CHAPTER 10

BRIDGE REHABILITATION/IMPROVEMENT

10.1 PRESENT CONDITION OF BRIDGES

10.1.1 Summary of Bridges

There are 125 bridges along the Study Road. Existing bridge locations and type of bridges are presented in Figure 10.1-1. A summary of existing bridges is shown in Table 10.1-1.

10.1.2 Problems of Bridges

Problems of the existing bridges are summarized as follows:

a) Problems of Standards

Substandard Width

According to the "Standard Drawings for Roads and Bridges, Bureau of Design, DPWH", the standard widths of carriageway and sidewalk are 7.32m and 0.76m, respectively.

Carriageway width of the existing bridges varies from 6.70m to 8.10m except for Paypay Bridge which is composed of two one-lane bridges with a carriageway width of 4.26m. In 86 bridges out of 125, carriageway width is narrower than the DPWH standard width.

Sidewalk width varies from 0 to 0.77m. Most bridges, amounting to 112 bridges out of 125, have narrower sidewalks than the DPWH standard width, including 4 bridges without sidewalk. 81 bridges accounting for 65% of total bridges have 0.40-0.49m sidewalks.

Load Limit

While DPWH stipulates the design load of 20 tons, the existing bridges are given the following load limits:

10 tons -	2 bridges
15 tons -	82 bridges
18 tons -	2 bridges
20 tons -	39 bridges
Total -	125 bridges

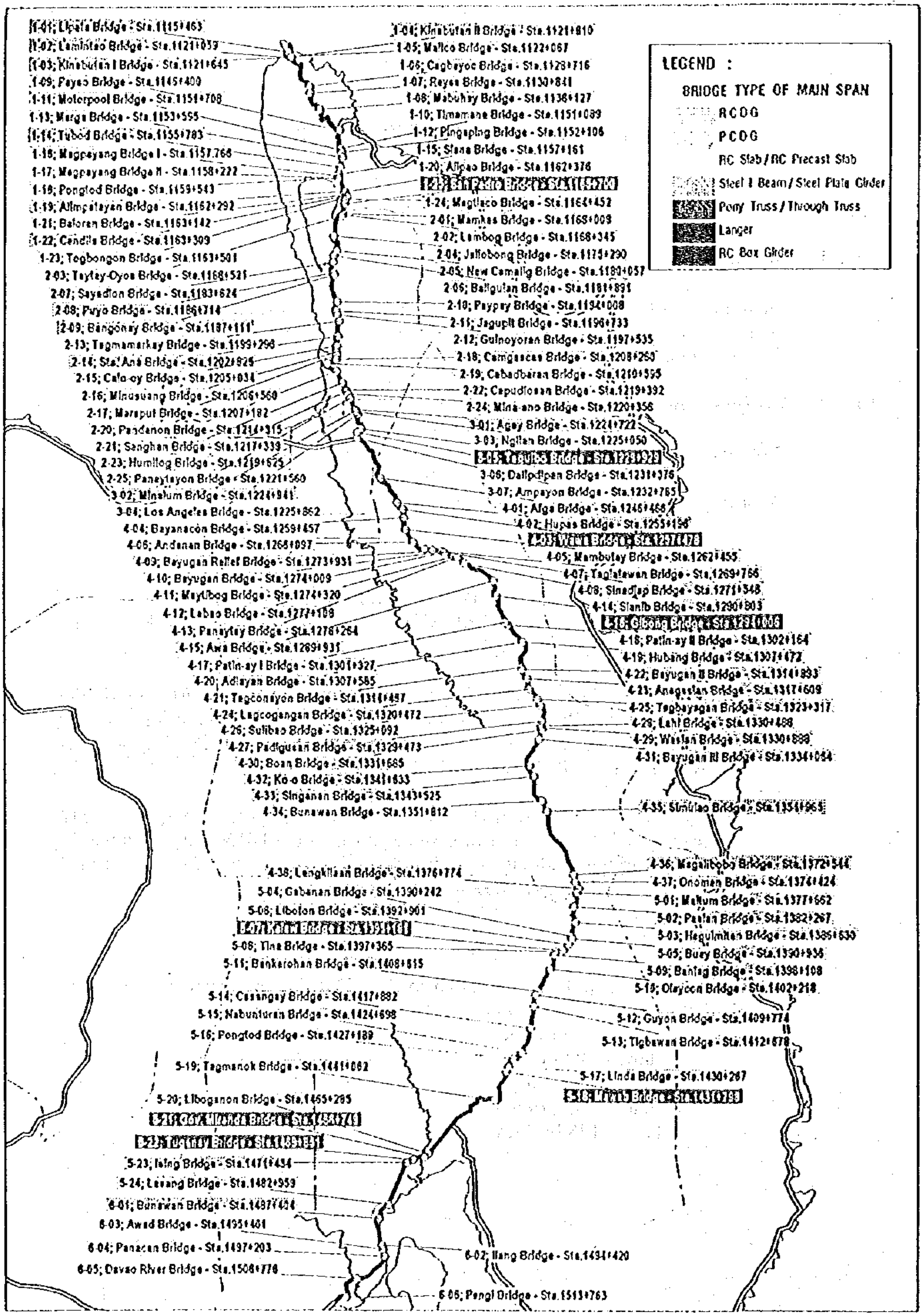


FIGURE 10.1-1 LOCATION OF EXISTING BRIDGES

TABLE 10.1-1 SUMMARY OF BRIDGES (1/3)

Package Number	Bridge Number	Bridge Name	Station	Bridge Type	Length (m)	Pavement Width (m)	Design Load (t)
1	1-01	Lipata	1115.463	1-Span Steel I Beam	16	7.45	20
	1-02	Lamintao	1121.059	1-Span Steel I Beam	25	7.30	20
	1-03	Kinabutan I	1121.645	1-Span Steel I Beam	16	7.30	20
	1-04	Kinabutan II	1121.810	3-Span Steel I Beam	93	7.30	20
	1-05	Malico	1122.067	3-Span RC Deck Girder	32	7.50	20
	1-06	Cagbayoc	1128.716	1-Span RCDG (*)	21	6.86	20
	1-07	Reyes	1130.841	3-Span RC Deck Girder	28	6.85	20
	1-08	Mabuhay	1136.127	4-Span RC Deck Girder	48	6.80	20
	1-09	Payao	1146.400	3-Span RC Deck Girder	30	6.83	20
	1-10	Timamana	1151.089	1-Span RC Deck Girder	15	6.80	20
	1-11	Motorpool	1151.708	1-Span RC Deck Girder	8	7.40	20
	1-12	Pingaping	1152.106	1-Span RC Deck Girder	14	6.80	20
	1-13	Marga	1153.595	1-Span RC Deck Girder	14	6.70	20
	1-14	Tubod	1155.783	1-Span Steel I Beam	25	7.30	20
	1-15	Siana	1157.161	1-Span RC Deck Girder	15	7.36	20
	1-16	Magpayang I	1157.766	3-Span RC Deck Girder	25	6.80	20
	1-17	Magpayang II	1158.222	1-Span Precast Slab	6	6.80	20
	1-18	Pongtod I	1158.543	3-Span RC Deck Girder	36	6.80	20
	1-19	Alimpatayan	1162.292	1-Span Steel I Beam	22	7.28	20
	1-20	Alipao	1162.376	1-Span RC Deck Girder	14	6.85	20
	1-21	Baloran	1163.142	1-Span RCDG (*)	18	6.80	20
	1-22	Candiis	1163.309	1-Span Steel I Beam	15	7.09	20
	1-23	Togbongon	1163.501	1-Span RC Deck Girder	10	6.90	20
	1-24	Magtiaco	1164.452	6-Span Steel I Beam	186	7.38	20
	1-25	San Pedro	1165.700	1-Span Pony Truss	45	7.32	20
2	2-01	Mamkas	1168.008	4-Span RC Deck Girder	51	6.70	15
	2-02	Lambog	1168.345	1-Span RCDG (*)	24	6.75	15
	2-03	Taytay-Oyos	1168.521	1-Span RCDG (*)	21	6.75	15
	2-04	Jaliobong	1175.290	3-Span RC Deck Girder	30	6.69	15
	2-05	New Camalig	1180.157	3-Span RC Deck Girder	42	7.36	15
	2-06	Baliguian	1181.891	3-Span RC Deck Girder	28	6.85	15
	2-07	Sayadion	1183.624	1-Span RCDG (*)	18	6.80	15
	2-08	Puyo	1186.714	4-Span Steel I Beam	124	7.35	20
	2-09	Bangonay	1187.111	9-Span Steel I Beam	168	7.38	20
3	2-10	Paypay	1194.008	1-Span RC Deck Girder 2-Span Pony Truss	84	8.52	20
	2-11	Jagupit	1196.733	1-Span RCDG (*)	17	6.70	15
	2-12	Guinoyoran	1197.535	1-Span RCDG (*)	21	7.75	15
	2-13	Tagmamarkay	1199.296	3-Span RC Deck Girder	26	7.35	15
	2-14	Sta. Ana	1202.825	4-Span Steel I Beam	99	7.35	20
	2-15	Calo-oy	1205.034	1-Span RCDG (*)	21	6.80	15
	2-16	Minusuang	1206.560	3-Span RC Deck Girder	26	6.90	15
	2-17	Maraput	1207.182	3-Span RC Deck Girder	28	6.70	15
	2-18	Comagascas	1208.260	3-Span RC Deck Girder	29	6.80	15
4	2-19	Cabadbaran	1210.595	6-Span PC Deck Girder	222	7.40	20
	2-20	Pandanon	1214.315	3-Span RC Deck Girder	24	6.75	15
	2-21	Sanghan	1217.339	2-Span RC Deck Girder	24	6.80	15
	2-22	Capudlosan	1219.392	1-Span RCDG (*)	18	6.80	15
	2-23	Humilog	1219.625	1-Span RCDG (*)	18	6.70	15
	2-24	Mina-ano	1220.356	2-Span RC Deck Girder	16	6.70	15
	2-25	Panaytayon	1221.560	2-Span Precast Slab	12	6.85	15
	3-01	Agay	1224.722	1-Span Steel I Beam	19	7.42	15
	3-02	Minalum	1224.941	1-Span Steel I Beam	22	7.55	15
	3-03	Ngilan	1225.050	3-Span Precast Slab	18	6.85	15
	3-04	Los Angeles	1225.862	2-Span Precast Slab	12	6.90	15
	3-05	Taguibo	1229.929	1-Span Steel I Beam 1-Span Steel Langer 2-Span Steel I Beam	222	7.45	15

Note : 1 Span RCDG (*) = 1 Span RC Deck Girder with Cantilever Spans

TABLE 10.1-1 SUMMARY OF BRIDGES (2/3)

Package Number	Bridge Number	Bridge Name	Station	Bridge Type	Length (m)	Pavement Width (m)	Design Load (t)
4	3-06	Dalipdipan	1231.376	1-Span RCDG (*)	21	6.70	15
	3-07	Ampayon	1232.785	2-Span Precast Slab	12	6.85	15
5	4-01	Afga	1246.466	1-Span RC Slab 1-Span RC Deck Girder	24	6.80	15
6	4-02	Hupas	1255.196	1-Span Steel Plate Girder	36	7.25	15
	4-03	Wawa	1257.478	2-Span Steel I Beam 2-Span Through Truss 1-Span Steel I Beam	228	7.45	20
	4-04	Bayanacon	1259.457	4-Span RC Deck Girder	56	6.75	15
	4-05	Mambutay	1262.455	1-Span RCDG (*)	21	6.80	15
	4-06	Andanan	1266.097	12-Span RC Deck Girder	180	6.86	15
	4-07	Taglatawan	1269.766	3-Span RC Deck Girder	26	6.76	15
7	4-08	Sinadjap	1271.548	4-Span RC Deck Girder	50	6.74	15
	4-09	Bayugan Relief	1273.931	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	20	6.71	15
	4-10	Bayugan	1274.009	4-Span RC Deck Girder	60	6.70	15
	4-11	Maytibog	1274.320	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	27	6.70	15
	4-12	Labao	1277.108	1-Span RCDG (*)	19	6.75	15
	4-13	Panaytay	1278.264	3-Span RC Deck Girder	34	6.70	10
	4-14	Sianib	1280.803	4-Span RC Deck Girder	53	6.78	15
	4-15	Awa	1289.931	1-Span Steel Plate Girder	41	7.40	15
8	4-16	Gibong	1294.006	2-Span RC Deck Girder 2-Span RC Box Girder 2-Span RC Deck Girder	121	6.75	15
	4-17	Patin-ay I	1301.327	1-Span RC Deck Girder	15	7.33	15
	4-18	Patin-ay II	1302.164	3-Span RC Deck Girder	24	6.70	15
9	4-19	Hubang	1307.472	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.70	15
	4-20	Adlayan	1307.585	1-Span RC Slab 2-Span RC Deck Girder	30	6.75	15
	4-21	Tagconayon	1314.467	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	24	6.75	15
	4-22	Bayugan II	1314.893	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.75	15
	4-23	Anagasian	1317.609	3-Span RC Deck Girder	32	6.70	15
	4-24	Lagcogangan	1320.472	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.80	15
	4-25	Tagbayagan	1323.317	3-Span RC Deck Girder	30	6.78	15
10	4-26	Sulibao	1325.092	5-Span RC Deck Girder	75	6.78	15
	4-27	Padigusan	1329.473	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.80	15
	4-28	Lahi	1330.486	3-Span RC Deck Girder	28	6.70	15
	4-29	Wasian	1330.888	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.70	15
	4-30	Boan	1331.685	1-Span RC Deck Girder	15	7.45	15
	4-31	Bayugan III	1334.064	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	22	6.80	15

Note : 1 Span RCDG (*) = 1 Span RC Deck Girder with Cantilever Spans

TABLE 10.1-1 SUMMARY OF BRIDGES (3/3)

Package Number	Bridge Number	Bridge Name	Station	Bridge Type	Length (m)	Pavement Width (m)	Design Load (t)
10	4-32	Ko-o	1341.633	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	27	6.70	15
	4-33	Singanan	1343.525	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	24	6.70	15
11	4-34	Bunawan I	1351.812	1-Span RC Box Girder 1-Span RC Box Girder 1-Span RC Box Girder	73	6.70	15
	4-35	Simulao	1354.965	3-Span Steel Plate Girder	137	7.30	20
12	4-36	Magalibobo	1372.544	1-Span Steel Plate Girder	25	7.25	20
	4-37	Onoman	1374.424	3-Span RC Deck Girder	24	6.70	15
	4-38	Langkilaan	1376.774	1-Span Steel Plate Girder	41	7.35	20
13	5-01	Maitum	1377.662	1-Span RCDG (*)	19	6.80	15
	5-02	Pasian	1382.267	1-Span Steel Plate Girder	36	7.40	15
	5-03	Haguimitan	1386.630	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	27	6.80	15
	5-04	Gabanan	1390.242	3-Span RC Deck Girder	45	6.80	15
	5-05	Buay	1390.936	5-Span RC Deck Girder	58	6.80	15
	5-06	Liboton	1392.901	3-Span RC Deck Girder	28	6.80	15
14	5-07	Kalaw	1395.181	2-Span RC Deck Girder 3-Span Pony Truss 1-Span RC Deck Girder	111	6.80	15
15	5-08	Tina	1397.365	3-Span RC Deck Girder	31	6.85	15
	5-09	Banlag	1398.108	3-Span RC Deck Girder	27	6.80	15
	5-10	Olaycon	1402.218	2-Span RC Deck Girder	30	6.80	15
	5-11	Bankerohan	1408.615	1-Span RC Deck Girder	15	7.40	15
	5-12	Guyon	1409.774	2-Span RC Deck Girder	21	6.80	15
	5-13	Tigbawan	1412.678	1-Span RCDG (*)	21	6.80	15
	5-14	Casangay	1417.882	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	26	6.80	15
	5-15	Nabunturan	1424.698	1-Span RC Deck Girder	15	6.80	15
16	5-16	Pongtod II	1427.189	1-Span RC Deck Girder	15	6.80	15
	5-17	Linda	1430.358	3-Span RC Deck Girder	34	6.80	15
	5-18	Mawab	1431.798	1-Span RC Slab 1-Span RC Box Girder 1-Span RC Slab	32	7.40	15
	5-19	Tagmanok	1441.062	1-Span RC Slab 1-Span RC Deck Girder 1-Span RC Slab	26	6.80	15
17	5-20	Liboganon	1465.285	3-Span RC Deck Girder	32	6.80	10
	5-21	Gov. Miranda	1466.749	1-Span RC Box Girder 2-Span Through Truss 1-Span RC Box Girder	146	7.45	15
18	5-22	Tuganay	1469.851	1-Span Through Truss	50	7.40	15
	5-23	Ising	1471.434	1-Span Steel I Beam 1-Span RC Deck Girder	25	7.40	18
	5-24	Lasang	1482.959	3-Span RC Deck Girder	55	7.40	18
	6-01	Bunawan II	1487.404	1-Span RC Deck Girder 1-Span Steel I Beam 1-Span RC Deck Girder	42	7.40	15
	6-02	Ilang	1494.420	2-Span RC Deck Girder	18	7.40	20
	6-03	Awad	1495.401	1-Span RC Slab	6	7.50	20
19	6-04	Panacan	1497.203	1-Span RCDG (*)	18	7.50	20
	6-05	Davao River	1506.776	5-Span PC Deck Girder	124	8.10	20
	6-06	Pangi	1513.763	4-Span PC Deck Girder	99	8.10	20

Note : 1 Span RCDG (*) = 1 Span RC Deck Girder with Cantilever Spans

b) Problems of Hydraulic Regime

Insufficient Freeboard

There are several bridges in which freeboards are remarkably insufficient causing rivers to flood during high-water. There are two cases in this situation; the elevation of bridge was too low from the beginning in one case and the riverbed has been raised due to sedimentation in the other case. Sometimes, both cases are combined.

Insufficient Length of Bridge

Where approach road embankment encroaches on the stream, the river is flooded due to shortage of discharge capacity at the bridge and the approach road embankment slope is subjected to erosion. This situation is often seen in the Philippines especially on rural roads but there is no remarkable case on the Study Road.

Where span length is too short even if total bridge length is reasonable, piers located at short intervals cause the reduction of discharge capacity. Many bridges on the Study Road are in such situation.

Lateral Scour

Where the river is meandering at the upstream of bridge, the river bank is eroded and the approach road embankment is damaged. This situation is often found in the Study Road.

Local Scour

Abutment ends and pier foundations are subjected to local scour in many bridges on the Study Road.

c) Structural Deterioration

Structural deterioration is observed in many bridges due to various causes such as insufficient structural capacity, passage of overloaded vehicles, collision of vehicles, river stream action, lack of maintenance operation, etc.

d) Lack of Aseismicity

No special aseismatic consideration is given to the existing bridges. Restrainers are to be used for existing bridges over 35mm length, when bridge seat width does not satisfy the requirement of AASHTO. There is a danger of falling in the occurrence of big earthquake in the worst case.

10.2 REHABILITATION CRITERIA AND REHABILITATION METHOD

10.2.1 Rehabilitation Criteria

As described in Section 10.1, problems in the existing bridges on the Study Road are broadly categorized into the following four:

a) Problems of standards
b) Problems of hydraulic regime
c) Structural deterioration
d) Lack of aseismicity

Basic considerations on how to cope with the problems are as follows:

a) Problems of Standards

Carriageway Width

Carriageway width of the existing bridges varies from 6.70m to 8.10m. In 86 bridges out of 125, carriageway is narrower than the DPWH standard width of 7.32m. Since every bridge has at least the standard width of the Pan-Philippine Highway of 6.70m, however, widening is not considered to be in urgent need except in the following case:

In case where approach roads on both sides are 4 or more-lane roads and traffic volume is quite high, the bridge is needed to be widened to 4 lanes to maintain a smooth flow of traffic avoiding bottleneck.

Sidewalk Width

Most bridges are substandard in sidewalk width, 112 bridges out of 125 having narrower sidewalk than the DPWH standard width of 0.76m. Sidewalks of less than 0.60m in width, in case where they are located in residential areas and many pedestrians pass thereon, are needed to be widened to secure safety of pedestrians and smooth passage of vehicles. In scarsely populated areas on the other hand, the widening of sidewalk is not considered to be in urgent need.

Load Limit

2 bridges are given a 10-ton load limit, 82 bridges 15-ton load limit, 2 bridges 18-ton load limit and the remaining 39 bridges 20-ton load limit which is the DPWH standard design load. The bridges with 10-ton load limit are needed to be reconstructed, while the bridges with 15- or 18-ton load limit are desirable to be also reconstructed but they are given lower priority. In this Study, only 10-ton load limit is used as one of the criteria for reconstruction.

b) Problems of Hydraulic Regime

Insufficient Freeboard

There are two cases in shortage of freeboard; bridge elevation being too low from the beginning and riverbed being raised due to sedimentation. In the former case, the bridge is needed to be raised by either whole reconstruction or heightening substructure and lifting or reconstructing superstructure. The latter way is not practical in this project because the bearing and structural capacity of the existing substructure is generally not enough to support the lifted superstructure and it is better to change the locations of substructure in most cases, and therefore, the former way will be applied. In case of raise of riverbed, either raise of bridge or dredging of riverbed sediment or both is selected depending on the river condition.

Insufficient Length of Bridge and Lateral Scour

Where approach road embankment encroaches on the stream, the bridge is needed to be extended by constructing additional span(s).

Where river bank is eroded due to meandering of the river at the upstream of bridge, remedial and protective measures are needed, such as spurdike, dredging, river bank protection, etc.

Local Scour

Where local scour is found at abutment slope or pier foundation, firm protective measures are needed to avoid damage by scour.

In most bridges, abutment slope is protected with grouted riprap but sometimes the protection is damaged. In such case, partial repair or total reconstruction is needed depending on the degree of damage. There is no bridge in which pier foundation is protected. If pier foundation is scoured, it is needed to be protected.

c) Structural Deterioration

Main Structures

If main structures, i.e., slab, girder and substructure, are deteriorated to the degree of dissatisfaction in their bearing and structural capacity, they are needed to be reconstructed. Only the portion in such condition is generally subject to reconstruction. However, girders are usually deteriorated to some degree when substructure supporting them is structurally defective and likewise slab is damaged when girders are defective. Therefore, reconstruction of girder will accompany reconstruction of slab and reconstruction of substructure will accompany reconstruction of girder and slab.

If main structures are damaged but still repairable, repair works such as partial reconstruction of damaged portion, crack sealing, partial replacement of steel member(s), etc. will be applied instead of reconstruction.

Other Components

Basic principles to cope with the damage of other components of bridge are as follows:

Railing : Partially or totally reconstructed depending on the degree of damage.
Slab overlay : Provided when adjacent road sections are to be overlayed.
Expansion joint: Replaced when seriously deteriorated or slab is reconstructed.
Bearing : Replaced when girder is reconstructed, or bearing is seriously damaged to fail in its function even if girder is not reconstructed, especially for roller or rocker expansion bearing.
Drainage pipe : Replaced when slab is reconstructed.
Approach road embankment slope: If embankment slope is unprotected and eroded, it shall be protected. If embankment slope is already protected but the protection is seriously damaged, it shall be reconstructed.
Approach road embankment settlement: Approach slab shall be provided if settlement is significant.

Repair of only expansion joint or drainage pipe without reconstruction of slab is not taken up in this Study because no serious case is found in the existing bridges.

d) Lack of Aseismicity

No special aseismatic consideration is given to the existing bridges. It is, however, necessary to prevent a bridge from falling in order to maintain road traffic even in the occurrence of earthquake. From this point of view, falling prevention measures should be taken for as many bridges as possible. It is a good opportunity when a bridge is totally reconstructed. For the other bridges, priority should be determined depending on significance of impact when falling and difficulty in taking urgent restoration measures. Length of bridge is one of the determinative factors. Based on the above considerations, the following bridges are selected as the bridge to take falling prevention measures:

- bridges to be totally reconstructed irrespective of length
- bridges of which superstructure is to be reconstructed.
- bridges of 35m or more in length when the bridge seat width does not satisfy AASHTO requirement.

Among various measures, the following are selected in this Study as a general rule, taking into consideration constructability and existing condition of bridges:

- Installation of longitudinal and lateral shear keys.
- Connection of slabs between spans.

10.2.2 Bridge Rehabilitation Methods and Application Criteria

Based on the considerations described in Section 10.1.2, bridge rehabilitation methods were selected for this Project as follows (see Table 10.2-1 for brief description of each method and its application criteria):

A. Total Reconstruction	1. Total Reconstruction of Bridge
B. Partial Reconstruction	2. Reconstruction of Entire Slab of Span 3. Reconstruction of All Girders of Span 4. Reconstruction of Substructure
C. Widening	5. Widening of Carriageway or Construction of Additional Bridge 6. Widening of Sidewalk
D. Extension	7. Construction of Additional Span
E. Major Repair	8. Partial or Total Reconstruction of Railing 9. Partial Reconstruction of Slab 10. Reconstruction of Concrete Girder 11. Replacement of Steel Girder/Member 12. Replacement of Bearing 13. Repair of Bridge Seat 14. Reinforcement of Pier 15. Reinforcement of Foundation
F. Minor Repair	16. Repair of Slab 17. Repair of Concrete Girder 18. Repainting of Steel Girder/Member 19. Repair of Substructure 20. Provision/Reconstruction of Slab Overlay
G. Protection from Scour	21. Repair of Abutment Slope Protection 22. Provision/Reconstruction of Abutment Slope Protection 23. Provision/Reconstruction of Pier Foundation Protection 24. Provision/Reconstruction of River Bank Protection
H. Approach Road Protection	25. Provision/Reconstruction of Approach Road Embankment Slope Protection 26. Provision of Approach Slab
I. River Control	27. Provision of Spurdike 28. Dredging
J. Aseismatic Protection	29. Widening of Bridge Seat 30. Provision of Shear Key and/or Slab Connection

Note: Methods 16 to 21, referred to as the minor works, should be done by the DPWH District Offices as maintenance work. Therefore, the bridges which need only the minor works will not be included in the rehabilitation project, expecting the District Offices' proper maintenance operation. For the bridges including both minor works and any other work, however, the minor works will be included in the scope of work of the rehabilitation project.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(1/8)

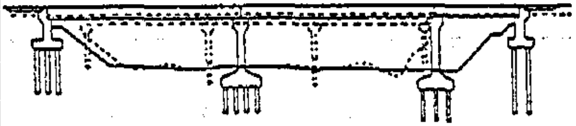
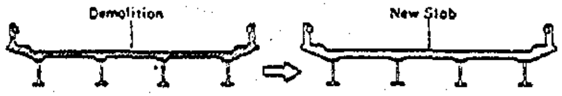
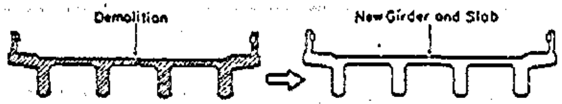
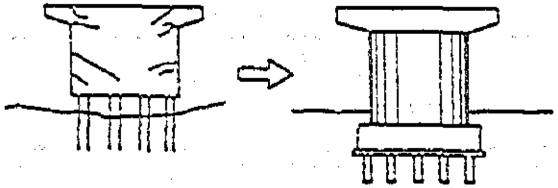
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
A. Total Reconstruction	1. Total Reconstruction of Bridge		Totally reconstruct a bridge providing sufficient waterway opening and aseismicity. Take protection measures against scour as necessary.	o All substructures are inadequate in their structural capacities, being obviously settled or tilted or concrete being seriously cracked and spalled and reinforcing steel being exposed and rusted. o Girders of all spans meet the conditions to apply Method 3 and substructure is not sound to be used as is. o *Load limit is below 15 tons.* o Because of low elevation of girders, freeboard is insufficient and bridge is in danger of submergence during high-water.
B. *Partial Reconstruction*	2. *Reconstruction* of Entire Slab of Span		Reconstruct entire slab of span(s) in problem.	o In most part of slab, wide cracks are found on both top and bottom surfaces, often, reinforcing steel being exposed and rusted or concrete block falling off.
	3. Reconstruction of All Girders of Span		Reconstruct all girders of span(s) in problem. Reconstruction of slab will be accompanied.	o Half or more concrete girders have shearing or bending cracks for lack of structural capacity. o Half or more steel girders are seriously *deformed for lack of structural capacity or* loss of cross-sectional area due to rust.
	4. Reconstruction of Substructure		Reconstruct substructure in problem. Usually reconstruction of slab and girders of the related span(s) will be accompanied.	o A certain substructure is inadequate in its structural capacity, being obviously settled or tilted or concrete being seriously cracked and spalled and reinforcing steel exposed and rusted.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(2/8)

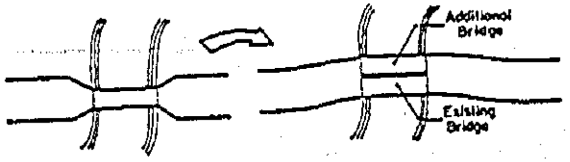
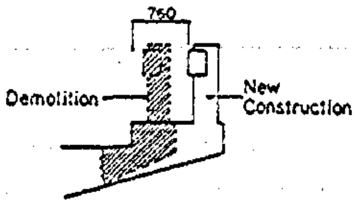
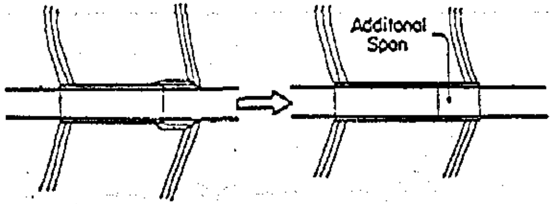
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
C. Widening	5. Widening of Carriageway or Construction of Additional Bridge		Demolish existing sidewalk and railing on one or both sides(s), widen substructure if necessary and construct additional girders and slab, or construct another bridge adjacent to and parallel with the existing bridge.	o Number of lanes is less than that of approach road on each side and traffic volume is high.
	6. Widening of Sidewalk		Demolish existing sidewalk and railing, widen substructure if necessary, construct additional girders if necessary, and construct new sidewalk and railing.	o Bridge is located in residential area and has less than 60cm wide sidewalk.
D. Extension	7. Construction of Additional Span		Take necessary measures to convert the existing abutment into pier or reconstruck it , and construct substructure and superstructure of additional span(s).	o Approach road embankment encroaches on waterway causing flooding upstream and erosion of approach road embankment.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(3/8)

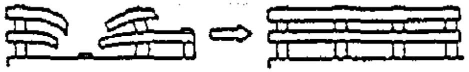
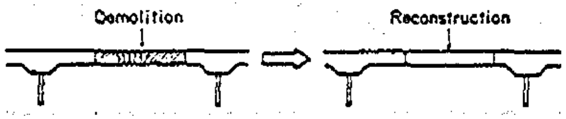
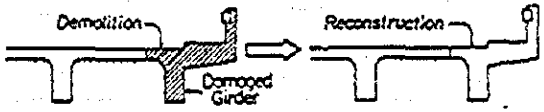
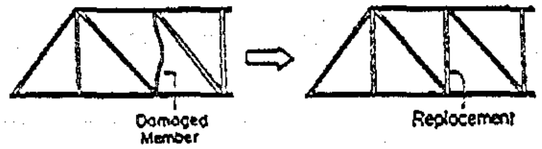
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
E. Major Repair	8. Partial or Total Reconstruction of Railing		Demolish existing railing partially or totally depending on the degree of damage and reconstruct it.	o Railing is damaged and endangers traffic and pedestrians.
	9. Partial Reconstruction of Slab		Demolish damaged portion of slab and reconstruct it.	o In a part of slab, wide cracks are found on both top and bottom surfaces, often, reinforcing steel being exposed and rusted or concrete block falling off.
	10. Reconstruction of Concrete Girder		Demolish damaged girder(s) and reconstruct them. Partial or total reconstruction of supported slab will be accompanied.	o A certain concrete girder has shearing or bending cracks for lack of structural capacity.
	11. Replacement of Steel Girder/ Member		Replace damaged girder(s)/member(s).	o A certain steel girder/member is deformed or thickly rusted.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(4/8)

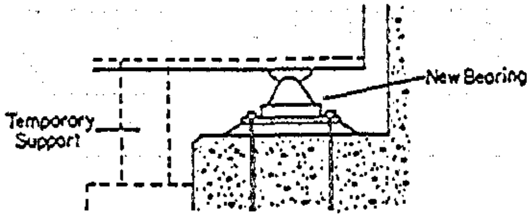
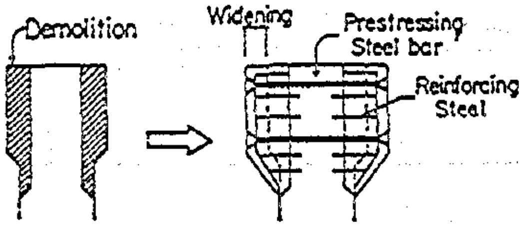
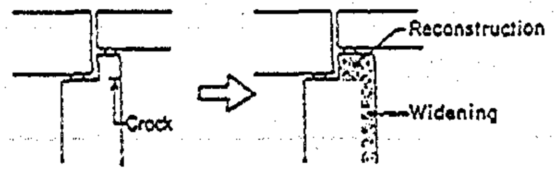
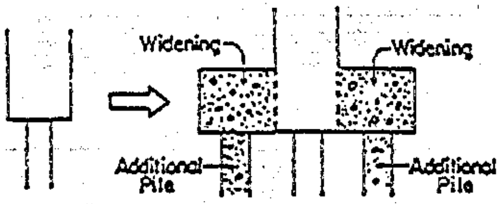
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
E. Major Repair (continued)	12. Replacement of Bearing		Provide temporary support in the vicinity of the bearing, jack up superstructure evenly, demolish and reinforce bridge seat, and install new bearing. If the width of bridge seat is insufficient from the aseismatic point of view, widen it.	o Bearing, especially roller or rocker expansion bearing, is seriously damaged to fail in its function and induce stresses in superstructure and substructure.
	13. Repair of Bridge Seat		Seal cracks by injecting them with low viscosity epoxy or demolish damaged portion as the case may be (usually temporary support is needed in the latter case), and widen bridge seat in the same manner as Method 28.	o Concrete at bridge seat is cracked or spalled.
	14. Reinforcement of Pier		Provide temporary support of related girders, demolish damaged portion of pier, and place reinforcing steel and concrete to widen the existing pier.	o Pier is seriously damaged, especially at top portion of pier supporting girders with different depth between neighboring girders, and needs to be strengthened.
	15. Reinforcement of Foundation		Widen footing with piles if necessary.	o Bearing capacity of foundation is insufficient or will be insufficient due to reconstruction of superstructure.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(5/8)

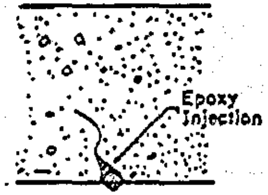
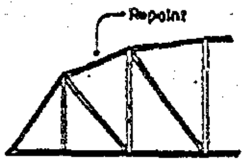
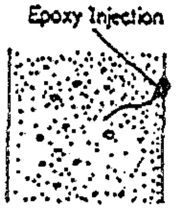
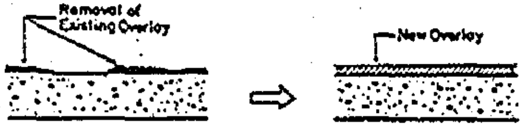
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
F. Minor Repair	16. Repair of Slab		Seal cracks by injecting them with low viscosity epoxy.	o Concrete slab is cracked or spalled but reinforcing steel is neither seriously deformed nor rusted.
	17. Repair of Concrete Girder		Seal cracks by injecting them with low viscosity epoxy.	o Concrete girder is cracked or spalled but reinforcing steel is neither seriously deformed nor rusted.
	18. Repainting of Steel Girder/ Member		Repaint all steel members.	o Steel girder/member is rusty but not structurally deteriorated.
	19. Repair of Substructure		Seal cracks by injecting them with low viscosity epoxy.	o Substructure concrete is cracked or spalled but reinforcing steel is neither seriously deformed nor rusted.
	20. Provision/ Reconstruction of Slab Overlay		Remove overlay if exists, and place asphalt overlay.	o Existing concrete overlay is considerably cracked or spalled. o Existing asphalt overlay is considerably cracked, distorted or disintegrated. o No overlay exists but it is considered to be needed in order to provide smooth riding surface or to protect reinforcing steel of slab.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(6/8)

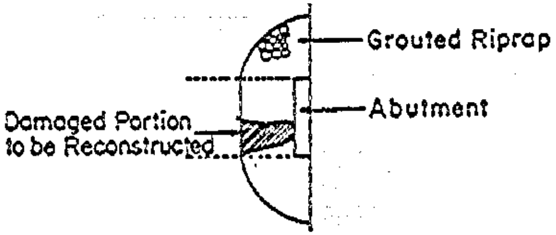
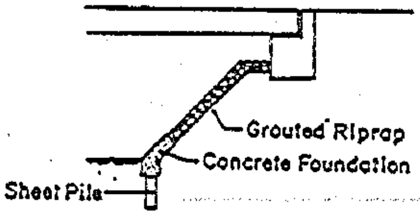
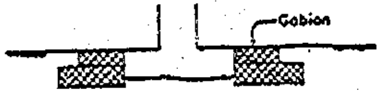
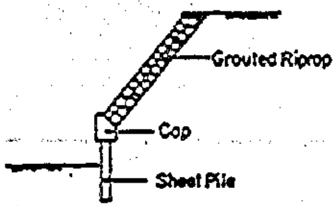
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
G. Protection from Scour	21. Repair of Abutment Slope Protection		Remove damaged portion of existing abutment slope protection and reconstruct it.	o Abutment slope protection is damaged and/or its foundation is scoured. But the damage is still repairable.
	22. Provision/ Reconstruction of Abutment Slope Protection		Remove abutment slope protection if exists, and (re)construct the protection with grouted riprap, concrete pitching, gabion, or so on.	o Abutment slope is protected but the protection is seriously damaged and its foundation is scoured. o Abutment slope is not protected, being exposed to scour.
	23. Provision/ Reconstruction of Pier Foundation Protection		Remove pier foundation protection if exists, and (re)construct the protection with stone or concrete pitching, concrete block, gabion or so on.	o Pier foundation, unprotected or protected but seriously damaged, is scoured.
	24. Provision/ Reconstruction of River Bank Protection		Remove river bank protection if exists, and (re)construct the protection with grouted riprap, concrete block, concrete crib, sheet pile, gabion or so on, to the extent within which bridge and/or approach road is affected when river bank is damaged.	o River bank, unprotected or protected but seriously damaged, is scoured or in danger of being scoured due to the effect of meandering stream.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(7/8)

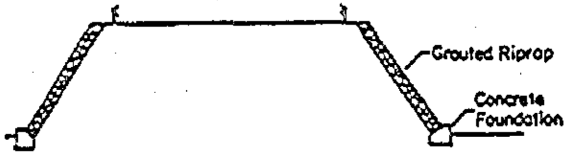
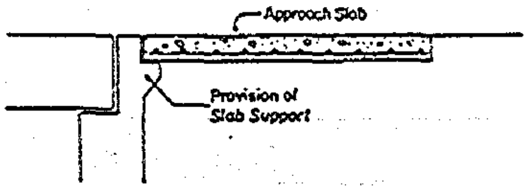
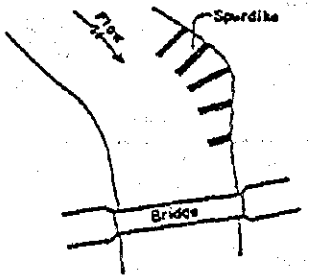
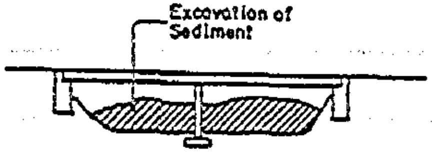
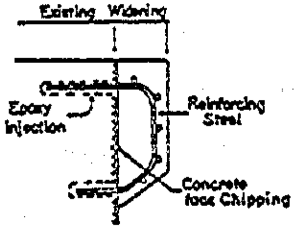
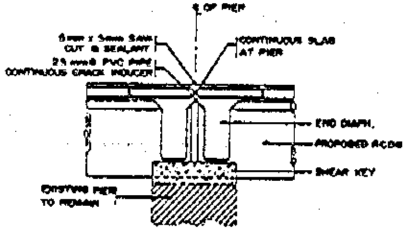
Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
H. Approach Road Protection	25. Provision/ Reconstruction of Approach Road Embankment Slope Protection		Remove approach road embankment slope protection if exists, and (re)construct the protection with grouted riprap, concrete block concrete crib, concrete retaining wall or so on.	o Approach road embankment slope, unprotected or protected but seriously damaged, is eroded or scoured.
	26. Provision of Approach Slab		Provide slab support on parapet of the existing abutment (reconstruct parapet if necessary) and construct reinforced concrete approach slab.	o Approach road embankment sinks by 20cm or more at the embankment end.
I. River Control	27. Provision of Spurdike		Construct spurdike with stone masonry, concrete block, gabion or so on to protect river bank and approach road by changing river flow direction.	o Control of river flow direction is considered to be needed in order to protect river bank and bridge approach.
	28. Dredging		Excavate riverbed sediment to recover freeboard.	o Riverbed rises due to sedimentation and consequently freeboard is insufficient and superstructure is in danger of submergence during high-water.

TABLE 10.2-1 BRIDGE REHABILITATION METHODS AND THEIR APPLICATION CRITERIA

(8/8)

Category	Rehabilitation Method	Sample Illustration	Description of Method	Criteria for Application
J. Seismic Protection	29. Widening of Bridge Seat		Widen bridge seat to provide allowable for displacement of superstructure, by inserting reinforcing steel and/or prestressing steel bar into the existing concrete body and placing concrete.	o This is applied to all concrete bridges and steel trusses of 35m or more in length, when bridge seat width does not satisfy AASHTO requirement.
	30. Provision of Shear Key and/or Slab Connection		Provide lateral shear key at substructure and slab connection.	o This is applied to all total reconstruction bridges and superstructure reconstruction bridges.

10.3 STRUCTURAL DESIGN CRITERIA

10.3.1 Design Specifications

AASHTO Standard Specifications for Highway Bridges, 15th Edition, Washington, D.C. 1992 with Interim Specifications 1993, 1994 & 1995.

The designer shall use Strength Design Method or Load Factor Design of AASHTO.

10.3.2 Design Load

1) Dead Load

a. Concrete	23.56 kN/m^3
b. Steel	76.97 kN/m^3
c. Earth	18.85 kN/m^3
d. Future Wearing Surface	1.05 kN/m^2

2) Live Load

a. Reconstructed Bridge	MS-18
b. Replaced Girder	MS-18
c. Replaced Slab	MS-18

3) Change in Temperature (Concrete Structure)

Rise	16.7°C
Fall	22.2°C

4) Earthquake Load

Seismic Design shall be as per division 1-A "Standard Specifications for Highway Bridges" AASHTO 15th Edition.

Minimum Acceleration Coefficient = 0.4
(Refer to Section 10.3.4 of this chapter)

5) Other Loads

In accordance with 1992 AASHTO Specifications with interim 1993-1995.

10.3.3 Materials

1) Concrete

Minimum compressive strength @ 28 days, f'c

Class (as per DPWH)	Use	SI metric	Remarks
A	Substructure and Superstructure	20.68 MPa	
B	Lightly Reinforced Substructure	16.50 MPa	
C	Railings/piles	20.68 MPa	
P	Prestressed Concrete	34.48 MPa	@ Service
	Prestressed Concrete	27.58 MPa	@ transfer.

2) Reinforcing Steel

i) All reinforcing steel shall be deformed bars conforming to ASTM A615 (AASHTO M31) & with the following yield stress.

Grade	Use	SI Metric
275	Stirrups, ties	275.79 MPa
415	Main reinforcement	413.69 MPa

ii) All prestressing steel shall conform to AASHTO M203 with the following yield stress.

270	Prestressing steel	1861.59 MPa

3) Elastomeric Bearing Pad

Bearing Pad shall be 60 Durometer Hardness laminated material.

10.3.4 Acceleration Coefficient For Selected Bridges

Acceleration coefficient for total reconstruction bridges was calculated using "Fukushima and Tanaka" formula which is expressed as follows:

$$\log_{10} Am = 0.41M - \log_{10}(R + 0.032 \times 10^{0.41M}) - 0.0034R + 1.30$$

where:
Am = Mean peak acceleration (cm/sec^2)
R = Shortest distance between the site and fault rupture (km)
M = Surface-wave magnitude

$A = Am/g$
A: Acceleration coefficient
g: gravity acceleration (cm/sec^2)

Philippine Fault was selected as the representative fault line of which surface-wave magnitude was assumed to be 7.3. Computed acceleration coefficient is summarized in Table 10.3-1.

TABLE 10.3-1 ACCELERATION COEFFICIENT (A) FOR TOTAL RECONSTRUCTION BRIDGES

Package No.	Bridge No.	Bridge Name	Distance To Philippine Fault	Computed "A"	Adopted "A"
2	2-05	New Camalig Br.	6	0.509	0.50
3	2-12	Guinoyoran Br.	4	0.547	0.55
4	2-21	Sanghan Br.	3	0.567	0.55
4	3-07	Ampayon Br.	4	0.547	0.55
6	4-06	Andanan Br.	6	0.509	0.50
6	4-07	Taglatawan Br.	7	0.492	0.50
9	4-24	Lagcogangan Br.	20	0.332	0.40
9	4-25	Tagbayagan Br.	21	0.323	0.40
10	4-29	Wasian Br.	19	0.342	0.40
13	5-04	Gabanan Br.	17	0.361	0.40
14	-	Monkayo Bypass Br.	16	0.372	0.40
15	5-08	Tina Br.	15	0.383	0.40
15	5-09	Banlag Br.	14	0.394	0.40
17	5-20	Liboganon Br.	23	0.307	0.40
17	-	New Gov. Miranda Br.	25	0.291	0.40
18	6-02	Ilang Br.	25	0.291	0.40

10.4 SCOPE OF WORKS FOR BRIDGES

Based on the field survey results and rehabilitation criteria, bridges were broadly classified into the following five categories:

a) Total reconstruction of an entire bridge, or new bridge along new alignment.
b) Partial Reconstruction: Superstructure.
c) Partial Reconstruction: Slab.
d) Rehabilitation other than a), b) and c).
e) Maintenance only.

Categories a) to d) are to be implemented under this project, whereas Category e) was proposed to be implemented under DPWH maintenance program.

10.4.1 Summary of Scope of Work

Scope of Work for bridges are summarized as follows (see Table 10.4-1 and Figure 10.4-1):

Category	No. of Bridges
a) Total reconstruction and new bridges	18
b) Partial reconstruction: Superstructure	24
c) Partial reconstruction: Slab	5
d) Other rehabilitation	27
Sub-total	74
e) Maintenance only	47
f) Reconstructed or being reconstructed by DPWH	6
Total	127

Table 10.4-2 shows scope of work for each bridge. Detailed description of present condition and scope of work for each bridge is presented in Appendix 10.4-1.

10.4.2 Total Reconstruction Bridges

1) Justification of Reconstruction

There are 16 total reconstruction bridges and 2 new bridges under this project. Justification and outline of new structure of these bridges are shown in Table 10.4-3.

TABLE 10.4-1 SUMMARY OF SCOPE OF WORK FOR BRIDGES

Package	Number of Existing Bridge	SCOPE OF WORK					Maintenance by DPWH	Reconstructed or being Reconstructed by DPWH
		Total Reconstruction and New Bridges	Partial Reconstruction		Other Rehabilitation	Sub-Total		
			Superstructure	Slab				
1	25	-	2 - Timamana - Magpayang II	1 - San Pedro	3 - Malico - Mabuhay - Payao	6	19	-
2	9	2 - Taytay-oyos - New Camalig	2 - Lambog - Baliguian	-	4 - Mamkas - Jaliobong - Puyo - Bangonay	8	1	-
3	9	1 - Guinoyoran	1 - Calo-oy	1 - Paypay	4 - Jagupit - Tagmamarkay - Sta. Ana - Maraput	7	2	-
4	14	2 - Sanghan - Ampayon	3 - Humilog - Panaytayon - Ngilan	-	3 - Cabadbaran - Agay - Taguibo	8	5	-
5	1	-	-	-	-	-	1	-
6	6	2 - Andanan - Taglatawan	1 - Mambutay	2 - Hupas - *Wawa*	1 - Bayanacon	6	-	-
7	8	-	6 - Sinadjap - *Bayugan Relief* - Bayugan - Maytibog - Labao - Sianib	-	-	6	1	1
8	3	-	-	-	1 - *Gibong*	1	2	-
9	7	2 - Lagcogangan - Tagbayagan	1 - Tagconayon	-	3 - Adlayan - *Bayugan II* - Anagasian	6	1	-
10	8	1 - Wasian	3 - Sulibao - Lahi - Singanan	-	2 - Boan - Ko-o	6	2	-
11	2	-	-	-	1 - Bunawan	1	1	-
12	3	-	-	-	-	-	3	-
13	6	1 - Gabanan	1 - Haguimitan	-	-	2	3	1
14	1 + 2 (New = 2)	2 - Monkayo Bypass No. 1 - Monkayo Bypass No. 2	-	-	-	2	1	-
15	8	2 - Tina - Banlag	2 - Olaycon - Tigbawan	-	-	4	3	1
16	4	-	-	-	3 - Linda - Mawab - Tagmanok	3	1	-
17	2	2 - Liboganon - New Gov. Miranda	-	-	-	2	-	-
18	6	1 - Ilang	2 - Ising - Bunawan	1 - Tuganay	-	4	1	1
19	3	-	-	-	2 - Davao River - Pangi	2	-	1
Total	125 + 2 = 127	18	24	5	27	74	47	6

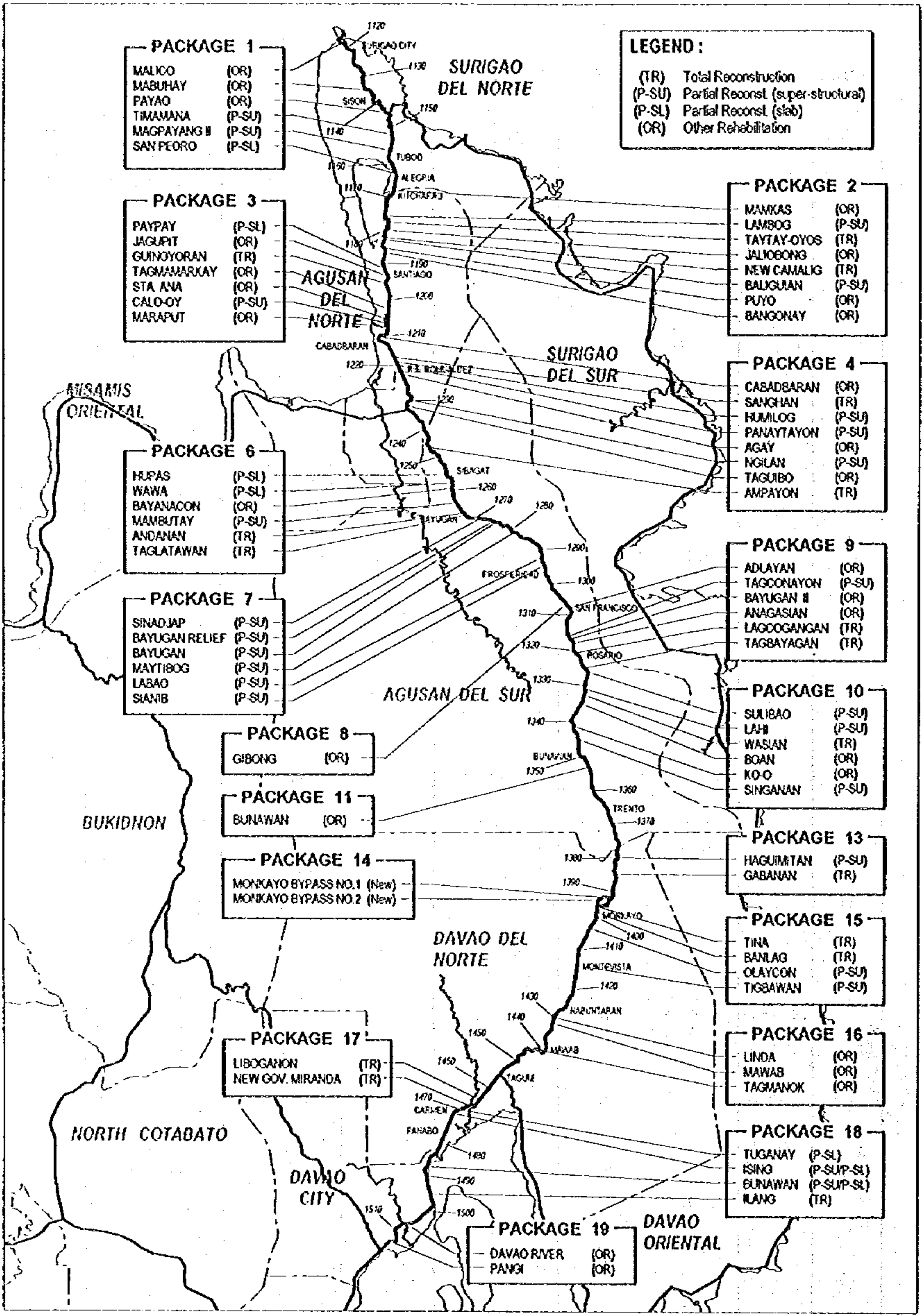


FIGURE 10.4-1 BRIDGES TO BE REHABILITATED/IMPROVED UNDER THIS PROJECT

TABLE 10.4 - 2 (1) SCOPE OF WORKS FOR EACH BRIDGE

(1/2)

REHABILITATION METHOD APPLIED	PACKAGE	1																								
	BRIDGE NUMBER	1-01	1-02	1-03	1-04	1-05	1-06	1-07	1-08	1-09	1-10	1-11	1-12	1-13	1-14	1-15	1-16	1-17	1-18	1-19	1-20	1-21	1-22	1-23	1-24	1-25
	BRIDGE NAME	Lipata	Laminlao	Kinabutan I	Kinabutan II	Malico	Cagbayoc	Reyes	Mabuhay	Payao	Timamana	Motorpool	Pingaping	Malga	Tubod	Siana	Magpayang I	Magpayang II	Pongtod	Alimpatayan	Alipao	Batoran	Candis	Togbongon	Magliaco	San Pedro
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge																									
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span										●							●								●
	3. Reconstruction of All Girders of Span										●							●								
	4. Reconstruction of Substructure																									
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge																									
	6. Widening of Sidewalk										●							●								
D. EXTENSION	7. Construction of Additional Span																									
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing																									
	9. Partial Reconstruction of Slab																									
	10. Reconstruction of Concrete Girder																									
	11. Replacement of Steel Girder / Member																									
	12. Replacement of Bearing																									
	13. Repair of Bridge Seat					●																				
	14. Reinforcement of Pier																									
	15. Reinforcement of Foundation																									
F. MINOR REPAIR	16. Repair of Slab						●	●	●			●	●	●	●	●	●		●	●		●	●	●	●	
	17. Repair of Concrete Girder						●		●			●	●	●		●	●		●		●	●		●		
	18. Repainting of Steel Girder / Member	●	●	●	●										●					●			●		●	
	19. Repair of Substructure																									
	20. Provision / Reconstruction of Slab Overlay																									
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection		●			●		●		●					●	●		●				●				
	22. Provision / Reconstruction of Abutment Slope Protection								●		●															
	23. Provision / Reconstruction of Pier Foundation Protection									●																
	24. Provision / Reconstruction of River Bank Protection								●									●								●
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection																									
	26. Provision of Approach Slab					●					●							●								
I. RIVER CONTROL	27. Provision of Spurdike																									
	28. Dredging																									●
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																									
	30. Provision of Shear Key or Slab Connection										●															
CATEGORY	Total Reconstruction																									
	Partial Reconstruction										●							●								●
	Other Rehabilitation					●			●	●																
	Maintenance	●	●	●	●		●	●				●	●	●	●	●	●		●	●	●	●	●	●	●	

REHABILITATION METHOD APPLIED	PACKAGE	2									3								
	BRIDGE NUMBER	2-01	2-02	2-03	2-04	2-05	2-06	2-07	2-08	2-09	2-10	2-11	2-12	2-13	2-14	2-15	2-16	2-17	2-18
	BRIDGE NAME	Mamkas	Lambog	Taytay-Oyos	Jaliobong	New Camalig	Baliguian	Sayadion	Puyo	Bangonay	Paypay	Jagupit	Guinoyoran	Tagmamarkay	Sta. Ana	Calo-oy	Minusuang	Marapuk	Comagascas
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge			●		●							●						
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span		●				●				●					●			
	3. Reconstruction of All Girders of Span		●				●									●			
	4. Reconstruction of Substructure																		
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge																		
	6. Widening of Sidewalk		●				●									●			
D. EXTENSION	7. Construction of Additional Span												●						
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing																		
	9. Partial Reconstruction of Slab																		
	10. Reconstruction of Concrete Girder																		
	11. Replacement of Steel Girder / Member																		
	12. Replacement of Bearing																		
	13. Repair of Bridge Seat				●														
	14. Reinforcement of Pier																		
	15. Reinforcement of Foundation																		
F. MINOR REPAIR	16. Repair of Slab	●						●									●		●
	17. Repair of Concrete Girder	●						●				●		●			●		●
	18. Repainting of Steel Girder / Member																		
	19. Repair of Substructure																		
	20. Provision / Reconstruction of Slab Overlay	●	●	●	●	●	●	●	●	●									
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection							●										●	●
	22. Provision / Reconstruction of Abutment Slope Protection		●				●			●						●			
	23. Provision / Reconstruction of Pier Foundation Protection	●							●					●				●	
	24. Provision / Reconstruction of River Bank Protection	●																	
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection				●										●				
	26. Provision of Approach Slab	●	●				●		●	●						●			
I. RIVER CONTROL	27. Provision of Spurdike																		
	28. Dredging											●			●				
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																		
	30. Provision of Shear Key or Slab Connection						●												
CATEGORY	Total Reconstruction			●		●							●						
	Partial Reconstruction		●				●				●					●			
	Other Rehabilitation	●			●				●	●		●		●	●			●	
	Maintenance							●									●		●

REHABILITATION METHOD APPLIED	PACKAGE	4														5	6				
	BRIDGE NUMBER	2-19	2-20	2-21	2-22	2-23	2-24	2-25	3-01	3-02	3-03	3-04	3-05	3-06	3-07	4-01	4-02	4-03	4-04	4-05	4-06
	BRIDGE NAME	Cabadbaran	Pandanon	Sanghan	Capudosan	Humilog	Mina-ano	Panaytayon	Agay	Minalum	Ngilan	Los Angeles	Taguibo	Dalipdipan	Ampayon	Alga	Hugas	Wawa	Bayanacon	Mambulay	Andanan
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge			●											●						●
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span					●		●			●						●	●		●	
	3. Reconstruction of All Girders of Span					●		●			●									●	
	4. Reconstruction of Substructure																				
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge																				
	6. Widening of Sidewalk					●		●			●									●	
D. EXTENSION	7. Construction of Additional Span																				
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing											(Being Reconstructed by DPWH)									
	9. Partial Reconstruction of Slab																				
	10. Reconstruction of Concrete Girder																				
	11. Replacement of Steel Girder / Member																	●			
	12. Replacement of Bearing																	●			
	13. Repair of Bridge Seat												●								
	14. Reinforcement of Pier																				
	15. Reinforcement of Foundation																				
F. MINOR REPAIR	16. Repair of Slab	●	●		●		●							●		●					
	17. Repair of Concrete Girder				●		●							●		●			●		
	18. Repainting of Steel Girder / Member									●											
	19. Repair of Substructure																				
	20. Provision / Reconstruction of Slab Overlay															●					
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection							●								●					
	22. Provision / Reconstruction of Abutment Slope Protection					●					●								●	●	
	23. Provision / Reconstruction of Pier Foundation Protection	●																●	●		
	24. Provision / Reconstruction of River Bank Protection																				
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection																				
	26. Provision of Approach Slab					●					●						●	●			
I. RIVER CONTROL	27. Provision of Spurdike																				
	28. Dredging								●												
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																				
	30. Provision of Shear Key or Slab Connection																	●			
CATEGORY	Total Reconstruction			●											●						●
	Partial Reconstruction					●		●			●						●	●		●	
	Other Rehabilitation	●							●				●						●		
	Maintenance		●		●		●			●				●		●					

TABLE 10.4 - 2 (2) SCOPE OF WORKS FOR EACH BRIDGE

(2/2)

REHABILITATION METHOD APPLIED	PACKAGE	6	7								8			9						
	BRIDGE NUMBER	4-07	4-08	4-09	4-10	4-11	4-12	4-13	4-14	4-15	4-16	4-17	4-18	4-19	4-20	4-21	4-22	4-23	4-24	4-25
	BRIDGE NAME	Tagtalawan	Sinadjap	Bayugan Relief	Bayugan	Maylibog	Labao	Panaylay	Sianib	Ava	Gibong	Palin-ay I	Palin-ay II	Hubang	Adlayan	Tagoonayan	Bayugan II	Anagasian	Lagoogangan	Tagbayagan
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge	●																	●	●
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span		●	●	●	●	●		●							●				
	3. Reconstruction of All Girders of Span		●	●	●	●	●		●							●				
	4. Reconstruction of Substructure																			
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge	●																		
	6. Widening of Sidewalk		●	●	●	●	●		●							●				
D. EXTENSION	7. Construction of Additional Span							(Reconstructed by DPWH)												
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing																			
	9. Partial Reconstruction of Slab																			
	10. Reconstruction of Concrete Girder																			
	11. Replacement of Steel Girder / Member																			
	12. Replacement of Bearing																			
	13. Repair of Bridge Seat										●									
	14. Reinforcement of Pier																			
	15. Reinforcement of Foundation																			
F. MINOR REPAIR	16. Repair of Slab											●	●	●						
	17. Repair of Concrete Girder										●	●	●	●	●		●	●		
	18. Repainting of Steel Girder / Member																			
	19. Repair of Substructure																			
	20. Provision / Reconstruction of Slab Overlay															●	●	●		
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection																			
	22. Provision / Reconstruction of Abutment Slope Protection		●	●	●	●	●		●						●	●				
	23. Provision / Reconstruction of Pier Foundation Protection		●		●	●									●		●	●		
	24. Provision / Reconstruction of River Bank Protection					●									●					
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection																			
	26. Provision of Approach Slab		●	●	●	●			●							●	●	●		
I. RIVER CONTROL	27. Provision of Spurdike																			
	28. Dredging					●	●													
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																			
	30. Provision of Shear Key or Slab Connection		●	●	●	●				●						●				
CATEGORY	Total Reconstruction	●																	●	●
	Partial Reconstruction		●	●	●	●	●		●							●				
	Other Rehabilitation										●				●		●	●		
	Maintenance									●		●	●	●						

REHABILITATION METHOD APPLIED	PACKAGE	10								11		12			13					
	BRIDGE NUMBER	4-26	4-27	4-28	4-29	4-30	4-31	4-32	4-33	4-34	4-35	4-36	4-37	4-38	5-01	5-02	5-03	5-04	5-05	5-06
	BRIDGE NAME	Sulibao	Padigusan	Labi	Wasian	Boan	Bayugan III	Ko-o	Singahan	Bunawan	Simulao	Magalibobo	Onoman	Langkilaan	Maltum	Pasian	Haguimitan	Gabanan	Buay	Libodon
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge				●													●		
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span	●		●					●								●			
	3. Reconstruction of All Girders of Span	●		●					●								●			
	4. Reconstruction of Substructure																			
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge																			
	6. Widening of Sidewalk	●		●					●								●			
D. EXTENSION	7. Construction of Additional Span																		(Reconstructed by DPWK)	
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing																			
	9. Partial Reconstruction of Slab																			
	10. Reconstruction of Concrete Girder																			
	11. Replacement of Steel Girder / Member																			
	12. Replacement of Bearing																			
	13. Repair of Bridge Seat																			
	14. Reinforcement of Pier																			
	15. Reinforcement of Foundation																			
F. MINOR REPAIR	16. Repair of Slab		●				●								●					●
	17. Repair of Concrete Girder	●	●				●	●		●					●					●
	18. Repainting of Steel Girder / Member																			
	19. Repair of Substructure																			
	20. Provision / Reconstruction of Slab Overlay	●	●	●		●	●	●	●	●	●				●	●	●	●		●
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection													●						
	22. Provision / Reconstruction of Abutment Slope Protection			●		●		●	●								●			
	23. Provision / Reconstruction of Pier Foundation Protection							●												
	24. Provision / Reconstruction of River Bank Protection					●														
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection																			
	26. Provision of Approach Slab	●		●		●		●	●	●							●			
I. RIVER CONTROL	27. Provision of Spurdike																			
	28. Dredging																			
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																			
	30. Provision of Shear Key or Slab Connection	●		●					●								●			
CATEGORY	Total Reconstruction				●													●		
	Partial Reconstruction	●		●					●								●			
	Other Rehabilitation					●		●		●										
	Maintenance		●				●				●	●	●	●	●	●				●

REHABILITATION METHOD APPLIED	PACKAGE	14	15								16				17		18						19			TOTAL
	BRIDGE NUMBER	5-07	5-08	5-09	5-10	5-11	5-12	5-13	5-14	5-15	5-16	5-17	5-18	5-19	5-20	5-21	5-22	5-23	5-24	6-01	6-02	6-03	6-04	6-05	6-06	
	BRIDGE NAME	Kalaw	Tina	Banlag	Olaycon	Bankerohan	Gujon	Tigbewan	Casangay	Nabuntaran	Pongliod	Linda	Mawab	Tagnanock	Liboganon	Gov. Miranda	Tuganay	Ising	Lasang	Bunawan	Ilang	Awad	Panacan	Davao River	Pangi	
A. TOTAL RECONSTRUCTION	1. Total Reconstruction of Bridge		●	●											●						●					15
B. PARTIAL RECONSTRUCTION	2. Reconstruction of Entire Slab of Span				●			●									●	●		●						29
	3. Reconstruction of All Girders of Span				●			●										●		●						24
	4. Reconstruction of Substructure																									0
C. WIDENING	5. Widening of Carriageway or Const. of Additional Bridge																				●					2
	6. Widening of Sidewalk				●			●																		22
D. EXTENSION	7. Construction of Additional Span									(Being widened to 4-Lane by DPWH)						(to be removed)						(Converted to RCBC by DPWH)	(Widened to 4-Lane by DPWH)			1
E. MAJOR REPAIR	8. Partial or Total Reconstruction of Railing																●									1
	9. Partial Reconstruction of Slab																									0
	10. Reconstruction of Concrete Girder																									0
	11. Replacement of Steel Girder / Member																									1
	12. Replacement of Bearing																									1
	13. Repair of Bridge Seat												●													5
	14. Reinforcement of Pier																									0
	15. Reinforcement of Foundation																									0
F. MINOR REPAIR	16. Repair of Slab	●				●	●		●		●															37
	17. Repair of Concrete Girder					●	●		●		●	●	●	●					●							44
	18. Repainting of Steel Girder / Member	●																								10
	19. Repair of Substructure																									0
	20. Provision / Reconstruction of Slab Overlay				●	●	●	●	●		●	●	●	●												36
G. PROTECTION FROM SCOUR	21. Repair of Abutment Slope Protection																									14
	22. Provision / Reconstruction of Abutment Slope Protection				●			●					●					●		●						28
	23. Provision / Reconstruction of Pier Foundation Protection											●		●										●	●	19
	24. Provision / Reconstruction of River Bank Protection				●								●													9
H. APPROACH ROAD PROTECTION	25. Provision/ Reconst. of Approach Road Embank. Slope Protection				●																					3
	26. Provision of Approach Slab							●										●		●						31
I. RIVER CONTROL	27. Provision of Spurdike																									0
	28. Dredging				●																					7
J. ASEISMATIC PROTECTION	29. Widening of Bridge Seat																									0
	30. Provision of Shear Key or Slab Connection				●																					14
CATEGORY	Total Reconstruction		●	●											●						●					15
	Partial Reconstruction				●			●									●	●		●						29
	Other Rehabilitation											●	●	●										●	●	27
	Maintenance	●				●	●		●		●								●							47

TABLE 10.4-3 JUSTIFICATION AND OUTLINE OF NEW STRUCTURE OF TOTAL RECONSTRUCTION AND NEW BRIDGES

(1/2)

Package No.	Bridge No., Name and Existing Structure	Justification of Reconstruction	Outline of New Structure
2	2-03 **Taytay-Oyos** 1-span RCDG with cantilever spans (L=3.4+14.0+3.4 = 20.8m)	• Located at sharp curve, but without proper superelevation and pavement widening, thus traffic accident prone. Needs to be widened. • Wide shear cracks at girders.	• Converted to RCBC 2-barrel RCBC (L=2x6.5 = 13.0m)
	2-05 **New Camalig** 3-span RCDG (L=3x14.0 = 42.0m)	• Located at sharp curve, but without proper superelevation and pavement widening. Needs to be widened. • Severe spalling at girders, thus main rebars exposed and corroded. Spalling will further develop to other areas of girders.	• 3-span RCDG (L=3x16.0 = 48.0m)
3	2-12 **Guinoyoran** 1-span RCDG with cantilever span (L=3.5+14.0+3.5 = 21.0m)	• Wide shear cracks at girders. • River oftenly changes its course, scouring bridge approach. • Too short in length, clogging the river. Needs to be extended.	• 2-span PCDG (L=2x22.25 = 44.5m)
4	2-21 **Sanghan** 2-span RCDG (L=2x12.0 = 24.0m)	• Wide shear cracks at girders. • Wide cracks at bridge seat. • Warning sign as "weak bridge" has been installed.	• 1-span PCDG (L=26.1m)
	3-07 **Ampayon** 2-span Precast Slab (L=2x6.0 = 12.0m)	• Precast slab seriously deteriorated with holes, though recurrently repaired. • A lot of pedestrians due to bus terminal located near the bridge. Widening of sidewalks needed.	• 1-span PCDG (L=22.0m)
6	4-06 **Andanan** 12-span RCDG (L=12x15.0 = 180.0m)	• Wide shear cracks at girders. • The river is meandered and changed its direction of flow by about 60 degrees in the past 38 years. Thus, waterflow hits piers at an acute angle, causing heavy scouring.	7-span PCDG (L=7x25.7 = 179.9m)
	4-07 **Taglatawan** 3-span RCDG (L=8.0+10.0+8.0=26.0m)	• Wide shear cracks at girders. • Located at urban center of Bayugan. A lot of local traffic such as pedicabs, tricycle and pedestrians. Needs to be widened to a 4-lane bridge.	1-span PCDG (4-lane) (L=22.1m)
9	4-24 **Lagcogangan** 2-span RC Slab 1-span RCDG (L=6.0+10.0+6.0=22.0m)	• Abutment settled excessively due to soft ground. • Piers settled and tilted. • Medium cracks at girdes.	1-span PCDG (L=21.3m)
	4-25 **Tagbayagan** 3-span RCDG (L=3x10.0 = 30.0m)	• Piers have differential settlement. Bridge seat of P2 has been widened towards span 3 due to tilting of pier. • Wide cracks at girders.	1-span PCDG (L=25.3m)

TABLE 10.4-3 JUSTIFICATION AND OUTLINE OF NEW STRUCTURE OF TOTAL RECONSTRUCTION AND NEW BRIDGES

(2/2)

Package No.	Bridge No., Name and Existing Structure	Justification of Reconstruction	Outline of New Structure
10	4-29 Wasian 2-span RC Slab 1-span RCDG (L=6.0+10.0+6.0=22.0m)	• Abutments settled due to soft ground. • Medium cracks at girders.	1-span PCDG (L=25.3m)
13	5-04 Gabanan 3-span RCDG (L=3x15.0 = 45.0m)	• Serious wide cracks at girders. • Bridge is located at stream bend causing deep scouring.	2-span PCDG (L=2x26.5 = 53.0m)
14	Monkayo Bypass No. 1	• New bridge along new alignment (Monkayo Bypass)	3-span PCDG (L=3x20.5 = 61.5m)
	Monkayo Bypass No. 2	• New bridge along new alignment (Monkayo) over Agusan River.	4-span PCDG (L=4x36.6 = 146.4m)
15	5-08 Tina 3-span RCDG (L=9.7+11.9+9.7=31.3m)	• Submerged during heavy rain. Bridge elevation needs to be raised.	1-span PCDG (L=31.3m)
	5-09 Banlag 3-span RCDG (L=6.0+15.0+6.0=27.0m)	• Submerged during heavy rain. Bridge elevation needs to be raised.	1-span PCDG (L=31.3m)
17	5-20 Liboganon 3-span RCDG (L=10.0+12.0+10.0 = 32.0m)	• Load limit of 10 tons imposed. • Serious wide cracks at girders. • Temporary shoring provided at 2 piers.	1-span PCDG (L=31.3m)
	5-21 Gov. Miranda 2-span RC Box Girder 2-span Through Truss (L=23.15+2x49.6+ 23.15 = 145.5m)	• Upon completion of dikes, approaches of this bridge will be submerged during heavy rains. • New bridge spanning dikes was planned to replace this bridge as a part of Liboganon River Flood Control.	18-span PCDG (L=18x36.1 = 649.8m)
18	6-02 Ilang 2-span RCDG (L=12.0+6.0 = 18.0m)	• Approach road of Davao City side (2nd approach) has been widened to 4-lane. • Heavy traffic. • Needs to be widened to a 4-lane bridge.	1-span PCDG (4-lane) (L=22.3m)

2) Alternative Study of Bridge Type

Alternative study of bridge type was undertaken for the following major bridges:

• Andanan Bridge	(Bridge Length = 180m)
• Monkayo Bypass No. 2 Bridge	(Bridge Length = 146m)
• New Gov. Miranda Bridge	(Bridge Length = 650m)

Other bridges for total reconstruction or new construction are 1 to 3-span bridges with bridge length less than 60 meters, therefore, the alternative study was not needed and commonly adopted type in the Philippines was selected for each bridge.

ANDANAN BRIDGE

Andanan Bridge has a good foundation or bearing layer at a depth of about 14-20 meters. Prestressed concrete or RC piles of this length usually allow economical short PCDG spans.

Peak discharge is estimated to be 417 m^3/sec.. Maximum high water level is estimated to be 21.0m in elevation and average water depth is about 2.5 meters. It is also observed that coconut logs of 10 to 15m flowed down the river. Minimum span length computed based on the following formula requires 22 meters:

$L = 20 + 0.005Q$.....(a)

where:

L = Minimum span length in meter

Q = Peak discharge (m^3/sec.)

In view of above, the following alternative schemes were prepared for comparison:

Scheme 1 : *Span length = 20m*
Number of spans = 9
Type of Superstructure: PCDG

Scheme 2 : Span length = 22.5m
Number of spans = 8
Type of Superstructure: PCDG

Scheme 3 : Span length = 25.7m
Number of spans = 7
Type of Superstructure: PCDG

Figure 10.4-2 shows a comparison of three schemes. Results of comparison can be summarized as follows:

- With regard to construction cost, there is practically no difference in three schemes.
- Scheme 3 is advantageous in terms of construction period and minimum disturbance to river flow.
- Three schemes have almost same standard for all other conditions.

Scheme 3 was recommended for this bridge.

MONKAYO BYPASS NO. 2 BRIDGE

This bridge is to be constructed over Agusan River. This river has narrow and meandering Section at about 1 to 2 km. downstream from this bridge site, which is considered to be a bottle neck of the river. Due to small discharge capacity at this bottle neck section, water level goes up at the bridge site and Monkayo Town Proper. Thus, velocity of water flow is not so high at the bridge site.

Peak discharge was estimated to be 2,900 m^3/sec. and maximum high water level to be 51.0m in elevation. To accomodate the said discharge, bridge length is required to be 146m. Width of ordinary waterway is about 60m. Minimum span length computed based on the formula (a) is 34.5m.

The bridge site has good foundation at a shallow depth. Pile length varies from 6 to 12 meters.

Three alternative schemes were developed mainly focusing on how to cross over the main channel (or low plain water) where water always flows.

Scheme 1 : 3 - span PCDG (3 x 34.9) at center portion
2 - span PCDG (20.7 x 2) at both sides
4 piers

Scheme 2 : 36.4m - span PCDG at center
2 - span PCDG (2 x 27.55) at each side span
4 piers

Scheme 3 : 4 - span PCDG (4 x 36.5)
3 piers

FIGURE 10.4-2 ALTERNATIVE SCHEMES FOR ANDANAN BRIDGE

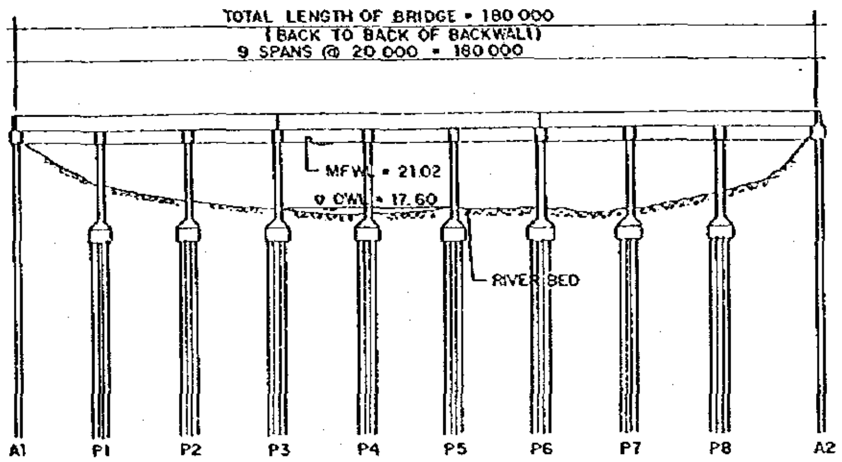
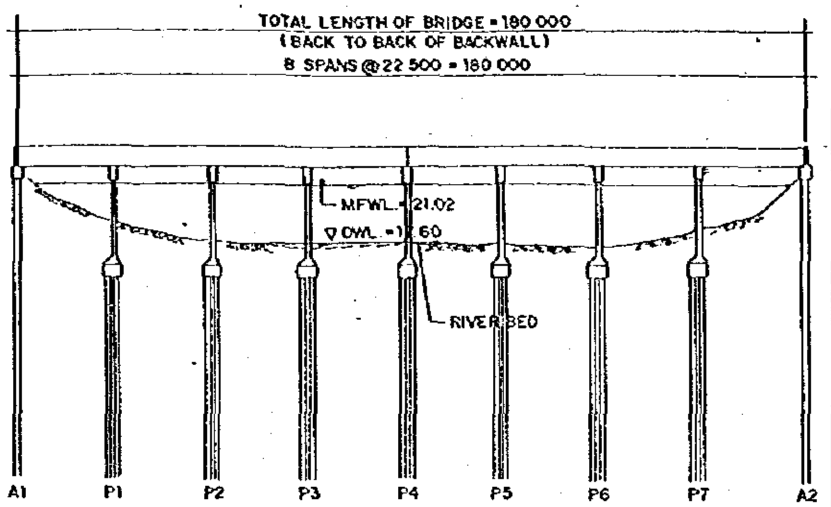
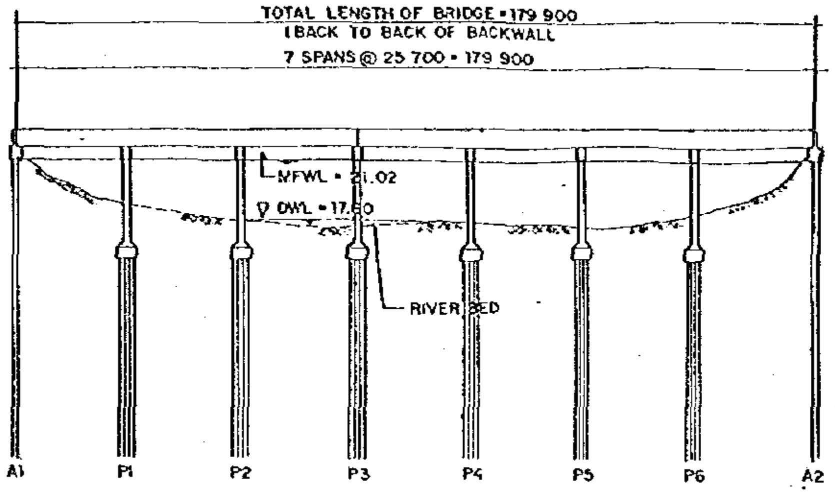
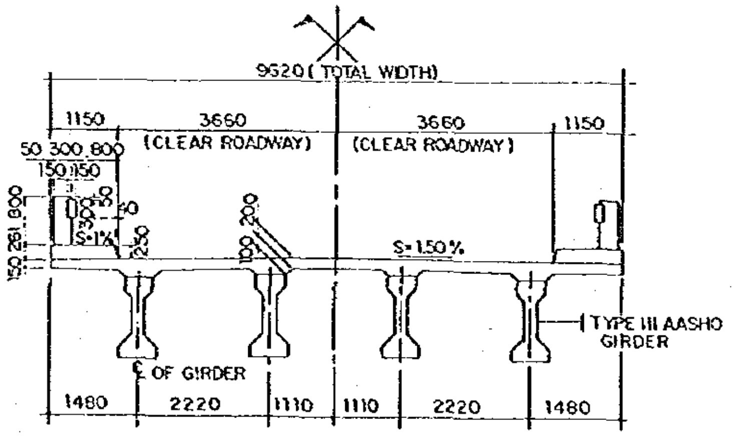
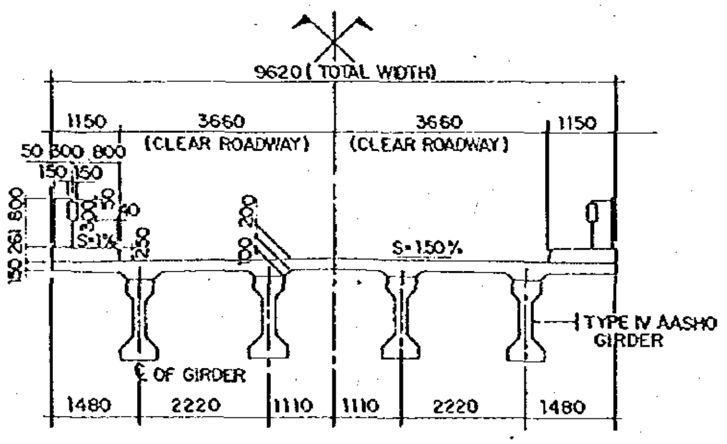
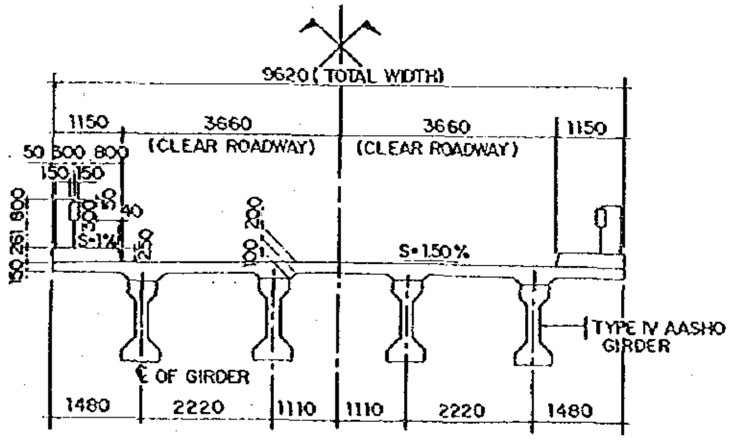
SCHEME	1	2	3
BRIDGE ELEVATION	PCDG TYPE III BRIDGE  	PCDG TYPE IV BRIDGE  	PCDG TYPE IV BRIDGE 
SUPERSTRUCTURE CROSS - SECTION	 TYPICAL CROSS SECTION	 TYPICAL CROSS SECTION	 TYPICAL CROSS SECTION
CONSTRUCTION COST (₱)	**42,700,000** NOTE: (CONSTRUCTION COST DOES NOT INCLUDE POST & RAILINGS, TEMPORARY JETTY, ABUTMENTS, ETC.)	**41,700,000**	**38,400,000**
%	**111**	**109**	**100**
REMARKS	ADVANTAGES: 1. PCDG BEAMS ARE EASY TO PRECAST, TRANSPORT AND ERECT BECAUSE OF THEIR SHORT LENGTH (20.0m.) DISADVANTAGES: 1. PROVIDES MOST COSTLY SCHEME, ALTHOUGH COST DIFFERENCE IS SMALL. 2. PIERS MOST CLOSELY SPACE, SCOUR PRONE. 3. LONGEST CONSTRUCTION PERIOD WITH MOST NUMBER OF PIERS.	ADVANTAGES: 1. PROVIDES LEAST COSTLY SCHEME BUT COST CLOSE TO SCHEME 3. 2. PCDG BEAMS (22.5m. LENGTH) EASY TO PRECAST AT THE SITE AND TO ERECT. DISADVANTAGES: 1. INTERMEDIATE CONSTRUCTION PERIOD (7 PIERS) 2. INTERMEDIATE SCOUR OF MEANDERING RIVER.	ADVANTAGES: 1. COST IS COMPARABLE TO SCHEME 2. 2. SHORTEST CONSTRUCTION PERIOD WITH LEAST NUMBER OF PIERS (6). 3. EASY ERECTION OF 25.7 m. LENGTH PCDG FROM RIVER BED HELPED BY RELATIVELY DRY RIVER BED. 4. LESS PIERS MEANS LESS SCOUR. SITE IS VERY SCOUR PRONE DUE TO MEANDERING STREAM.
ADOPTED SCHEME	NOT RECOMMENDED.	NOT RECOMMENDED	RECOMMENDED

Figure 10.4-3 shows comparison of three schemes. Results of comparison can be summarized as follows:

- With regard to construction cost, Scheme 3 is most advantageous.
- Less number of piers is preferred in consideration of construction period and disturbance to water flow. Thus, Scheme 3 is the most preferred one among three.
- With regard to other conditions, three Schemes have little difference.

Scheme 3 was recommended for this bridge

NEW GOV. MIRANDA BRIDGE

Peak discharge of Liboganon River was estimated to be 2,489 m^3/sec. The minimum distance from bank to bank (or minimum river width) at the bridge site was computed to be 650 meters and maximum high water level to be 5.0m in elevation. The width of ordinary water channel (or low water plain) is about 70 meters. Minimum span length computed based on formula the (a) is 32.5 meters.

The subsurface soil condition at this site is not good. Boring results show that even at a depth of 50 meter, no hard or bearing layer was confirmed, thus introduction of friction pile is required.

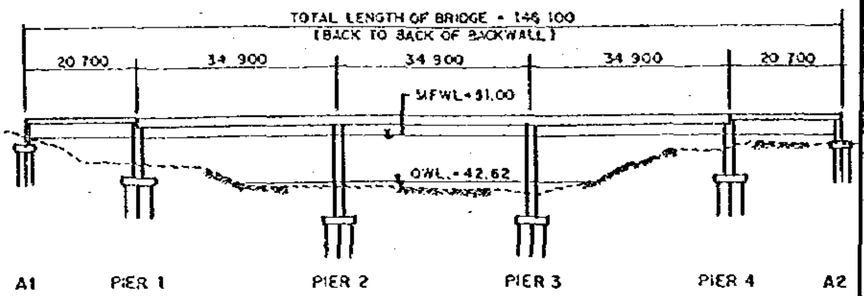
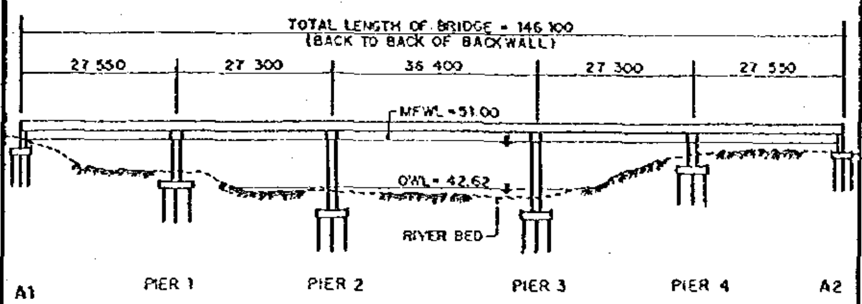
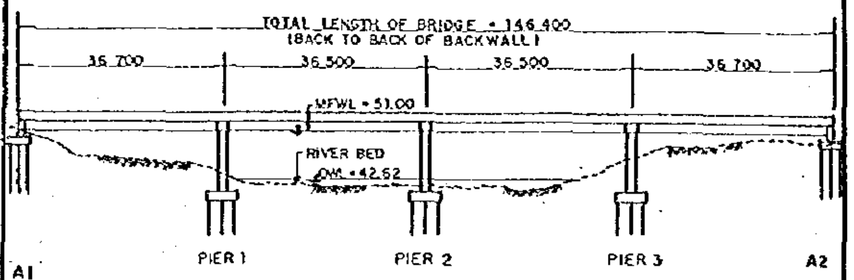
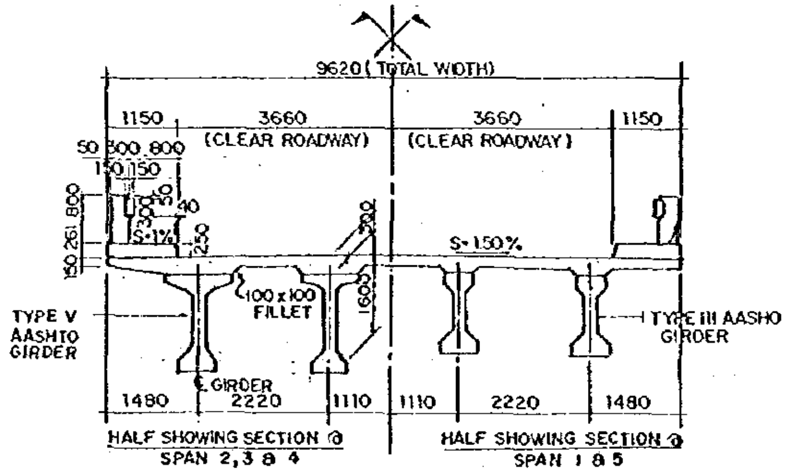
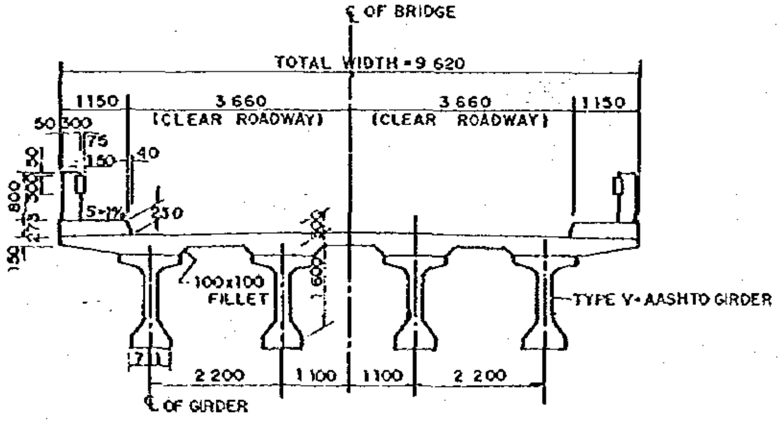
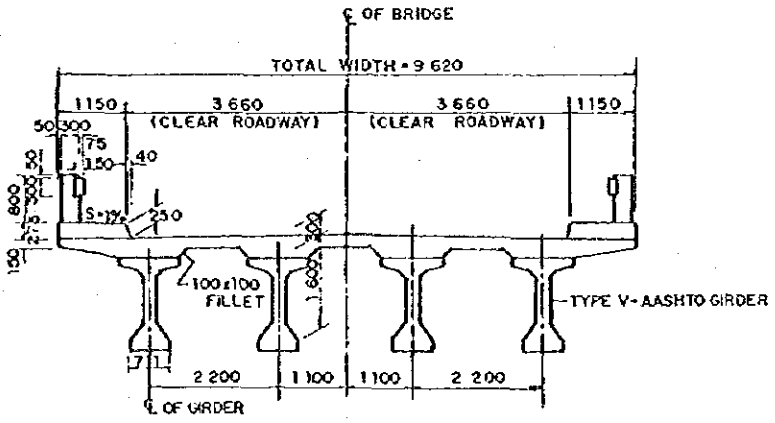
Under above circumstances, longer span length is preferred and following four alternative schemes were prepared for comparison.

Scheme 1 : 18 - span PCDG (18 x 36.11)
No. of piers = 17
No. of piers at ordinary water channel = 2

Scheme 2 : 16 - span PCDG (16 x 40.63)
No. of piers = 15
No. of piers at ordinary water channel = 2

Scheme 3 : 14 - span PCDG (14 x 46.40)
No. of piers = 13
No. of piers at ordinary water channel = 2

FIGURE 10.4-3 ALTERNATIVE SCHEMES FOR MONKAYO BYPASS 2 BRIDGE

SCHEME	1	2	3
BRIDGE ELEVATION	COMBINATION OF PCOG TYPE III & TYPE V BRIDGE 	PCOG TYPE V BRIDGE 	PCOG TYPE V BRIDGE 
SUPERSTRUCTURE CROSS - SECTION			
CONSTRUCTION COST (₱)	29,300,000 NOTE: (CONSTRUCTION COST DOES NOT INCLUDE POST & RAILINGS, TEMPORARY JETTY, ABUTMENT, ETC.)	30,100,000	26,600,000
%	110	113	100
REMARKS	ADVANTAGES: 1. CENTER PIERS ARE EASILY CONSTRUCTED WITH SAND ISLANDS AT THE EDGE OF WATER TO PROVIDE ACCESS TO FOOTING FOUNDATION CONSTRUCTION. DISADVANTAGES: 1. TWO CENTER PIERS OCCURS IN NORMAL RIVER CHANNEL. 2. MORE PIERS (4) CAUSE MORE OBSTRUCTION TO RIVER FLOW AND THUS MORE SCOUR THAN ONLY THREE (3) PIERS.	ADVANTAGES: 1. CENTER PIERS ARE EASILY CONSTRUCTED WITH SAND ISLANDS AT THE EDGE OF WATER TO PROVIDE ACCESS TO FOOTING FOUNDATION CONSTRUCTION. 2. SHORT END SPANS MAKE SINGLE 36.4 m. CENTER SPAN EASIER TO ERECT BY LIFTING AT EACH END FROM SHORT SPAN DECK. DISADVANTAGES: 1. TWO CENTER PIERS OCCUR IN NORMAL RIVER CHANNEL. 2. MORE PIERS (4) CAUSE MORE OBSTRUCTION TO RIVER FLOW AND THUS MORE SCOUR.	ADVANTAGES: 1. ONLY ONE CENTER PIER OCCURS IN NORMAL RIVER CHANNEL. 2. LEAST PIERS (3) MAKE SUBSTRUCTURES EASIEST TO CONSTRUCT AND CUTS CONSTRUCTION TIME. 3. LEAST PIERS (3) LESS OBSTRUCTION OF RIVER FLOW AND THUS LEAST SCOUR. 4. ALL BEAMS HAVE SAME LENGTH AND MAYBE CAST ON SITE WITH SAME FORMWORK AND SAME PRESTRESSING.
ADOPTED SCHEME	NOT RECOMMENDED	NOT RECOMMENDED	RECOMMENDED

Scheme 4 : 14 - span Steel Plate Girder (14 x 46.4)
No. of piers = 13
No. of piers at ordinary water channel = 2

Figure 10.4-4 shows comparison of four schemes. Results of comparison can be summarized as follows:

- In terms of construction cost, all PCDG schemes were estimated to be almost the same. Steel plate girder scheme is high in cost.
- In terms of difficulty of construction, schemes 2 and 3 are not preferred, as difficult construction at the ordinary water channel is expected.
- Scheme 1 will disturb water flow the most among alternative schemes, however, span length is more than required minimum length, therefore, no serious problem is expected.
- Overall evaluation shows that scheme 1 is the most preferred scheme.

It was recommended that Scheme 1 be adopted for this bridge.

3) Design of Total Reconstruction/New Bridges

Detailed discussions on how bridge length, type of foundation, etc. were decided are presented in Appendix 10.4-2.

FIGURE 10.4-4 ALTERNATIVE SCHEMES FOR GOVERNOR MIRANDA BRIDGE (1/2)

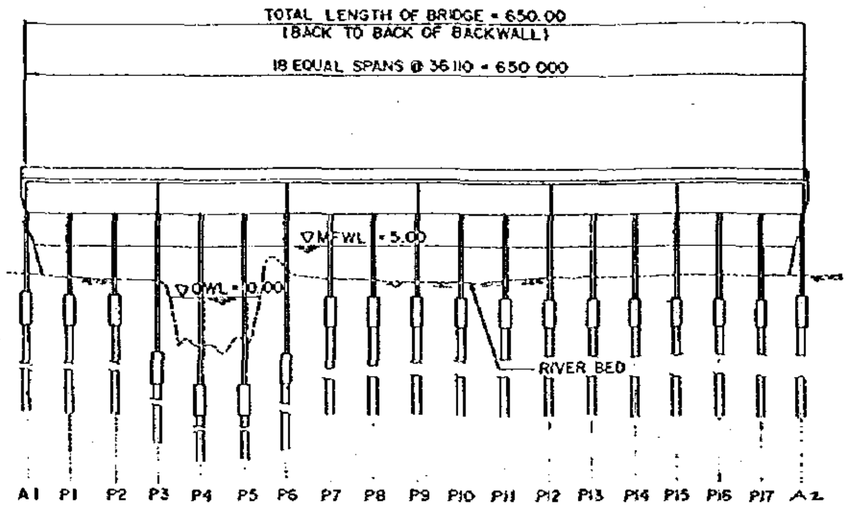
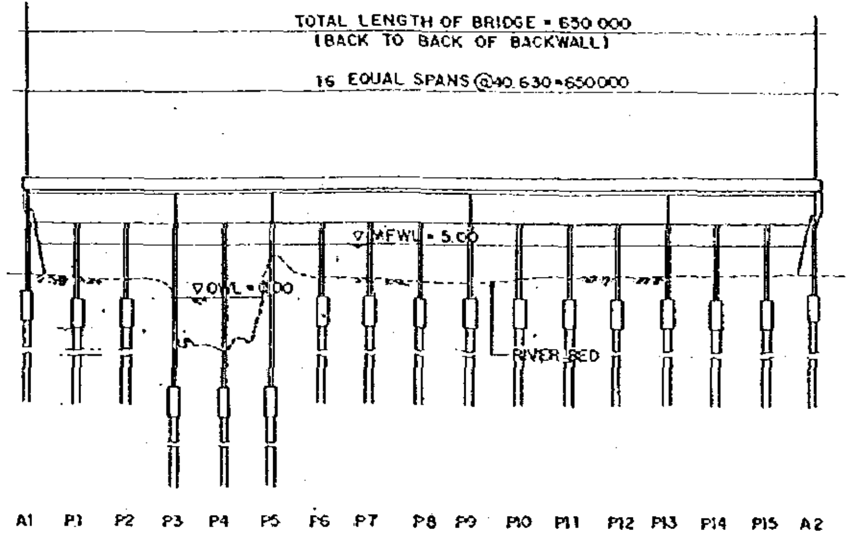
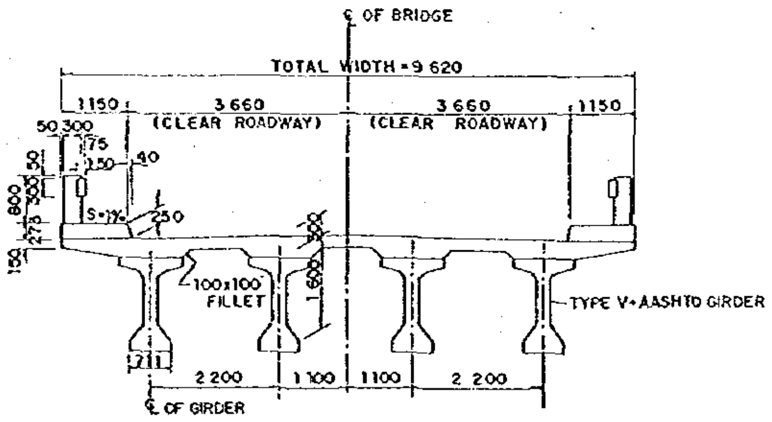
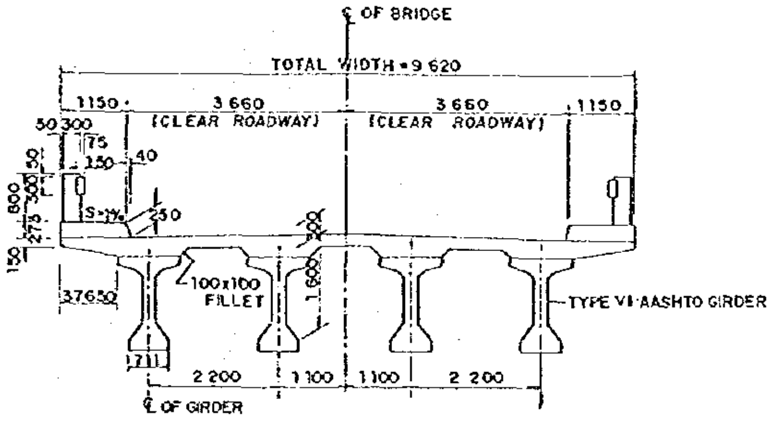
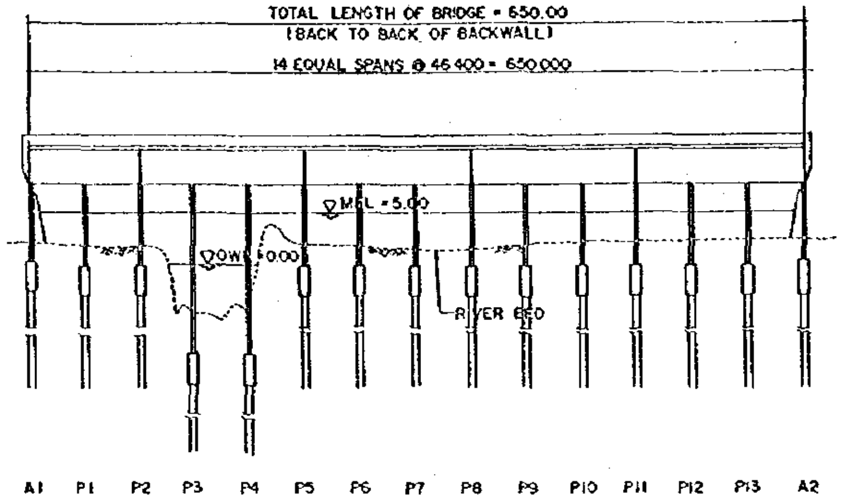
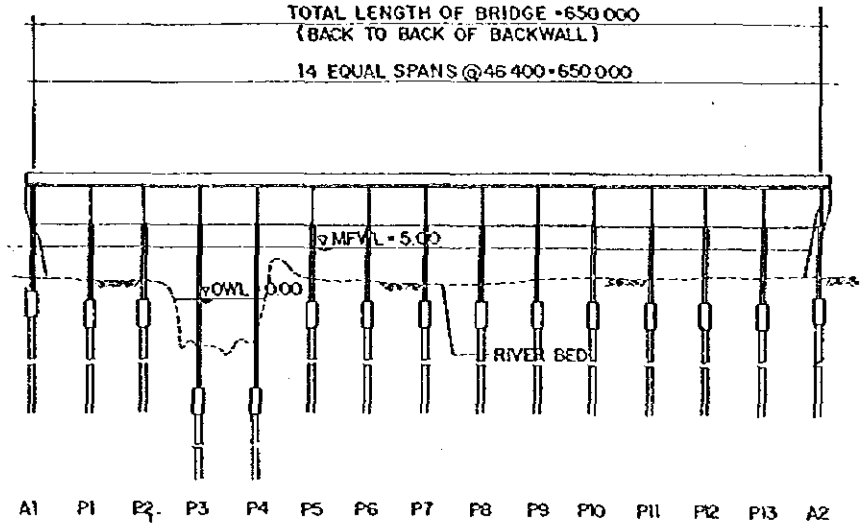
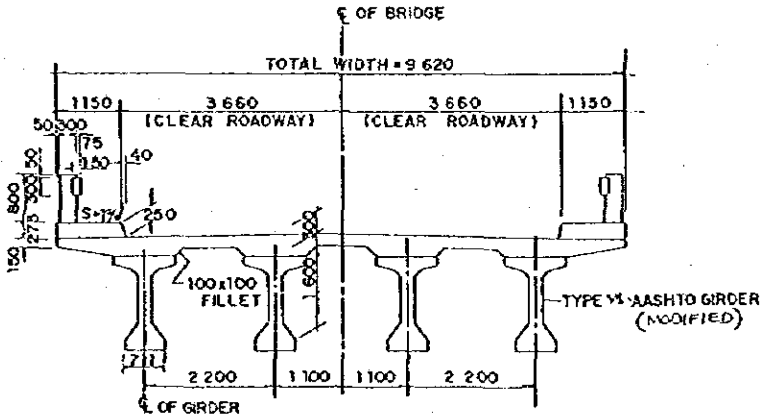
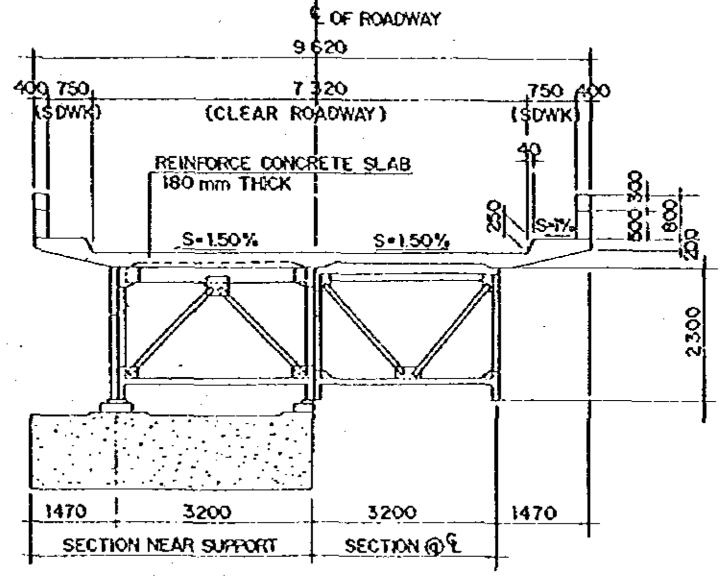
SCHEME	1	2
BRIDGE ELEVATION	PCDG TYPE V BRIDGE 	PCDG TYPE VI BRIDGE 
SUPERSTRUCTURE CROSS - SECTION		
CONSTRUCTION COST (₱)	141,400,000 NOTE: (CONSTRUCTION COST NOT INCLUDE POST AND RAILINGS, TEMPORARY JETTY, ABUTMENT, ETC.)	146,700,000
%	100	104
REMARKS	ADVANTAGES : 1. PROVIDES COMPETITIVE COSTWISE. 2. SHORT SPANS ARE EASY TO FABRICATE & EASIEST TO ERECT SUPERSTRUCTURES. 3. ONLY TWO (2) PIERS ON RIVER STREAM AT NORMAL WATER LEVEL. DISADVANTAGES : 1. PIERS UNDER ORDINARY WATER LEVEL IS DIFFICULT TO CONSTRUCT. 2. MOST PIERS (17) LENGTHENS CONSTRUCTION PERIOD AND OBSTRUCT STREAM FLOW THE MOST.	ADVANTAGES : 1. COST IS COMPARABLE TO OTHER SCHEME. DISADVANTAGES : 1. PCDG BEAMS ARE LONG & DIFFICULT FOR ERECTION. 2. THREE (3) PIERS ARE ERECTED IN THE STREAM COMPARED TO TWO (2) IN SCHEME 1.
ADOPTED SCHEME	RECOMMENDED	NOT RECOMMENDED

FIGURE 10.4-4 ALTERNATIVE SCHEMES FOR GOVERNOR MIRANDA BRIDGE (2/2)

SCHEME	3	4
BRIDGE ELEVATION	PCDG TYPE VI BRIDGE  	STEEL PLATE GIRDER BRIDGE 
SUPERSTRUCTURE CROSS - SECTION	 	
CONSTRUCTION COST (₱)	**142,800,000**	**157,600,000**
%	**101**	**112**
REMARKS	ADVANTAGES : 1. LEAST NUMBER OF PIERS (13) MAKES CONSTRUCTION OF SUBSTRUCTURES SHORTEST. 2. LEAST PIERS MEANS LEAST DISTURBANCE TO WATER FLOW AND LEAST SCOUR. DISADVANTAGES: 1. MORE COST THAN SCHEME 1 2. LONG PCDG BEAMS, DIFFICULT FOR ERECTION.	ADVANTAGES: 1. FEWER NUMBER OF PIERS (13) AND LEAST DISTURBANCE TO WATER FLOW. 2. EASIEST TO ERECT BECAUSE OF LIGHTWEIGHT. DISADVANTAGES: 1. MATERIAL MUST BE IMPORTED MEANING LONG LEAD TIME AND PAID FOR IN FOREIGN CURRENCY THUS INCREASING FOREIGN COST OF THE PROJECT. 2. STEEL BRIDGE REQUIRE MORE MAINTENANCE AND FREQUENT PAINTING. 3. STEEL CORRODES IF NOT PROPERLY MAINTAINED. 4. MOST EXPENSIVE SCHEME.
ADOPTED SCHEME	NOT RECOMMENDED	NOT RECOMMENDED

10.4.3 Partial Reconstruction Bridges

a) Superstructure Reconstruction

As the existing substructures and foundations are to be utilized, the same type of superstructure was selected. Necessary measures to increase seismic resistance or to prevent girders to fall down during earthquake such as longitudinal/transverse shear keys at bridge seats and/or slab connection between spans were incorporated in the design.

b) *Slab Reconstruction*

Slab reconstruction was proposed only for the steel bridges. Thicker slab depth than the existing was adopted. Maximum spacing of main rebar was selected not to exceed slab thickness. Detour road was proposed during slab reconstruction for the most bridges except long bridges for which detour road construction cannot be economically justified.

10.4.4 Other Rehabilitation Bridges

Most commonly required rehabilitation works are as follows:

- Pier foundation protection
- Abutment slope protection
- River bank protection

DPWH can implement these rehabilitation works for the bridges located in Priority Packages C and D, as implementation under this project is scheduled after year 2000.

CHAPTER 11

SLOPE PROTECTION

11.1 DESIGN CRITERIA

11.1.1 Basic Policies

Following basic policies were established:

- Slopes not only failed but also with high potential shall be protected. (Low potential slopes are excluded from the project because of low possibility of occurrence and low impact on road traffic, even if it occurs).
- Protection works shall be selected in due analysis of causes of failure and recurrence of failure shall be eliminated.
- Emphasis shall be placed on the drainage of surface and underground water.
- Protection works shall be so selected that environment can be preserved.
- Maximum utilization of locally available materials shall be planned.

11.1.2 Design Standards

Detailed design was based on and referenced to the following guidelines:

- Design Guidelines, Criteria and Standards, BOD, DPWH
- Guidelines for Slope Protection and Stability Works,
  Japan Road Association

11.1.3 Design Policies

In order to prepare effective but economical designs, the following basic policies/guidelines were established:

- No unsupported fill slopes in excess of 1.5:1 shall be built.
- Concrete retaining structures shall be minimized.
- Riprap structures are used only as surface armouring.
- Vegetation shall be used as much as possible for surface protection.
- Surface run-off water shall be controlled so as to eliminate erosion of the structures.
- Slopes shall be designed for a safety factor of 1.2 under normal conditions.

11.1.4 Generally Applicable Protection Works

Type of protection work must be selected in due consideration of causes as well as type of slope failure. Table 11.1-1 shows slope protection works generally applicable to each type of slope failure by cause.

TABLE 11.1-1(1) GENERALLY APPLICABLE SLOPE PROTECTION WORKS TO EACH TYPE OF SLOPE FAILURE

(1/4)

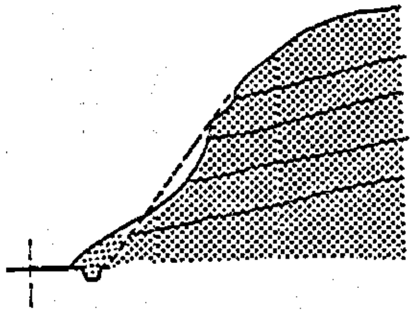
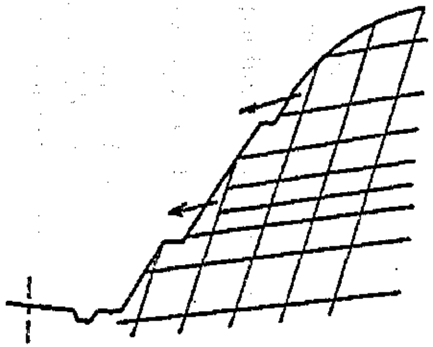
TYPE OF DISASTER	CAUSE OF DISASTER	ILLUSTRATION	APPLICABLE WORKS
CUT SLOPE FAILURE	Failure of highly weathered layer due to drying up or erosion by surface water.		a) Re-cutting with stable gradient b) Protection works: - Concrete spraying - Concrete crib - Anchor work - Wattling c) Catch Work: - Concrete catch wall
	Failure of slope due to developed cracks.		a) Recutting with stable gradient b) Protection Works: - Concrete spraying - Concrete crib - Anchor work c) Catch Work: - Concrete catch wall

TABLE 11.1-1(2) GENERALLY APPLICABLE SLOPE PROTECTION WORKS TO EACH TYPE OF SLOPE FAILURE

(2/4)

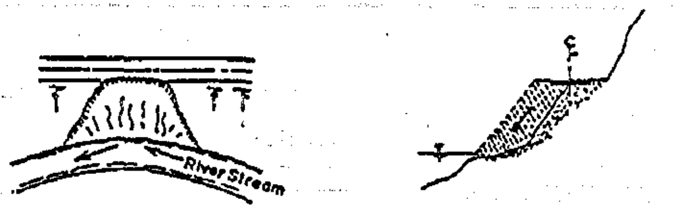
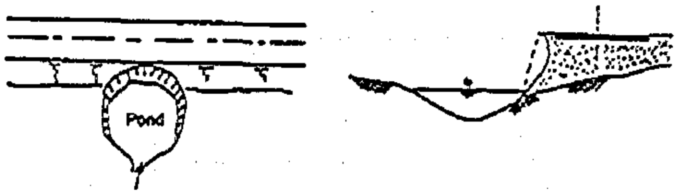
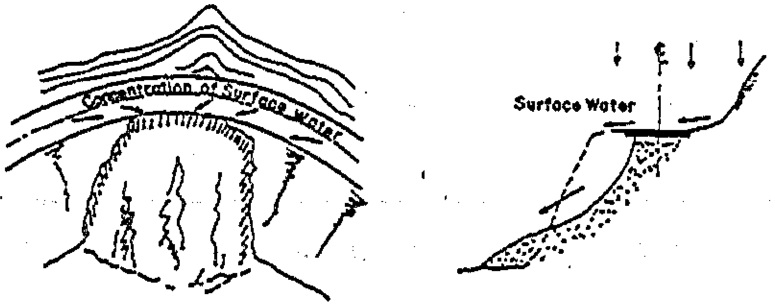
TYPE OF DISASTER	CAUSE OF DISASTER	ILLUSTRATION	APPLICABLE WORKS
EMBANKMENT SLOPE FAILURE	Failure of slope caused by scour due to effect of river stream, or due to rising/lowering of pond water level.	• River  • Pond  	a) Retaining Walls: - Gabion wall - Concrete wall b) Protection works: - Grouted riprap - Concrete crib - Concrete pitching - Cylinder gabion
	Failure caused by erosion due to concentrated surface water, especially on curved or sagged portion.	 	a) Retaining Wall: - Concrete wall b) Protection Works: - Grouted riprap - Concrete crib - Concrete pitching - Concrete pavement of shoulder c) Drainage Works: - Vertical ditch - Water channel - RCPC/RCBC

TABLE 11.1-1(3) GENERALLY APPLICABLE SLOPE PROTECTION WORKS TO EACH TYPE OF SLOPE FAILURE

(3/4)

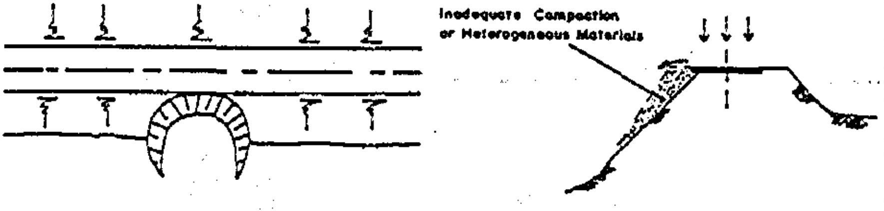
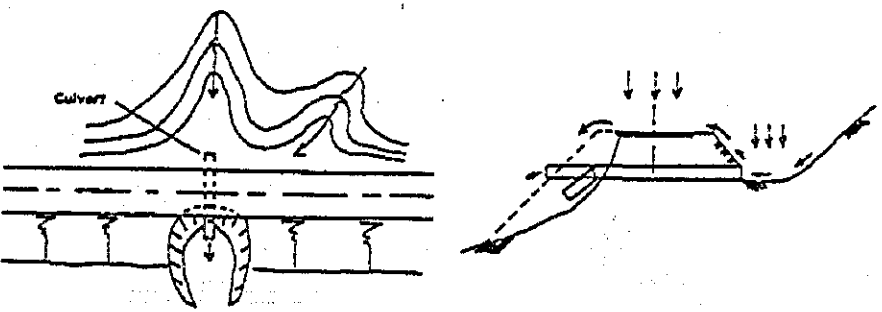
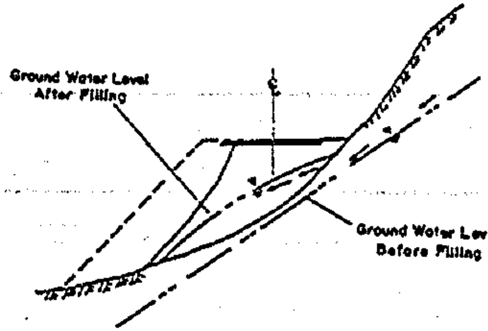
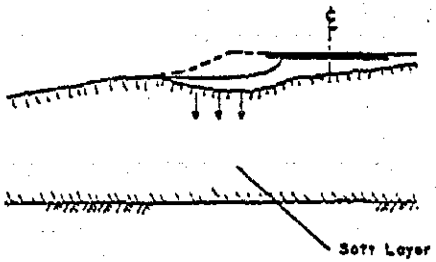
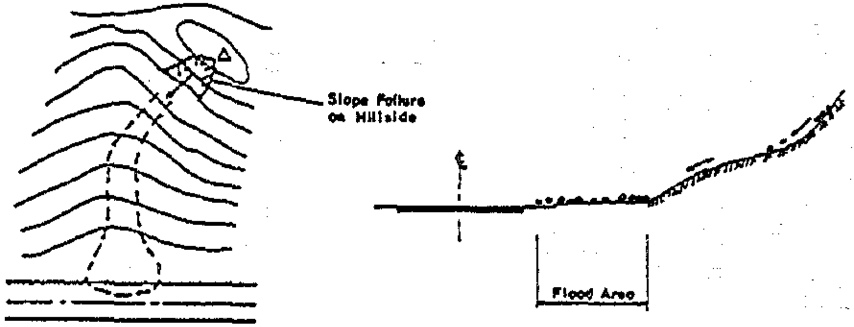
TYPE OF DISASTER	CAUSE OF DISASTER	ILLUSTRATION	APPLICABLE WORKS
EMBANKMENT SLOPE FAILURE	Failure due to inadequate compaction of embankment or use of heterogeneous materials.		a) Earth Work: - Re-filling b) Retaining Wall: - Concrete wall c) Protection Works: - Grouted riprap - Concrete crib - Concrete pitching - Concrete pavement of shoulder d) Drainage Works: - Vertical ditch - Water channel
	Failure of embankment at valley due to inadequate capacity or lack of cross drainage.		a) Retaining Walls: - Concrete wall - Stone masonry wall b) Protection Works: - Grouted riprap - Concrete crib - Concrete pitching - Concrete pavement of shoulder - Gabion foot protection c) Drainage Works: - Vertical ditch - Water channel - RCPC/RCBC
	Failure of embankment in mountainous area due to effect of groundwater permeating the embankment.		a) Retaining Wall: - Concrete wall b) Protection Works: - Grouted riprap - Concrete crib - Gabion foot protection c) Drainage Works: - Vertical ditch - Water channel - Subsurface drainer - Horizontal drain hole - RCPC/RCBC

TABLE 11.1-1(4) GENERALLY APPLICABLE SLOPE PROTECTION WORKS TO EACH TYPE OF SLOPE FAILURE

(4/4)

TYPE OF DISASTER	CAUSE OF DISASTER	ILLUSTRATION	APPLICABLE WORKS
EMBANKMENT SLOPE FAILURE	Failure due to settlement of embankment constructed on the soft ground.		a) Earth Work: - Replacement - Counterweight filling - Earth removal b) Protection Works: - Grouted riprap - Gabion foot protection
DEBRIS FLOW	Flow of debris. Debris supplied by hillside slope failures carried down by stream.		a) Retaining Wall: - Gabion wall b) Hillside Works: - Vegetation or Afforestation - Water channel c) Avoiding Problem: - Bridge - RCBC
LANDSLIDE	Movement along sliding plane in cohesive soil layer induced by the raise of groundwater level.		a) Earth Works: - Counterweight filling - Earth removal b) Structural Works: - Gabion wall - Piling - Anchor work c) Drainage Works: - Subsurface drainer - Horizontal drain hole

11.2 SCOPE OF WORK FOR SLOPES

11.2.1 Summary of Scope of Work

Of the identified 102 slopes as failed or potential, 16 slopes has been or being restored by DPWH, 13 slopes were evaluated as either "low potential" or "no measures required yet", and the remaining 73 slopes required slope protection or appropriate measures (see Table 11.2-1). Number of slopes which required slope protection by type of slope failure is as follows (see Figure 11.2-1):

Cut slope failure : 1 slope
Embankment slope failure : 71 slope
Landslide : 1 slope

TABLE 11.2-1 SUMMARY OF SCOPE OF WORK FOR SLOPE PROTECTION

Package	No. of Slopes Identified	No. of Slopes Protected Under This Project				No. of Slopes Restored By DPWH	No. of Slopes with Low Potential or No Measures Needed Yet
		Cut Slope Failure	Embankment Slope Failure	Landslide	Total		
1	7	-	1	-	1	3	3
2	10	-	4	-	4	3	3
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	16	1	13	1	15	-	1
6	-	-	-	-	-	-	-
7	18	-	18	-	18	-	-
8	4	-	4	-	4	-	-
9	8	-	8	-	8	-	-
10	1	-	1	-	1	-	-
11	4	-	4	-	4	-	-
12	3	-	3	-	3	-	-
13	6	-	4	-	4	2	-
14	1	-	-	-	-	1	-
15	9	-	4	-	4	1	4
16	13	-	5	-	5	6	2
17	-	-	-	-	-	-	-
18	2	-	2	-	2	-	-
19	-	-	-	-	-	-	-
	102	1	71	1	73	16	13

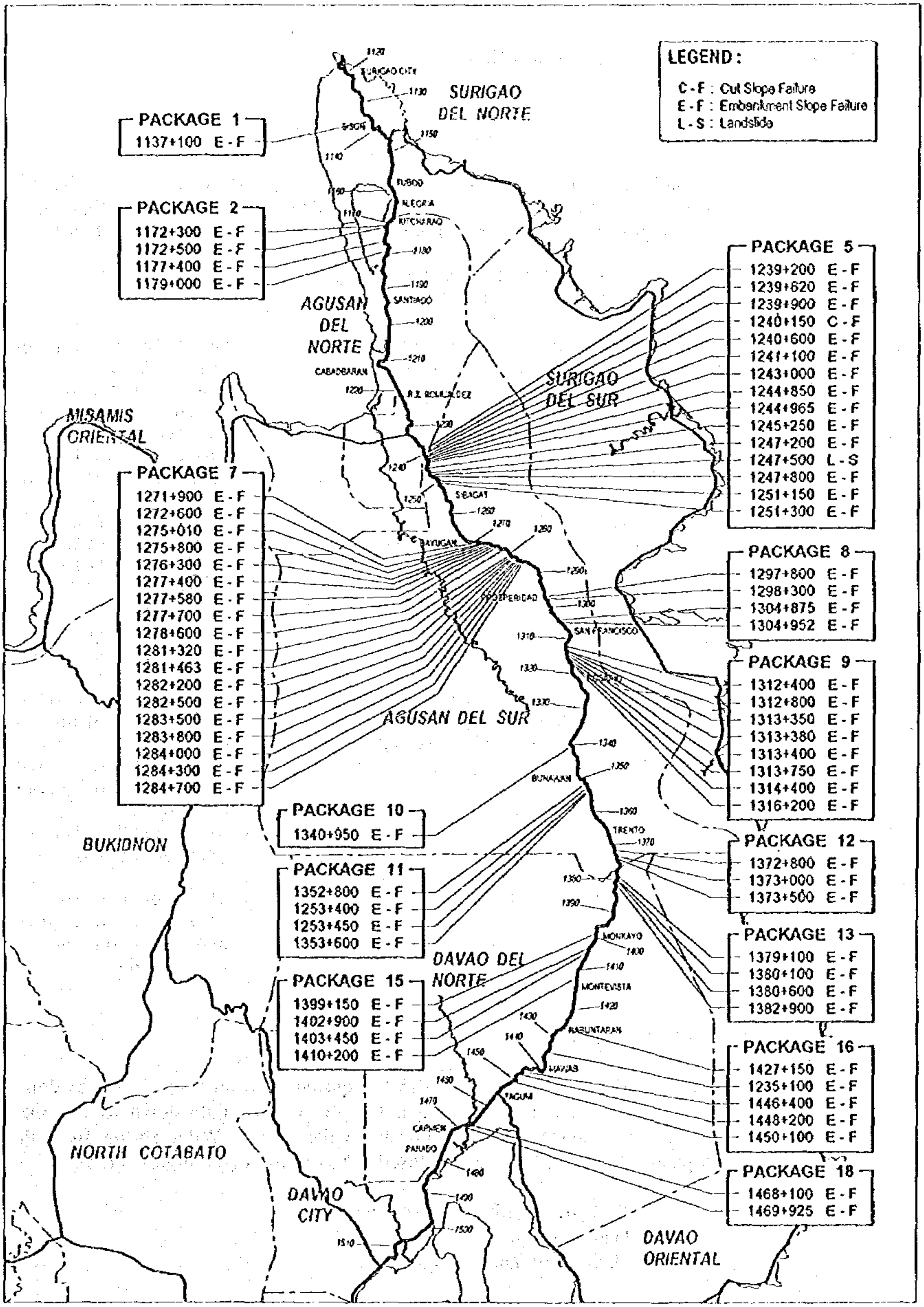


FIGURE 11.2-1 SLOPES FOR PROTECTION WORKS

11.2.2 Scope of Work for Each Slope

1) Embankment Slope Failure

Embankment slope failure is the predominant type of slope failure under this project and all of them are small in scale of failure. Causes of embankment slope failure and major protection works are summarized in Table 11.2-2.

TABLE 11.2-2 CAUSES OF EMBANKMENT SLOPE FAILURE AND SLOPE PROTECTION WORKS

Type 1 :	Loose compaction of embankment and concentration of surface water (36 slopes)	• Refilling with proper compaction. • Construction of side ditch and paved shoulder • Slope protection with grouted riprap.
Type 2 :	Defects of Culverts at inlet/outlet (27 slopes)	• Provision of headwalls, scour protection, gabions at inlet/ outlet. Refilling with grouted riprap slope protection.
Type 3 :	Soft Layer Near Road Surface and Steep (or unstable) Slope Gradient (7 slopes)	• Reconstruction of road-bed with replacement of weak layer. • Construction of side ditches and paved shoulder. • Slope protection with grouted riprap.
Type 4 :	River Water Flow (1 slope)	• Slope protection with grouted riprap and gabion scour protection

2) Cut Slope Failure

One cut slope at Km. 1240+150 required measures to stabilize slope. Highly weathered mudstone along the steep slope falls down to the road surface when surface water infiltrate to the slope. Water spring from the slope also exists. Measures proposed are as follows (see Figure 11.2-2):

- Re-cutting with berms and berm ditch
- Gabion catchwalls
- Underdrain and side ditch

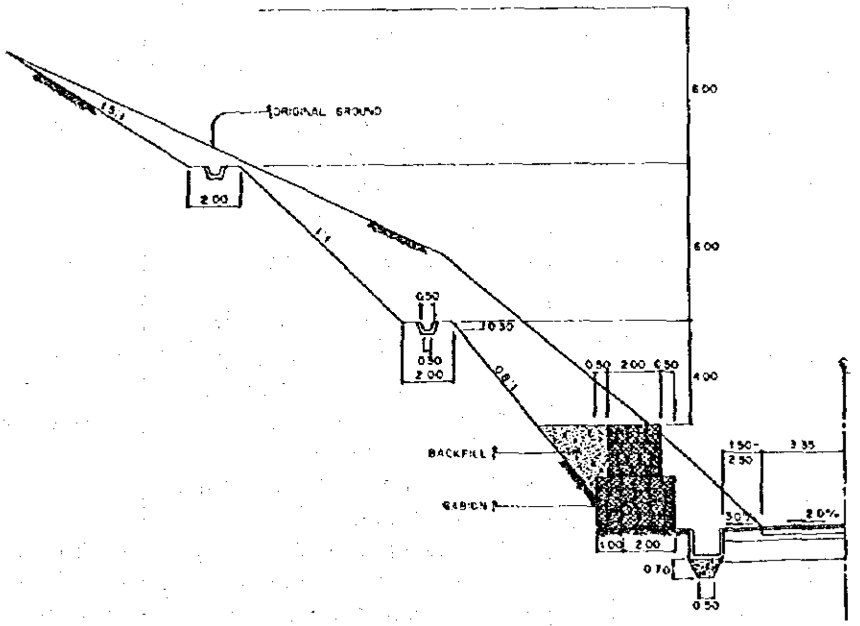


FIGURE 11.2-2 SLOPE PROTECTION WORK AT KM 1240+150

3) Landslide

Landslide at Km 1247+500 seems to be stabilized after DPWH undertook re-cutting of the mountain side slope, as movement of earth has not been observed for the last 2 years. In order to increase overall stability of the slope, the following measures were incorporated in the design:

- Shifting of the centerline toward the mountain side.
- Re-cutting of mountain side slope.
- Provision of underdrain and side ditch.

4) Scope of Work for Each Slope

Scope of work for each slope is presented in Table 11.2-3.

TABLE 11.2 - 3(1) SCOPE OF WORK FOR EACH SLOPE

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
1	1113 + 450	C - F	Low Potential	• Infiltration of surface water into weathered rock	(No countermeasures needed yet)
	1113 + 700	C - F	Low Potential	• Infiltration of surface water into weathered rock	(No countermeasures needed yet)
	1115 + 800	E - F	Failed	• Infiltration of water into boundary surface between the inclined original ground and embankment	(Already restored by DPWH)
	1116 + 200	C - F	Potential	• Failure of surface layer along cracks in sandstone • Infiltration of surface water	(Already restored by DPWH)
	1126 + 100	C - F	Low Potential	• Surface failure induced by surface water concentration	(No countermeasures needed yet)
	1135 + 150	E - F	Failed	• River current hits the slope causing scouring • Concentration of surface water from mountain side	(Already restored by DPWH)
	1137 + 100	E - F	Failed	• No outlet facility at existing RCPC, causing scouring	• Provide headwalls at inlet/outlet • Refilling
2	1170 + 650	C - F	Low Potential	• Exfoliation of weathered limestone	(No countermeasures needed yet)
	1170 + 900	C - F	Low Potential	• Surface layer erosion due to surface water	(No countermeasures needed yet)
	1172 + 300	E - F	Failed	• No outlet facility at culvert	• Provide headwalls at inlet and outlet • Provide riprap slope protection
	1172 + 500	E - F	Failed	• No outlet facility at culvert	• Provide headwalls at inlet and outlet • Provide riprap slope protection
	1173 + 430	E - F	Failed	• Erosion due to water of lake	(Restored by DPWH)
	1177 + 000 1177 + 200	Debris Flow	Failed	• Deposit at mountain side slope flashed down during heavy rain	(Gabion catch wall and line canal constructed by DPWH)
	1177 + 400	E - F	Failed	• No inlet and outlet facilities at culvert	• Provide headwalls at inlet and outlet • Restore embankment
	1179 + 000	E - F	Failed	• Weak riprap headwall at inlet • No outlet facility	• Demolish existing riprap headwall at inlet • Provide concrete headwalls at inlet and outlet • Restore embankment
	1180 + 700	C - F	Potential	• Surface failure of weathered granite due to surface water	(No countermeasures. Judging from present vegetation, slope better remain as it is)
5	1239 + 200	E - F	Failed	• Scouring by flow of river	• Refilling of scoured portion • Riprap wall with gabions at foot of wall
	1239 + 620	E - F	Failed	• Scouring due to no facilities at inlet and outlet at culvert	(Right side or outlet side slope protection, headwall and apron were constructed by DPWH) • Provide inlet side headwall and slope protection with grouted riprap • Provide gabions at outlet adjacent to existing apron

TABLE 11.2 - 3(2) SCOPE OF WORK FOR EACH SLOPE 2/7

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
5	1239 + 900	E - F	Failed	• Scouring due to no facilities at inlet and outlet at culvert	• Provide headwalls at inlet/outlet • Provide grouted riprap slope protection on both sides • Provide grouted riprap scour protection at outlet
	1240 + 150	C - F	Failed	• Surface failure induced by surface water	• Re-cutting with berms and berm ditches • Provide gabion catch wall • Provide side ditches with underdrain
	1240 + 600	E - F	Failed	• Scouring due to no facilities at inlet and outlet at culvert	• Provide headwall at inlet and vertical ditch at outlet • Provide grouted riprap slope protection
	1241 + 100	E - F	Failed	• Scouring due to no facilities at inlet and outlet at culvert	• Provide headwalls at inlet and outlet • Provide gabions at outlet to prevent scouring of slope
	1243 + 000	E - F	Failed	• Insufficient compaction of embankment • Concentration of surface water	• Embankment slope protection by grouted riprap • Provide side ditches
	1244 + 850	E - F	Failed	• *Insufficient compaction of* embankment • Concentration of surface water	• *Embankment slope protection* by grouted riprap • Provide side ditches
	1244 + 965	E - F	Failed	• Insufficient compaction of embankment • Concentration of surface water	• Embankment slope protection by grouted riprap • Provide side ditches
	1245 + 250	E - F	Failed	• Insufficient compaction of embankment • Concentration of surface water	• Construction of gravity type retaining wall • Shoulder pavement with curb/ gutter type side ditch
	1247 + 200	E - F	Failed	• Scouring due to no facilities at inlet and outlet at culvert	• Provide headwalls at inlet/outlet • Provide gabions and grouted riprap at outlet to prevent scouring • Re-fill and provide grouted riprap slope protection
	1247 + 500	Landslide		• Movement of earth mass along a sliding plane induced by the raise of ground water	• Shifting of road centerline towards mountain side • Re-cutting of mountain slope to reduce weight of earth mass
	1247 + 800	E - F	Failed	• No inlet and outlet facilities at culvert	• Provide headwalls at inlet/outlet • Provide gabions at outlet against scouring • *Provide grouted riprap slope* protection
	1249 + 750	Landslide	Potential	• No movement observed for the last 2 years	(No countermeasures)
	1251 + 150	E - F	Failed	• Insufficient compaction of embankment • Surface water concentration	• Embankment slope protection by grouted riprap • Provide side ditches
	1251 + 300	E - F	Failed	• No inlet and outlet facilities at culvert	• Provide headwall, shute type vertical drain and gabions at foot of vertical drain for outlet • Provide catch basin at inlet • Provide grouted riprap slope protection

TABLE 11.2 - 3(3) SCOPE OF WORK FOR EACH SLOPE

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
7	1271 + 900	E - F	Failed	• No inlet and outlet facilities at culvert	• Provide headwalls at inlet/outlet • Provide grouted riprap slope protection
	1272 + 600	E - F	Failed	• No inlet and outlet facilities at culvert	• Provide headwalls at inlet/outlet • Provide grouted riprap slope protection
	1275 + 010	E - F	Failed	• Settlement of embankment due to soft ground	• Reconstruction to the level of replacement of subgrade (1 m) • Shoulder pavement to prevent surface water infiltration • Provide side ditches • Slope protection by grouted riprap
	1275 + 800	E - F	Failed	• Insufficient compaction of embankment • Surface water infiltration	• Reconstruction to the level of replacement of subgrade (0.6 m) • Provide side ditch at mountain side to control surface water • Provide grouted riprap slope protection
	1276 + 300	E - F	Failed	• Insufficient compaction of embankment • Surface water infiltration	• Replacement of subgrade (0.6 m) • Provide side ditch at mountain side and curb and gutter at valley side to control surface water • Provide grouted riprap slope protection
	1277 + 400	E - F	Failed	• Water from access road crosses the road, scouring embankment slope • Scouring at outlet of box culvert also affect embankment slope stability	• Provide grouted riprap slope protection • Provide gabion apron at outlet
	1277 + 580	E - F	Failed	• Loose compaction of embankment	• Reconstruction to the level of replacement of subgrade (0.6 m) • Grouted riprap slope protection
	1277 + 700	E - F	Failed	• Loose compaction of embankment	• Reconstruction to the level of replacement of subgrade (0.6 m) • Grouted riprap slope protection • Provide side ditches
	1278 + 600	E - F	Failed	• Settlement of embankment due to soft layer • Infiltration of water raising ground water level	• Reconstruction to the level of replacement of subgrade (1.2 m) • Grouted riprap slope protection • Provide shoulder pavement
	1281 + 320 and 1281 + 463	E - F	Failed	• Loose compaction of embankment • Embankment with steep slope	(Already refilled by DPWH, but compaction is still insufficient) • Reconstruction to the level of subgrade replacement (1.2 m) • Provide shoulder pavement
	1282 + 200	E - F	Failed	• Unstable slope due to soft layer	• Replacement of soft layer to the level of subgrade replacement (1.2 m) • Slope protection with grouted riprap • Shoulder pavement and side ditches to control infiltration of surface water

TABLE 11.2 - 3(4) SCOPE OF WORK FOR EACH SLOPE

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
	1282 + 500	E - F	Failed	• Unstable slope due to soft layer	• Replacement of soft layer to the level of subgrade replacement (1.2 m) • Slope protection with grouted riprap • Shoulder pavement and side ditches to control infiltration of surface water
	1283 + 500	E - F	Failed	• Unstable slope due to soft layer	• Replacement of soft layer to the level of subgrade replacement (1.2 m) • Slope protection with grouted riprap • Shoulder pavement and side ditches to control infiltration of surface water
	1283 + 800	E - F	Failed	• Unstable slope due to soft layer	• Replacement of soft layer to the level of subgrade replacement (1.2 m) • Slope protection with grouted riprap • Shoulder pavement and side ditches to control infiltration of surface water
	1284 + 000	E - F	Failed	• Unstable slope due to soft layer	• Replacement of soft layer to the level of subgrade replacement (1.2 m) • Slope protection with grouted riprap • Shoulder pavement and side ditches to control infiltration of surface water
	1284 + 300	E - F	Failed	• Loose compaction of embankment • Concentration of surface water due to sag portion	• Provide side ditch • Embankment slope protection with grouted riprap
	1284 + 700	E - F	Failed	• No inlet and outlet facility at culvert • Concentration of surface water due to sag portion	• Provide side ditch • Provide headwalls at inlet/outlet and gabion apron at outlet • Embankment slope protection with grouted riprap
8	1297 + 800	E - F	Failed	• Loose compaction of embankment	• Embankment slope protection with grouted riprap
	1298 + 300	E - F	Failed	• Loose compaction of embankment	• Embankment slope protection with grouted riprap
	1304 + 875	E - F	Failed	• Loose compaction of embankment	• Refilling
	1304 + 952	E - F	Failed	• Loose compaction of embankment	• Refilling
9	1312 + 400	E - F	Failed	• Loose compaction of embankment	• Refilling
	1312 + 800	E - F	Failed	• Water from mountain side access road crosses the road and scoured embankment	• Embankment slope protection with grouted riprap

TABLE 11.2 - 3(5) SCOPE OF WORK FOR EACH SLOPE

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
	1313 + 350	E - F	Failed	• No wing walls at box culvert • Loose compaction of embankment • Concentration of surface water	• Provide wing walls and gabions at outlet against scouring • Embankment slope protection with grouted riprap • Provide side ditches
	1313 + 380	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with grouted riprap
	1313 + 400	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with grouted riprap
	1313 + 750	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with grouted riprap
	1314 + 400	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with grouted riprap
	1316 + 200	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Refilling with 2:1 slope
10	1340 + 950	E - F	Failed	• Insufficient pipe capacity and no inlet/outlet facility	• Convert to RCBC with wing walls
11	1352 + 800	E - F	Failed	• Pipe culvert without inlet/outlet facilities	• Extend pipe length and provide headwalls • Embankment slope protection with grouted riprap
	1353 + 400	E - F	Failed	• Insufficient capacity of pipe • No inlet/outlet facility	• Replace existing pipe with higher capacity culvert with headwalls
	1353 + 450	E - F	Failed	• Insufficient capacity of pipe • No inlet/outlet facility	• Replace existing pipe with higher capacity culvert with headwalls
	1353 + 600	E - F	Failed	• Insufficient capacity of pipe • No inlet/outlet facility	• Replace existing pipe with higher capacity culvert with headwalls
12	1372 + 800	E - F	Failed	• No inlet/outlet facilities	• Provide headwalls • Embankment slope protection with grouted riprap
	1373 + 000	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with riprap
	1373 + 500	E - F	Failed	• Loose compaction of embankment • Too steep slope	• Embankment slope protection with riprap
13	1378 + 500	E - F	Failed	• Inadequate inlet and outlet facilities of culvert • Infiltration of water into boundary between the ground and embankment	(Restored by DPWH)
	1378 + 800	E - F	Failed	• Inadequate inlet and outlet facilities of culvert • Infiltration of water into boundary between the ground and embankment	(Restored by DPWH)

TABLE 11.2 - 3(6) SCOPE OF WORK FOR EACH SLOPE 6/7

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
	1379 + 100	E - F	Failed	• No facilities at inlet/outlet of culvert • Too steep slope	• Provide headwalls and gabion scour protection at outlet • Provide embankment slope protection with grouted riprap
	1380 + 100	E - F	Failed	• Concentration of surface water • Too steep slope	• Provide side ditches • Embankment slope protection with grouted riprap
	1380 + 600	E - F	Failed	• Concentration of surface water • Too steep slope	• Provide gravity type retaining wall • Provide shoulder pavement and side ditches on both sides to control surface water
	1382 + 900	E - F	Failed	• Loose compaction of embankment	• Embankment slope protection with grouted riprap • Provide shoulder pavement and side ditches on both sides to control surface water
14	1395 + 800	E - F	Failed	• Loose compaction of embankment • Box culvert clogged and water level went up	(Restored by DPWH)
15	1396 + 050	E - F	Potential	• River water flow hits the slope	(No countermeasure needed yet)
	1399 + 150	E - F	Potential	• Clogging of box culvert resulting in raising of water elevation	• Desilt waterway and culvert
	1401 + 300	E - F	Potential (Failed about 10m away from shoulder edge)	• Scouring due to river current	(No countermeasure needed yet)
	1401 + 400	E - F	Potential (Failed about 10m away from shoulder edge)	• Scouring due to river current	(No countermeasure needed yet)
	1401 + 850	E - F	Failed	• Scouring due to river current	(Restored by DPWH)
	1402 + 900	E - F	Failed	• Loose compaction of embankment	• Refilling
	1403 + 450	E - F	Failed	• Loose compaction of embankment	• Refilling
	1410 + 200	E - F	Failed	• No inlet/outlet facilities at culvert • Insufficient pipe capacity	• Replace the existing pipe with higher capacity culvert • Provide headwalls
	1411 + 800	E - F	Potential	• Scouring due to river water flow	(No countermeasure needed yet)
16	1427 + 150	E - F	Failed	• Saturated loose embankment	• Embankment slope protection by grouted riprap • Reconstruction to the level of subgrade replacement (left lane)
	1429 + 150	E - F	Potential	• Scouring due to river water flow	(No countermeasure needed yet)
	1430 + 950	E - F	Failed	• Scouring due to river water flow	(Restored by DPWH)
	1435 + 100	E - F	Failed	• No inlet/outlet facilities at culvert • Loose compaction	• Provide headwalls at inlet/outlet • Refilling

TABLE 11.2 - 3(7) SCOPE OF WORK FOR EACH SLOPE 7/7

Pkg. No.	Location (Km.)	Type of Disaster	Failed/ Potential	Case of Failure	Scope of Work
	1441 + 000	E - F	Potential (Failed about 10m away from shoulder edge)	• Scouring due to river water flow	(No countermeasure needed yet)
	1442 + 900	E - F	Failed	• No inlet/outlet facilities at culvert	(DPWH will restore)
	1445 + 700	E - F	Failed	• Saturated loose fill • Too steep slope	(Restored by DPWH)
	1446 + 400	E - F	Failed	• Surface water concentration	• Re-alignment of road center line
	1448 + 200	E - F	Failed	• Loose embankment fill	• Refilling • Provide side ditches to control surface water
	1449 + 400	E - F	Failed	• Saturated loose fill • Too steep slope	(Restored by DPWH)
	1449 + 700	E - F	Failed	• Saturated loose fill • Too steep slope	(Restored by DPWH)
	1449 + 950	E - F	Failed	• Saturated loose fill • Too steep slope	(Restored by DPWH)
	1450 + 100	E - F	Failed	• Concentration of surface water	• Refilling • Provide side ditches to control surface water
18	1468 + 100	E - F	Failed	• Insufficient capacity of culvert near the slope	• Replace with RCBC • Refilling
	1469 + 925	E - F	Failed	• Loose compaction of embankment	• Refilling

CHAPTER 12

COUNTERMEASURES AGAINST FLOOD

12.1 DESIGN CRITERIA

12.1.1 Return Period For Design of Countermeasures Against Flood

Return period to estimate peak discharge for the design of countermeasures against flood was established as follows:

Type of Structure	Return Period
• Bridges	50 years
• Box Culverts	25 years
• Pipe Culverts	10 years
• Embankment	10 years (except Simulao River flood area where 25 years was adopted)
• Liboganon River Bank	50 years

Based on above criteria, peak discharge for each flood sections was computed as discussed in Chapter 6.

12.1.2 Evaluation of Severity of Flood

Severity of flood is dependent on flood depth, duration and frequency. For the purpose of selection of countermeasures for flood sections, severity of flood is assessed based on the criteria as shown in Table 12.1-1.

TABLE 12.1-1 CRITERIA FOR ASSESSMENT OF FLOOD SEVERITY

Flood Depth	Duration	Return Period				
		Less than 2 years	2~5 years	5~10 years	10~15 years	More than 15 years
Less than 15cm (passable to all types of vehicle with care)	Any	B	C	D	D	D
15~30cm (passable to bus and truck only)	Less than 5 hrs.	B	B	C	D	D
	5 hrs. or more	A	B	B	C	D
30cm or more (Impassable to all types of vehicle)	Less than 5 hrs.	A	A	B	B	B
	5 hrs. or more	A	A	A	B	B

A: High
B: Medium
C: Low
D: Negligible

12.1.3 Classification of Type of Countermeasures

There are principally two types of countermeasures for flood prevention and protection:

- Countermeasures along the road to protect the road.
- Countermeasures along a river to prevent flood water spilling out.

The following three countermeasures are proposed as countermeasure along the road:

Countermeasure - 1: Protect the road against flood water (Flood protection)
Countermeasure - 2: Install flood interception canal (Flood prevention)
Countermeasure - 3: Raise the road elevation above floodwater level (Flood prevention)

Illustrative description of each countermeasure along the road is presented in Table 12.1-2.

Countermeasures along the river are selected taking into account characteristics of the rivers along the study road. The following four countermeasures are proposed:

Countermeasure - 4: Dredge the river (Flood prevention)
Countermeasure - 5: Construct Sabo dam (Flood prevention)
Countermeasure - 6: Construct flood protection dike (Flood prevention)
Countermeasure - 7: Provide cut-off channel (Flood prevention)

Table 12.1-3 presents illustrative description of countermeasures along the river.

12.1.4 Selection Criteria of Countermeasures

Basically countermeasures along the road shall be selected for all types of flood but adoption of countermeasures along the river shall be considered under the following circumstances:

- Flood damage other than the road is also serious, and it is economically worth to protect vicinity area as well as the road itself.
- It is obvious that countermeasure along the river is technically and economically superior than countermeasure along the road.

<u>Criteria for Selection of Countermeasures along the Road</u>

Countermeasure along the road is selected based on severity of flood and roadside development. The basic criteria for selection of countermeasure along the road is as follows:

a) Severity of flood is A or B, and
   Roadside development is high .... Countermeasure 2
b) Severity of flood is A or B, and
   Roadside development is low .... Countermeasure 3
c) Severity of flood is C .... Countermeasure 1
d) Severity of flood is D .... Do Nothing

TABLE 12.1-2 COUNTERMEASURES ALONG ROAD

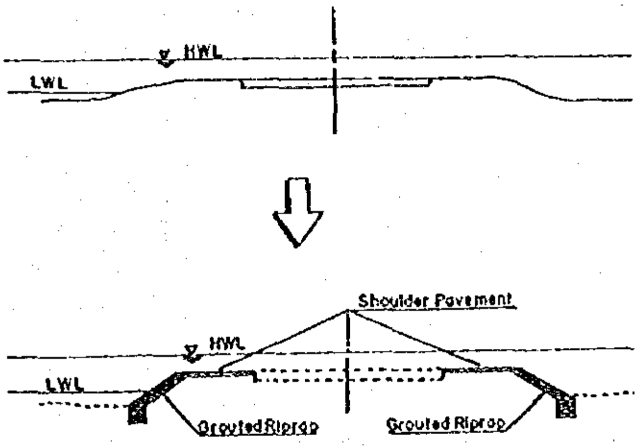
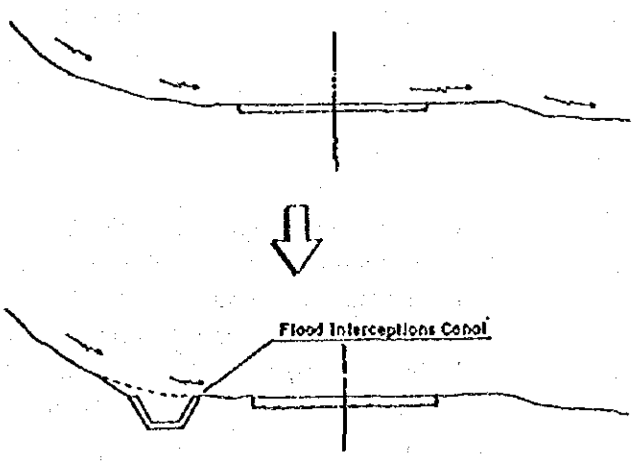
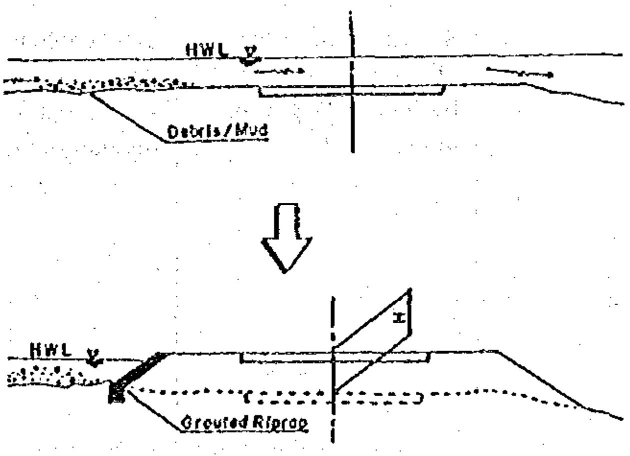
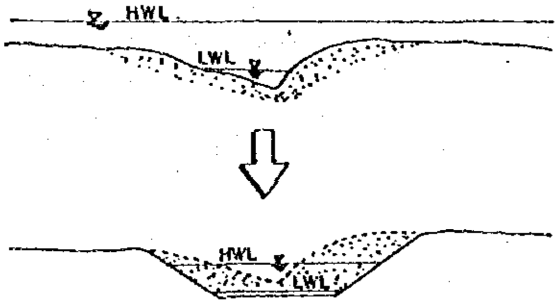
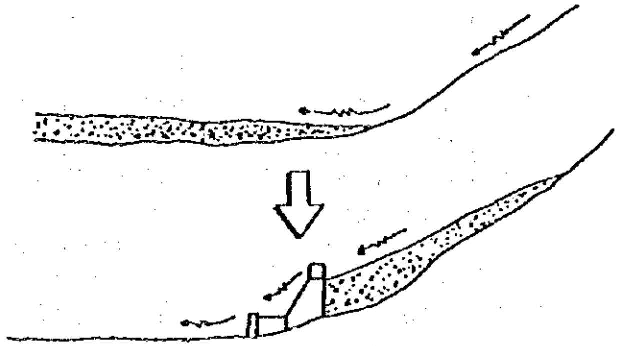
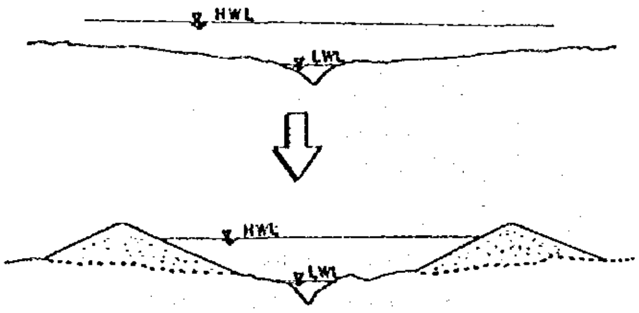
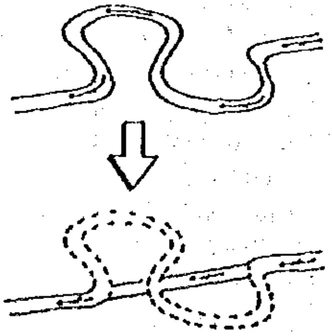
Sample Illustration	Description of Method	Application Criteria
COUNTERMEASURE 1 Protection of Road  	- Protect the road with grouted riprap and shoulder pavement. - Adequate capacity of side ditch and cross drainage facilities shall be installed.	- Flood elevation is not so high. - No mud/debris flow. - Suitable to urbanized area. - Suitable to area where flood interception canal doesn't work properly.
COUNTERMEASURE 2 Flood Interception Canal  	- Install adequate capacity of flood interception canal. - Size of canal is dependent on flood discharge and distance to convey flood water. - Grouted riprap and shoulder pavement may be provided if there still be possibility of overflow. - Cross drainage facility such as RCPC, RCBC shall be installed at proper location.	- Flood depth is not so deep. - No mud/debris flow accompanied. - Suitable to urbanized area. - Periodic dredging of canal is required.
COUNTERMEASURE 3 Raise of Road  	- Raise the road above expected high water level. - Height of embankment is dependent on elevation of flood water. - Embankment slope exposed to flood water may be protected by grouted riprap. - Cross drainage facility such as RCPC, RCBC shall be installed at proper location.	- Flood elevation is high. - Mud/debris flow accompanied. - Suitable to not urbanized area.

TABLE 12.1-3 COUNTERMEASURES ALONG RIVER

Sample Illustration	Description of Method	Application Criteria
COUNTERMEASURE 4 Riverbed Dredging 	- Remove sediments on the river by excavation. - Dimension of river is determined based on amount of discharge and nature of river channel.	- Applicable to rivers in alluvial fan which exhibits excessive sedimentation and aggradation of riverbed. - Periodic dredging is required to maintain stream steady.
COUNTERMEASURE 5 Sabo Dam 	- Construct sabo dam at top of an alluvial fan. - Exact location and size of dam shall be determined by experienced engineer after thorough investigation.	- Applicable to middle or minor rivers in alluvial fan. - Additional sabo dam may be required at upstream when downstream dam is filled with sediments.
COUNTERMEASURE 6 Dike 	- Construct earth dike high enough to prevent flood water spilling-out. - Embankment slope may be protected by grouted riprap if velocity of flood is high.	- Applicable to rivers in flat plain. - Rivers whose surrounding area has economically high value.
COUNTERMEASURE 7 Cut-off Channel 	- Straighten river channel at meandering section by introducing man-made canal.	- Applicable to rivers in flat plain whose water course meanders significantly.

12.2 SCOPE OF WORK OF COUNTERMEASURES

12.2.1 Summary of Scope of Work

There are 16 flood sections along the project road. DPWH is implementing countermeasures against flood at one section (the flood section No. 7 at Km. 1184+250 in Agusan del Norte), comprising of raising of road elevation, construction of box culvert, interception canal and gabion catchwall, thus no additional measures was judged to be necessary. For the rest of 15 flood sections, the countermeasures were planned and designed. Countermeasures adopted were summarized in Table 12.2-1 and shown in Figure 12.2-1.

TABLE 12.2-1 *COUNTERMEASURES ADOPTED*

Package	Flood Section No.	Location (Km)	Flood Section Length (m)	Severity of Flood	Counter-measures Adopted *
1	1	1160+700~1161+700	1,000	A	3
1	2	1163+600~1164+100	500	B	3
1	3	1164+750~1165+100	350	A	3
1	4	1166+600~1167+900	1,300	A	2
2	5	1182+100~1182+590	490	B	2
2	6	1183+100~1183+260	160	C	1
2	7	1184+250~1185+200	950	A	[3]
2	8	1187+600~1189+200	1,600	A	3
3	9	1192+000~1193+800	1,800	A	2
3	10	1196+400~1196+720	320	B	[1]+4
3	11	1199+600~1203+870	4,270	A	3
4	12	1219+700~1220+100	400	C	3
4	13	1224+200~1224+640	440	B	[3]+4
11	14	1355+200~1357+620	2,420	A	3
		1360+100~1361+220	1,120		
14	15	1393+400~1398+300	2,400	A	3+7
17	16	1460+500~1468+000	7,500	A	5+6

* [ ]: already implemented or being implemented by DPWH.

Countermeasure	
1	Protection of Road
2	Installation of Flood Interception Canal
3	Raising of Road Elevation
4	Riverbed Dredging
5	Construction of Flood Protection Dike
6	Provision of Cut-off Channel
7	Construction of Bypass

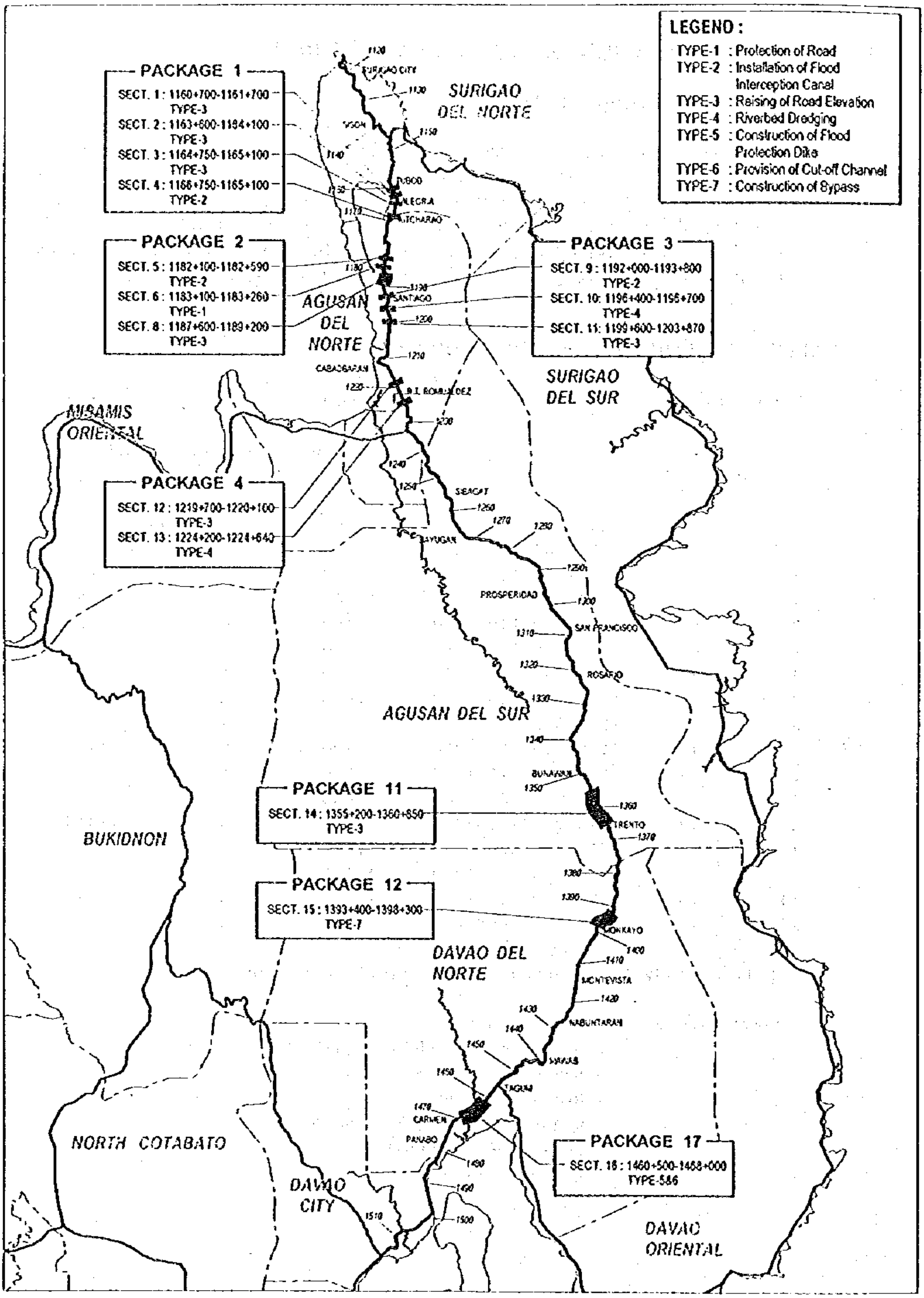


FIGURE 12.2-1 FLOOD SECTIONS NEEDING COUNTERMEASURES

12.2.2 Countermeasures Against Flood Of Each Flood Section

Countermeasures against flood of each flood section is presented in Table 12.2-2.

Outline of countermeasures of large scale flood sections is presented hereunder.

1) Flood Section 14: Simulao River Flood Area, Trento, Agusan del Sur

Hydrological analysis in Chapter 6 estimated flood water elevation for the return period of 25 years. The result of analysis shows that flooded water from Simulao River does not overflow the road, as the road elevation is higher than estimated flood water elevation.

This road section was submerged in 1981 at the sections where road elevation is relatively lower than other road sections. Flood in 1981 was simulated and 1981 flood water elevation was estimated. The simulation result is shown in Figure 12.2-2, which indicates the following:

- Flood water spilled over the road at the following sections:

Km. 1355 + 500 - Km. 1355 + 700
Km. 1356 + 200 - Km. 1357 + 600
Km. 1360 + 400 - Km. 1360 + 800

Based on above facts, it was proposed that road elevation of the following sections be raised:

<u>Sections Where Road Elevation To Be Raised</u>

• Km. 1355 + 200 - Km. 1357 + 620	(to E.L. = 26.0m)
• Km. 1360 + 100 - Km. 1361 + 220	(to E.L. = 28.0m)

2) Flood Section 15: Monkayo Town Flood Area

Proposed countermeasures against flood for this section was to construct Monkayo Bypass which was discussed in Section 8.6 of this report.

3) Flood Section 16: Liboganon River Flood Area

Right dike (or west dike) of Liboganon River was constructed by NIA. Left dike (or east dike) at the upstream portion is being constructed by DPWH. Due to incomplete construction of left dike, downstream side area of left dike is always flooded. During the Feasibility Study, it was agreed that construction of left dike is to be included in this project. Required scope of work is as follows (see Figure 12.2-3):

• Construction of Left Dike ------------------	1.5 km
• Extension and Raising of Right (or NIA) Dike -----	1.0 km
• Construction of Cut-off Channel -------------	1.9 km
• Construction of New Gov. Miranda Bridge -------	650m
• Removal of existing road and a bridge	

TABLE 12.2 - 2(1) COUNTERMEASURES AGAINST FLOOD OF EACH FLOOD SECTION

Flood Set No.	Pkg. No.	Location	Nature of Flood • Flood Depth • Flood Duration • Frequency • Traffic Disturbance	Cause of Flood	Damage to Road	Scope of Work of Countermeasures
1	1	1160+700 - 1161+700 L = 1,000 m Alipao, Surigao del Norte	• 60 cm. • 6 hrs. • 3 times a year • Impassable to all type of vehicle	• Flood water from mountain slope • Lack of cross drainage	• Mud and debris deposit on the road • Shoulder scouring	• Raising of road elevation from Km 1160+580 to Km 1161+980 • Construction of additional culverts
2	1	1163+600 - 1164+100 L - 500 m Candiis, Surigao del Norte	• 30 m. • 4 hrs. • 3 times a year • Passable only to buses and trucks	• Flood water from mountain slope	• Mud deposit on the road	• Raising of road elevation from Km 1163 to Km 1164+400 • Construction of additional culverts
3	1	1164+750 - 1165+100 L = 350 m Magtiaco, Surigao del Norte	• 35 cm. • 12 hrs. • 2 times a year • Passable only to buses and trucks	• Overflow from Legaspi River	• No significant damage to road facility	• Raising of road elevation from Km 1164+800 to Km 1165+220
4	1 and 2	1166+600 - 1167+900 L = 1,300 m Alegria, Surigao del Norte	• 50 cm. • 12 hrs. • 2 times a year • Impassable to all vehicles for about 6 hrs.	• Overflow from Legaspi River	• Shoulder scouring	• Construction of interception canal • Conversion of existing culverts to bigger size culverts
5	2	1182+100 - 1180+590 L = 490 m Baliguian, Agusan del Norte	• 30 cm. • 4 hrs. • 2 times a year • Passable only to buses and trucks	• Overflow from Baliguian River	• Shoulder scouring	• Construction of interception canal
6	2	1183+100 - 1183+260 L = 160 m Baliguian, Agusan del Norte	• 10 cm. • 3 hrs. • Once in 2 years • Passable	• Overflow from Sayadion River	• Mudflow heavily silted box culvert • Shoulder scouring near box culvert	• Construction of additional culverts and conversion of existing culverts to bigger size culverts • Shoulder pavement
7	2	1184+250 - 1185+200 L = 950 m Toliago, Agusan del Norte	• 60 cm. • 6 hrs. • 2 times a year • Impassable to all type of vehicle	• Flood water from mountain slope	• Mud and debris deposits on the road surface	(Raising of road elevation, construction of additional box culvert, interception canal, gabion catchwalls ae being implemented by DPWH)
8	2	1187+600 - 1189+200 L = 1,600 m Bangonay, Agusan del Norte	• 30 cm. • 6 hrs. • Once a year • Passable only to buses and trucks	• Overflow from Puyo River	• Road damage is not significant • Huge amount of drift woods stuck below Bangonay Bridge	• Raising of road elevation from Km 1187+560 to Km 1188+220 • Conversion of existing culverts to bigger size culverts
9	3	1192+000 - 1193+800 L = 1,800 n Santiago, Agusan del Norte	• 40 cm. • 6 hrs. • 2 times a year • Impassable to all types of vehicle	• Flood water from mountain slope	• Mud and debris deposit on the road • Shoulder scouring	• Conversion of existing culverts to bigger size culverts • Construction of interception canal • Shoulder pavement
10	3	1196+400 - 1196+720 L = 320 m Jagupit, Agusan del Norte	• 25 cm. • 4 hrs. • 3 times a year • Passable only to buses and trucks	• Overflow from Jagupit River	• No clearance below Jagupit Bridge	(Shoulder pavement has been completed by DPWH) • Dredging of Jagupit River

TABLE 12.2 - 2(2) COUNTERMEASURES AGAINST FLOOD OF EACH FLOOD SECTION

Flood Set. No.	Pkg. No.	Location	Nature of Flood • Flood Depth • Flood Duration • Frequency • Traffic Disturbance	Cause of Flood	Damage to Road	Scope of Work of Countermeasures
11	3	1199+600 - 1203+870 L = 4,270 m Sta. Ana, Agusan del Norte	• 40 cm. • 6 hrs. • 2 times a year • Impassable to all type of vehicles	• Overflow from Sta. Ana River, Tagmamarkay River, Kinahiloan River and Maniswag River	• Debris deposits on the road • Shoulder scouring	• Raising of road elevation from Km 1200+940 to Km 1201+340 and from Km 1202+960 to Km 1203+380 • Conversion of existing culverts to bigger size culverts
12	4	1219+700 - 1220+100 L = 400 m Agay, Agusan del Norte	• 15 cm. • 6 hrs. • 3 times a year • Passable with care	• Low land area	• Shoulder scouring and pavement damage at culverts	• Raising of road elevation from Km 1219+670 to Km 1220+200 • Conversion of existing culverts to bigger size culverts
13	4	1224+200 - 1224+640 L = 440 m Los Angeles, Butuan City	• 30 cm. • 10 hrs. • 2 times a year • Passable only to buses and trucks	• Overflow from Agay River • Low land area	• Road damage is not significant • Agay River is heavily silted	(DPWH has raised road elevation) • Dredging of Agay River
14	11	1355+200 - 1364+200 L = 9,000 m Torento, Agusan del Sur	• 60 cm. • 48 hrs. • Once in 5 years • Impassable to all types of vehicle at Km 1356 + 450	• Overflow from Simulao River	• No significant road damage	• Raising of road elevation from Km 1355+200 to Km 1357+620 and Km 1360+100 to Km 1361+220 • Construction of additional box culvert
15	14	1393+400 - 1398+300 L = 2,4000 m Monkayo, Davao del Norte	• 200 cm. • 3 days • Once in 5 years • Impassable to all types of vehicle	• Overflow from Agusan River	• No significant damage to road structure • Monkayo town proper totally submerged under flood water	• Construction of Monkayo Bypass (L = 2.587 km) which includes two bridges (L = 61.6 + 146.4=208.0 m)
16	17	1460+500 - 1468+000 L = 7,500 m Tagum Davao del Norte	• 60 cm. • 24 hrs. • Once a year • Impassable to all types of vehicles	• Overflow from Libogano River • West bank of Liboganon River constructed, however, east bank is not completed yet	• Shoulder scouring	• Realignment of existing road (new alignment L = 1.65 km) • Construction of New Gov. Miranda Bridge spanning new dikes (L = 650 M) • Construction of East Dike (L = 1.5 km) which connects the dike being constructed by DPWH • Extension of NIA (or West) Dike with higher elevation (L = 1.0 km) • Construction of cut-off channel (L = 1.85 km) • Removal of the existing road between dikes including existing Gov. Miranda Bridge

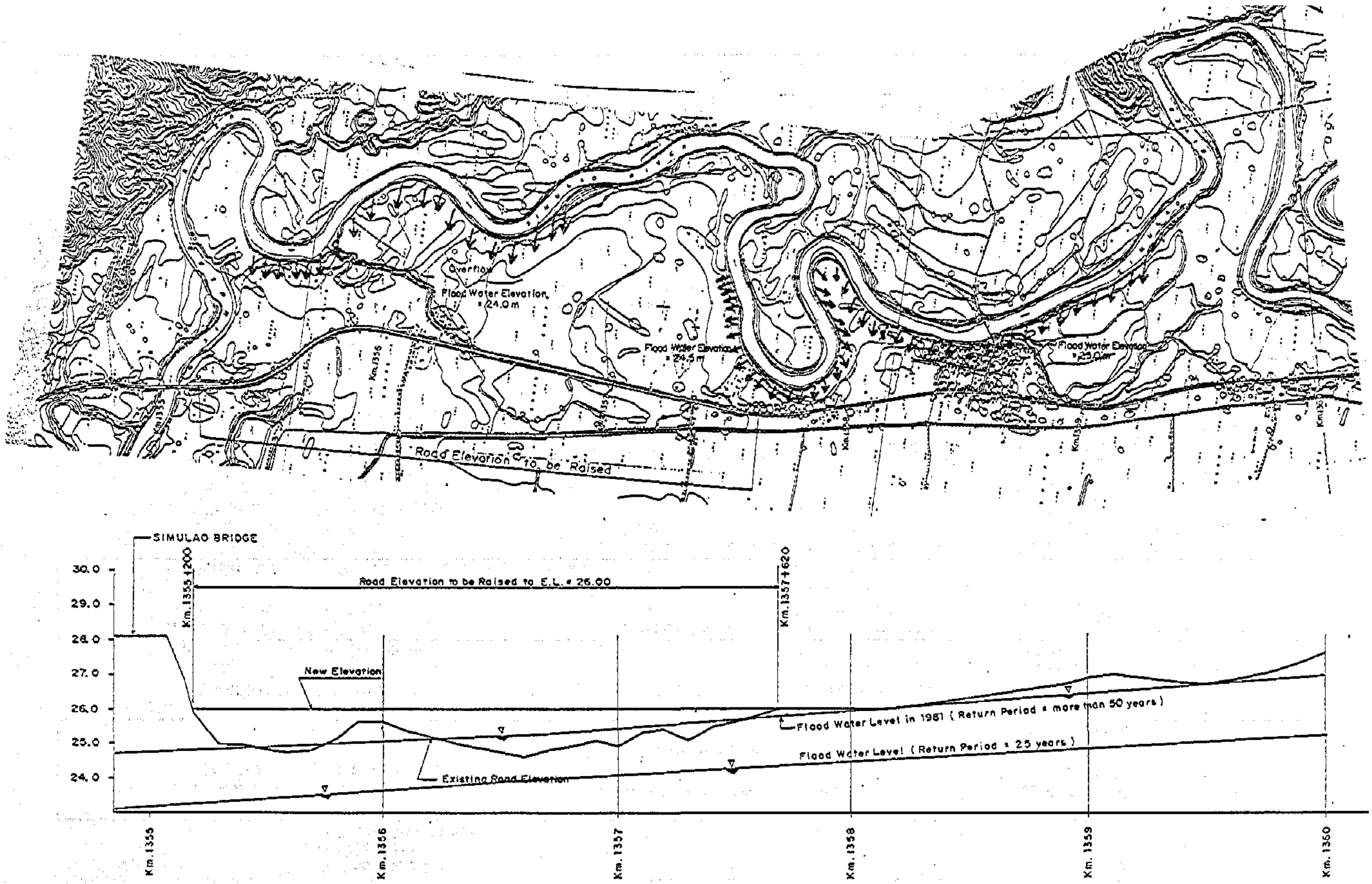


FIGURE 12.2-2 SIMULAO RIVER FLOOD AREA (1/2)

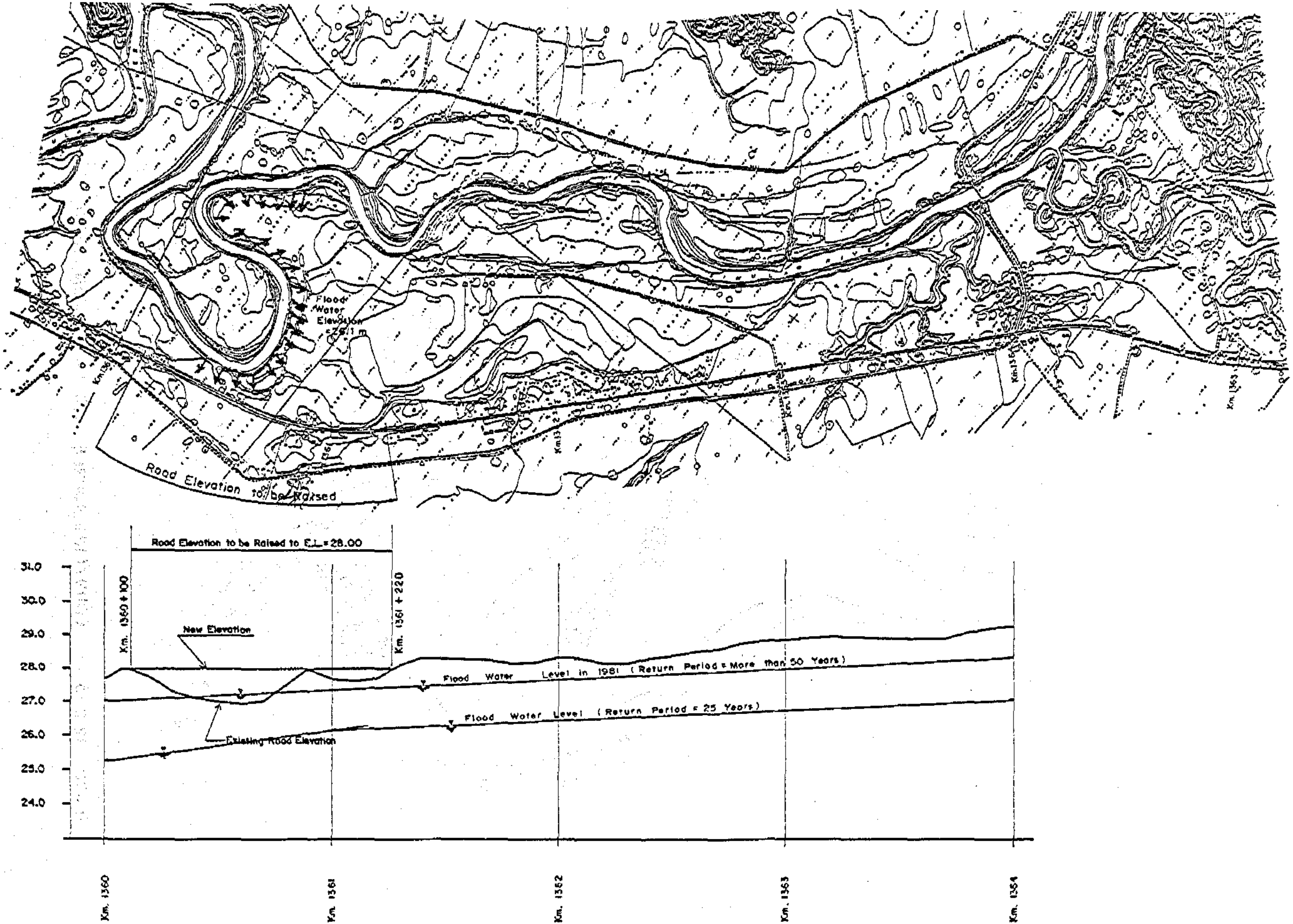


FIGURE 12.2-2 SIMULAO RIVER FLOOD AREA (2/2)

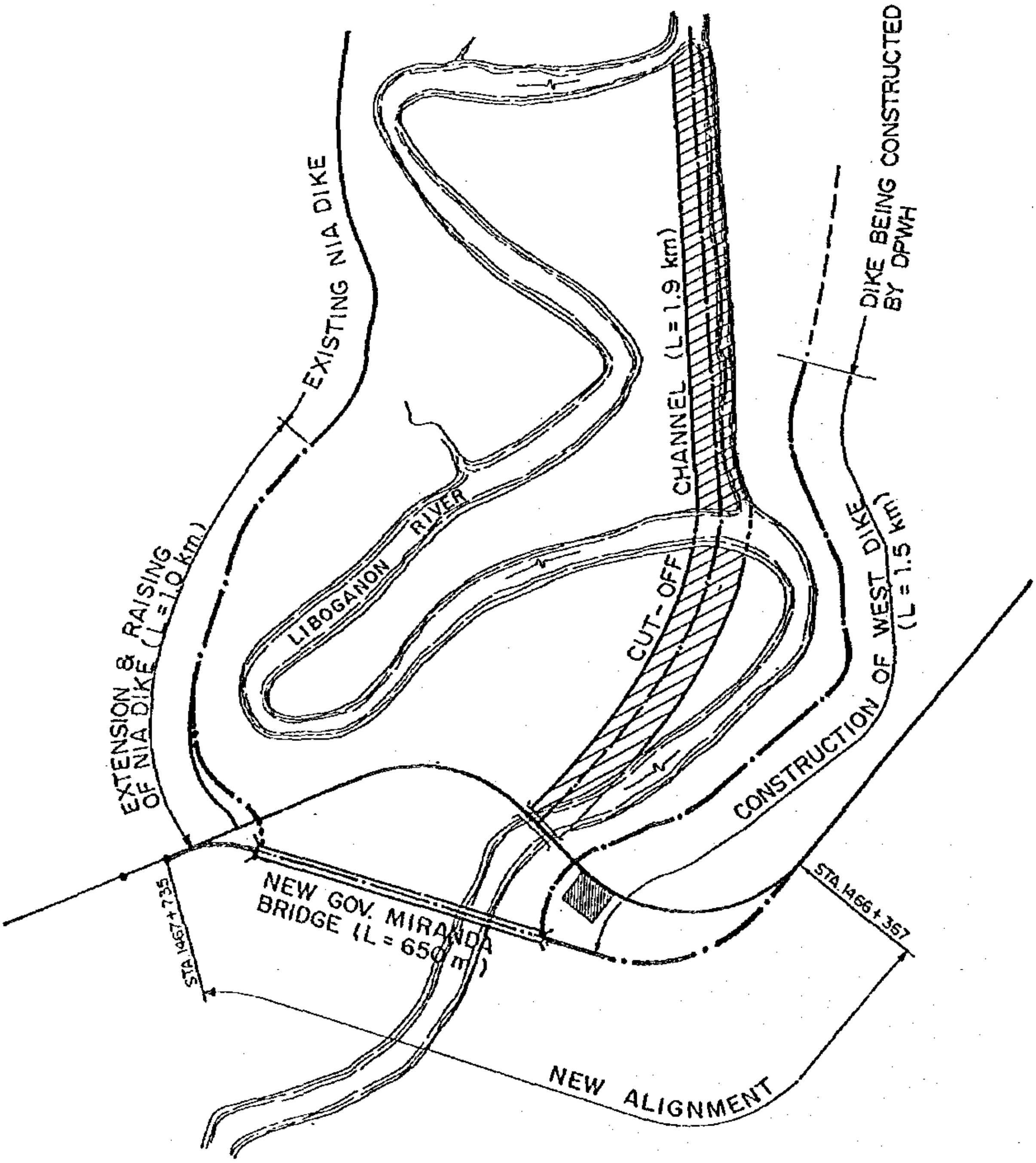


FIGURE 12.2-3 COUNTERMEASURES FOR LIBOGANON RIVER