be suited for the site condition, for instance, by use of concrete sheet pile for the base of masonry or by replacement of banking soil with gravel.

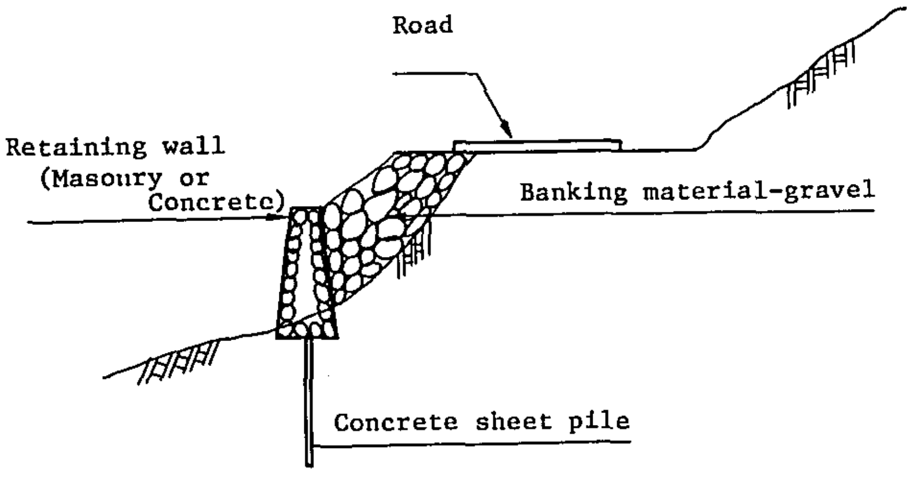


Figure 5-3

Photo - 5 - 1

Photo - 5 - 2

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

Through our site-investigations, the main causes of damages by typhoon Didang have been summarized as follows:

(1) Scouring of foot of embankments by high water.

(2) Slope failure and erosion of side cut slopes and natural slopes.

(3) Destruction of drainage systems

From these points of view, we investigated the damaged portions by ocular survey, and we always paid careful attention of recommend the more practical counter-measures as much as possible.

We estimated the whole volume and cost required to the restoration works for the damaged portions around Dalton Pass.

Through those works, it was always required more serious discussions how completeness and safty of road traffic against natural disasters must be adequate and necessary to the Philippine-Japan Friendship Highway when considering the present financial situation for the road administration in this country. In another words, it is a matter of fact that the present share of road budget in this country is more urgent to be distributed to the constructions of new road rather than the establishment of more safty traffic system. After all, we tried to recommend the counter-measures by using the more economical and own produced materials and works. Sometimes, we recommended, however, more advanced counter-measures being rather expensive and with difficult material to get in this country. As far to these proposed works and materials, further study must be discussed to find alternative works under consideration of local situations.

Also, it is expected that the further detail investigation and more accurate survey must be performed when those counter-measures are actually designed, because our mission did not have enough time to design the counter-measures with the actually surveyed data, but just only ocular.

Anyhow, the countermeasure for preventing the damages must be considered from the following points of view:

(1) Economical.

(2) Reliable and durable enough to prevent further coming disasters.

(3) Using of materials easy to adopt in this country.

On the results of the increase of newly constructed roads with large scale earth works, innevitably it is expected that the damages due to the unusual meteorological conditions will be more taken place along them. So, more cautious and active design for preventing damages must be considered with more expenditure of construction in future.

Lastly, we wish that these technical cooperation might be helpfull to get more close and friendly relationship between two countries.

We would like to express our appreciation with our whole hearts to Mr. Salbador and his excellent staffs in P.J.H.L. office, also project engineers in the region offices for their efficient cooperations and their heartfull hospitality. And also we thank very much Dr. Iwama and his staffs in Katahira & Engineers Inc. for their effective advice and help not only indoors, but also outdoors.