2.3 Road Network

2.3.1 National Road Classification and Standards

The Direction of Road of MTI recorded 19,000 km of roads in Nicaragua in 1999. 41.8 % (8,000 km) is the Basic Road Network, with 58.2% (11,000 km) being the Rural Road Network. Only 10.1% of network is paved, most of which are part of the Basic road network. The remaining earth roads and almost half of the gravel roads become impenetrable during each rainy season. Table 2.3.1 and Figure 2.3.1 show the National Road Network in Nicaragua.

Table 2.3.1 National Road Network in Nicaragua (1999)

Administrational Classification	Total Length (km)	Percentage
Basic Road Network	7,920.92	41.8%
Paved Road	1,794.14	9.5%
Gravel Road	5,359.23	28.3%
All Year Earth Road	767.55	4.1%
Rural Road Network	11,025.70	58.2%
Paved Road	119.08	0.6%
Gravel or Stone Paved Road	34.86	0.2%
All Year Earth Road	10,871.76	57.4%
Total National Road	18,946.62	100.0%

1) Road Classification

For the Basic Road Network in Nicaragua, the National Transportation Plan (NTP) recommended the following classification introduced to a network of 7,442.6 km.

Class A: (14 trunk roads, 1,748 km)

Class A road are defined as trunk roads (with a total length of 1,748 km) taking between 80 and 90% of the National Traffic. The function of the trunk road network is to secure the integration both of national and international traffic.

Class B: (30 collectors, 636 km)

Class B roads are collector roads connecting important population centers to each other and to the Class A road network. The function of the collector road is an access to the trunk road network servicing for traffic.

Class C: (50 strategic local roads, 2,052 km)

Class C roads are generally existing local roads with the potential to serve as :

- a connector to national and international trunk road
- as a collector road

- as a new trunk road
- an access to a port or airport

Class D: (Local Penetrating Road)

Class D roads are local roads which penetrate and service local areas, linking with other roads in the Basic Road Network.

Based on the above classification above, the objective roads in this study are Class A, Trunk Road, with the exception of NIC.5, which is classified as a Class B, Collector Road, due its relatively low traffic volume.

Table 2.3.2 Road Classifications

Objective Road	Classification	Function
NIC.1	Class A	International Trunk Road
NIC.3	Class A	National Trunk Road
NIC.5	Class B	Collector connecting with population center
NIC.15	Class A	International Trunk Road
NIC.24	Class A	International Trunk Road
NIC.26	Class A	National Trunk Road

Typical geometric characteristics of the country's paved roads are set out in Table 2.3.3.

Table 2.3.3 Road Physical Geometric Characteristic

Item	Geometric Characteristic
The width of crown	6.0 - 10.0 m
The width of pavement	6.0 – 7.3 m
Right of way	20.0 – 40.0 m
Gradient	2 – 3%
Design Speed	60 – 80 Km
Maximum vertical	3 – 8%

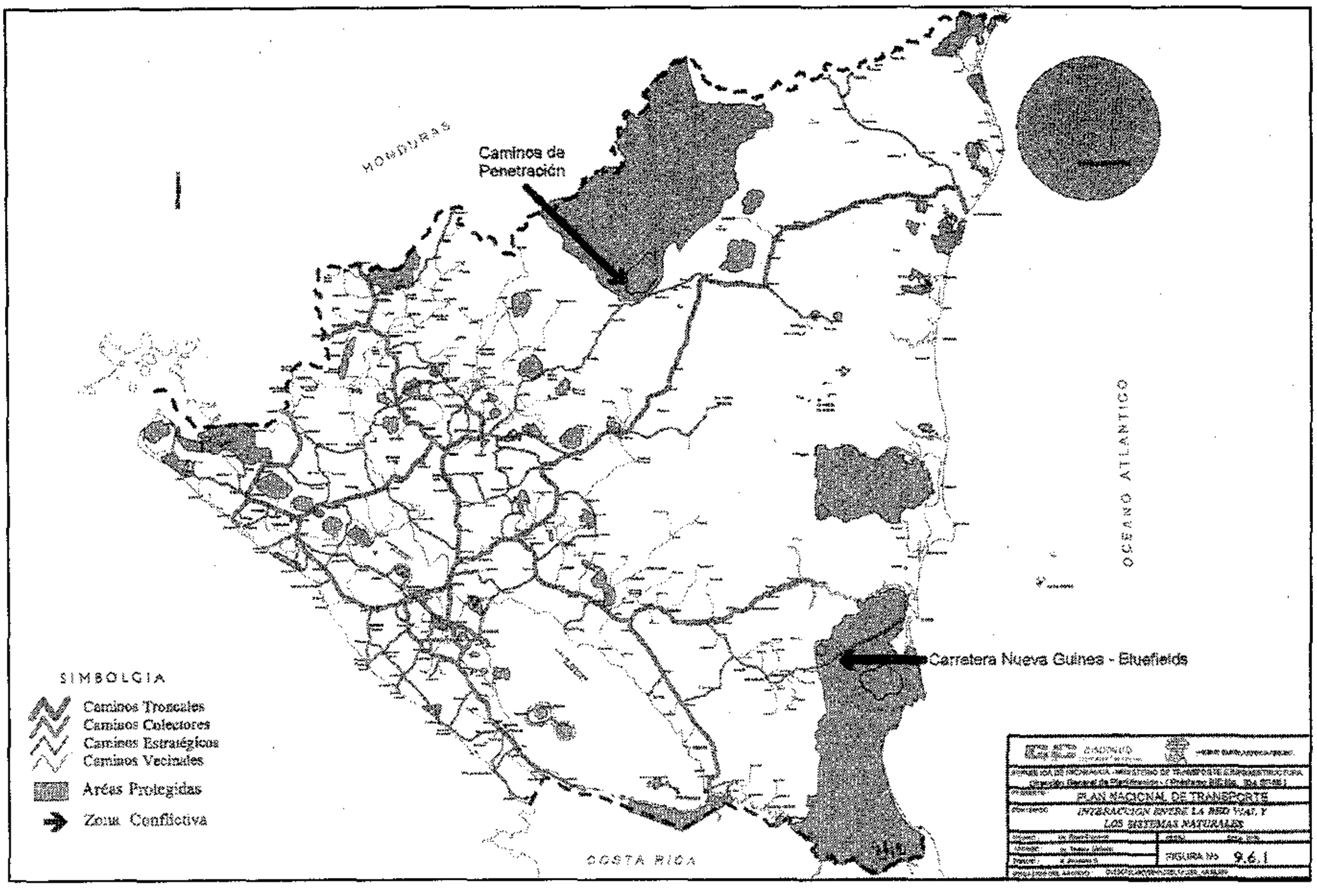


Figure 2.3.1 National Road Network in Nicaragua

2) Design Standards

Road Geometric Design Standards of Nicaragua were established in 1972 under the *General Specification for Road Geometric Project* and a revised manual published in 2001. The new standards include modifications to AASHTO standards to be applied to the countries of Central America with the support of USAID.

The classification of Roads for Geometric Design is identifies three types: Regional Motorway, Trunk Road and Collector Road. In Nicaragua, there are no Regional Motorways, or roads with full access control, and so design standards for Class A (Trunk Road) and Class B (Collector Road) are appropriate for this study.

Based on the Design Standards, a practical application to all classified roads in Nicaragua has been prepared by the NTP as shown in Tables 2.3.4 and 2.3.5 and in Figure 2.3.2.

Table 2.3.4 Elements of Geometric Design of Regional Roads

No.	Description	Regional Motorway	Trunk Road		Collector Road	
			suburbans	rurals	suburbans	rurals
1	AADT	> 20,000	0		3,000-500	3,000-500
2	Hourly Traffic	> 2,000			300 - 50	450 - 75
3	Peak Hour Rate	0.92	0.92	0.95 - 0.91	0.92	0.85
4	Design Vehicle	WB-20	WB-20	WB-15	WB-15	WB-15
5	Type of Field	P O M	P O M	P O M	P O M	P O M
6	Design Speed , (Km/hour)	110 90 70	90 80 70	80 70 60	70 60 50	70 60 50
7	Number of Lanes	4 to 8	2 to 4	2 to 4	2	2
8	Lane Width, mts	3.6	3.6	3.6	3.3 - 3.6	3.3
9	Shoulder Width, mts	Int: 1.0 - 1.5 Ext: 1.8 - 2.5	Int: 1.0 - 1.5 Ext: 1.8 - 2.5	Int: 0.5 - 1.0 Ext: 1.2 - 1.8	Ext: 1.2 - 1.5	Ext: 1.2 - 1.5
10	Surface Type	Pav	Pav	Pav	Pav	Pav. - Gravel
11	Stop Distribution, mts	110-245	110-170	85-140	65-110	65-110
12	Advancement distribution,	480-670	480-600	410-540	350-480	350-480
13	Minimum Curve Radio	195-560	195-335	135-250	90-195	90-195
14	Maximum Curve Grade	5º 53' - 2º 03'	5º 53' - 3º 25'	8º 29' - 4º 35'	12º 44' - 5º 53'	12º 44' - 5º 53'
15	Maximun Vertical Grade	6	8	8	10	10
16	Superelevation, percentage	10	10	10	10	10
17	Transversal slope %	1.5 - 3	1.5 - 3	1.5 - 3	1.5 - 3	1.5 - 3
18	Shoulder Slope, %	2 - 5	2 - 5	2 - 5	2 - 5	2 - 5
19	Bridge Width, meters	Variable	Variable	Variable	7.8 - 8.7	7.8 - 8.1
20	Bridge Design Load, (AASHTO)	HS 20-44 +25%	HS20-44 +25%	HS20-44 +25%	HS20-44	HS20-44
21	Road Right Width, mts	80-90	40-50	40-50	20-30	20-30
22	Median Width, mts	4 -12	4 -10	2 - 6		
23	Service Level	B-C	C-D	C-D	C-D	C-D
24	Type of Access Control	Total Control	Partial Control	Without Control	Without Control	Without Control
25	Functional Classication	AR-TS	AR-TS-TR	WB-15	TS-CS	TS-CR

Notes:
Pav.= Asfaltic pavement
P= Plane O= Ondulated M=Mountainous
AR= Regional motorway TS= Suburban trunk road TR= Rural trunk road CS= Subarban colector road CR Rural colector road

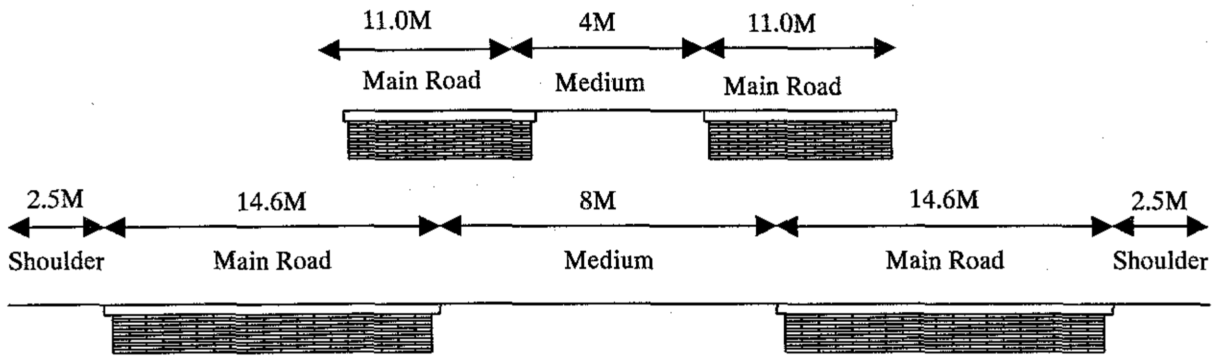
Table 2.3.5 Geometric Specifications of Reference

No.	Volume of Traffic (AADT)	>20,000	20-10,000	10-3,000	3,000-5,000	1,000-300	<300
1	Functional Classification	A1-B1	A1-B1	A2-A3-B1-B2	A3-B2	A3-B2	D
2	Surface	Pavement	Pavement	Pavement	Pavement	Pave/ Gravel	Gravel
3	Design Speed (kph)	80-100	60-100	80-100	60-100	50-100	40-60
4	Access	Prohibited	Controlled	Controlled	-	-	-
5	Intersections	Unevenness	Unevenness Rotundas Semaphores	Rotundas Semaphores Labels	Semaphores Labels	Labels	-
6	Number of lane in one direction	3-4	2-3	1	1	1	*
7	Lane width	3.00-3.65	3.00-3.65	3.30-3.65	3.30-3.65	3.30-3.65	*
8	Shoulder width	0.0-2.50	1.00-2.50	1.50-1.80	1.00-1.80	1.00-1.80	-
9	Medium	2.00-4.0	1.00-4.0	1.00-4.0	**	**	-
10	Right of Way	30	30	30	20	20	15
11	Width of Road	10	10	10	5	5	5

A1: Special Trunk Road (Motorway)
A2: Trunk Road, suburban
A3= Trunk Road, rural
B1= Collector Road, suburban
B2= Collector Road, rural
D= Local Road
* = Width of minimum road 5.00 m
** = Only applicable in urban zones

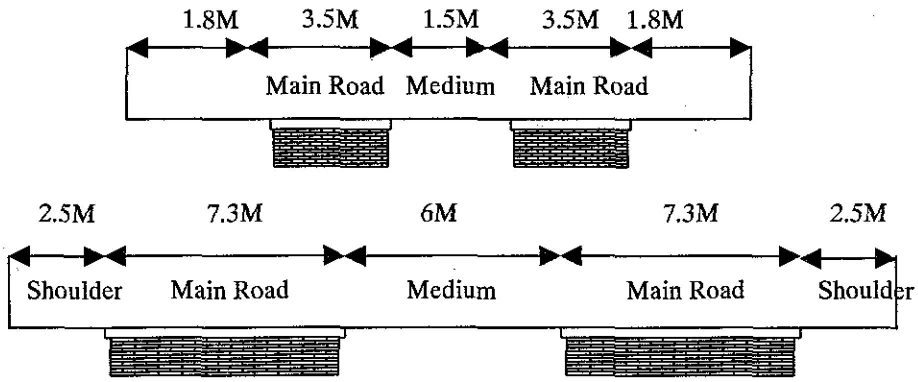
A1 - SPECIAL MOTORWAY

Paved with marginal roads and paved access control



A2 – SUBURBAN TRUNK ROAD

Paved



A3 – RURAL TRUNK ROAD

Paved

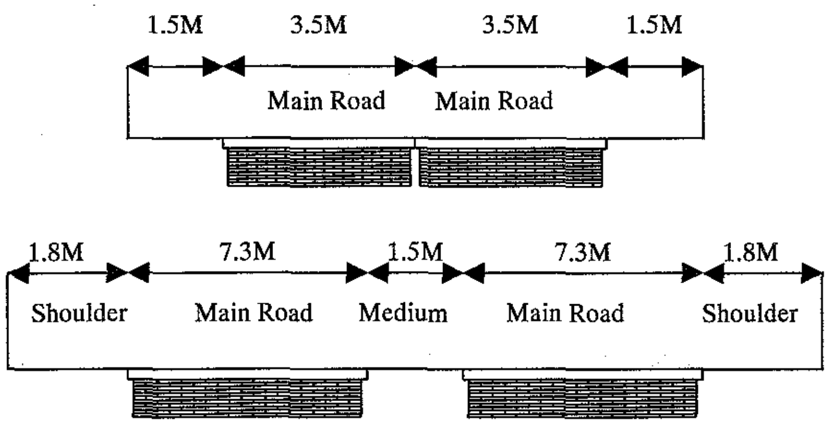
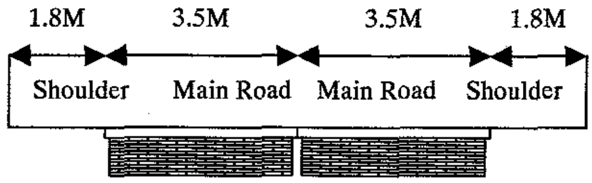
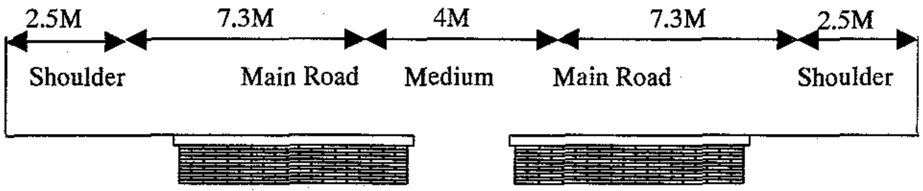


Figure 2.3.2 National Transportation Plan (1/2)
Transversal Sections of Reference

B1 – SUBURBAN COLLECTORS

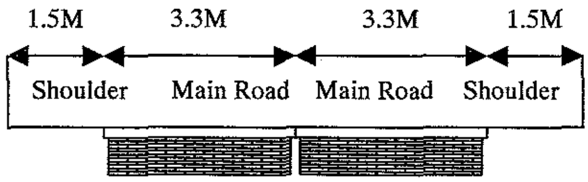
Paved

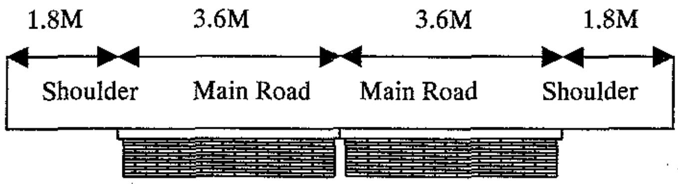




B2 – RURAL COLLECTORS

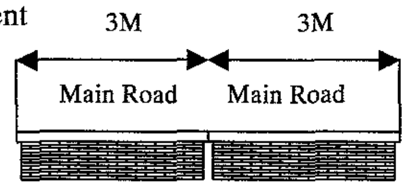
Paved

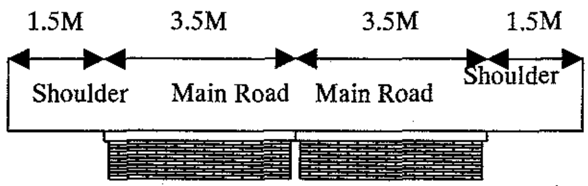




C – STRATEGIC LOCAL ROAD

Gravel or Stone or Pavement





D – LOCAL PENETRATING ROAD

Gravel or Stone

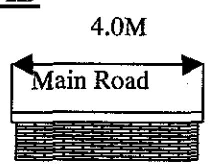


Figure 2.3.2 National Transportation Plan (2/2)
Transversal Sections of Reference

2.3.2 Road Maintenance

The responsible organization for National Road Maintenance is the Direction of Road Maintenance in the General Direction of Road within MTI

1) Organization and Budget

Under the General Direction of Road, there are 5 directions : Direction of Road Construction, Direction of Road Maintenance, Direction of Administration, World Bank Projects and IDB Projects.

The Direction of Road Maintenance has an Administration Unit, a Supervising Engineer, and 6 Supervisors with 37 Inspectors.

The total organization of the General Direction of Road and the Direction of Road Maintenance is shown in Fig. 2.3.3 and Table 2.3.6 shows the number of staffs in each Direction and the budget for the year 2002 under the General Direction of Road.

Table 2.3.6 Number of Staff and Budget for 2002 under the General Direction of Road (Million Cordobas)

	General Direction of Road	Direction of Road Construction	Direction of Road Maintenance	Direction of Administration	World Bank Project	IDB Project	Total
Staff Nº.	5	27	59	67	19	25	270
Contract	0	5.0	56.0	0			61.0
Management	0.6	5.0	27.3	3.2			36.1
Tax	0	5.5	10.9	0			16.4
Sub-Total	0.6	15.5	94.2	3.2	(2.7)	(3.7)	113.5
External Aid		117.5	0.0	0	(10.9)	(20.9)	117.5
Grand Total	0.6	133.0	94.2	3.2	(13.6)	(24.6)	231.0

Note: 67 persons included, who belong to unknown divisions.

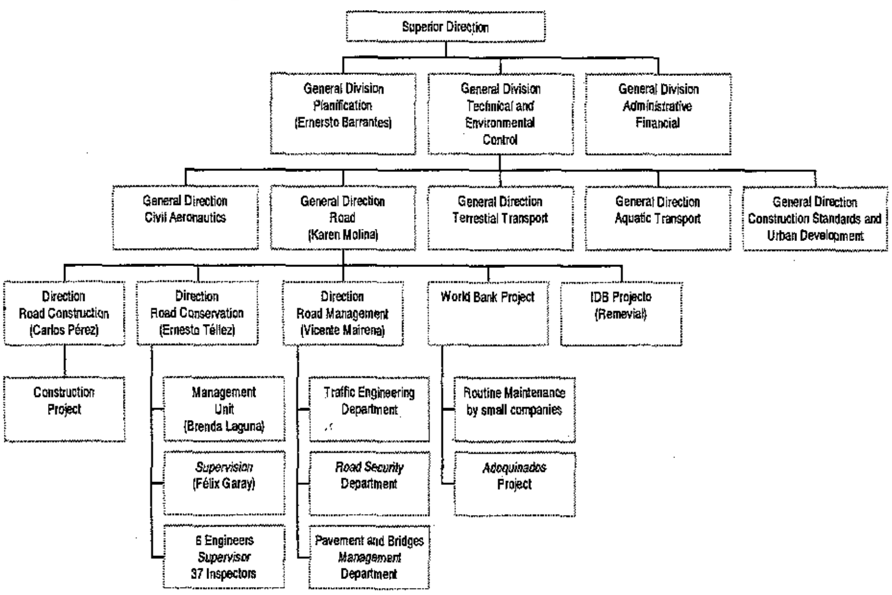


Figure 2.3.3 Organization of the General Direction of Road in MTI

2) Road Maintenance Target

Table 2.3.7 shows all organizations with responsibilities for road maintenance.

Table 2.3.7 Various Work Target and Budget of Road Maintenance

Group	Main Work	Budget & Works by
Dirección de Conservación Vial (Road Conservation Division)	Patching and periodical maintenance using equipment under the supervision of Road Conservation Division Staff	Annual budget is about $12 million and almost works will be ordered to COERCO group as mentioned later
World Bank Program of Routine maintenance for small company	Mainly routine works such as manual cleaning of road and shoulder. 80% is on Pan-Am highway, and 20% is for secondary road.	Annual Budget is about US$ 1 million (80% by WB) for the 1600 km length of road by using 28 small companies.
IDB Program of "Remevial" (Rehabilitation of Carretera Panamericana)	Conservation works of Pan Am Highway from San Benito to Las Manos. Reconstruction of Bridge of Carretera Masaya (Km 14) (Puente Arroyo)	Pan Am highway US$21 million Bridge to Masaya $3.6 million Total US$24.6 million 85% loan from IDB 15% from domestic as tax deduction.

In the Direction of Road Maintenance, 7 supervisors and 37 Inspectors manage road maintenance works conducted by the Corporation de Empresas Regionales de Constract Regionales de Constractión (COERCO), which is a parastatal contractor.

Based on the information corrected through the director of Road Maintenance, main issue of the road maintenance is the shortage of budget. Indeed, the budget for road maintenance in the year 2002 is about 40% of the previous year's budget.

2.3.3 Road Traffic

Road traffic in Nicaragua is growing rapidly. Economic growth will underpin further growth in traffic.

The highest traffic volume in the country is on NIC.1 on the section from Managua to the International Airport.

Table 2.3.8 shows the growth of Annual Average Daily Traffic (AADT) and Daily Truck Traffic (DTT) on each section of Objective Roads.

Based on the practical application of the road classification proposed in the NTP, the following classification of both total traffic demand and commodity movement demand has been introduced.

Class A:		AADT	>3,000		DTT	>300
Class B:	3,000>	AADT	>300	300>	DTT	>30
Class C:		AADT	<300		DTT	<30

As the result of the classification, NIC.1 and 3 are the highest classes of road both total traffic demand and commodity movement. NIC.5, 15, 24 and 26 are classified as Class B level of total Traffic Demand, but NIC.15, 24 and 26 are also classified as class A level for commodity movement.

Table 2.3.8 Traffic Volume on Objective Road

Name of Road	Section	Dist (Km)	Annual Average Daily Traffic (AADT)			Class	Daily Truck Traffic (DTT)			Class
			1997	1999	2001		1997	1999	2001	
NIC.1	Managua (Portezuelo)-Airport	10.0	---	23,000~ 41,000	30,000~ 47,000	A	---	3,000~ 4,600	3,200~ 4,400	A
	Airport- San Benito	21.0	4,100~ 9,300	5,000~ 16,000	6,000~ 20,000	A	1,100~ 1,700	1,500~ 2,400	1,600~ 3,800	A
	San Benito-Sébaco	64.1	2,400~ 2,600	3,100~ 3,500	---	A	650~ 720	820~ 900	---	A
	Sébaco- Estelí	44.9	1,700~ 2,300	2,000~ 3,000	2,100~ 3,000	A	400~ 480	500~ 730	610~ 770	A
	Estelí-Yalagüina	59.5	900~ 1,800	1,000~ 2,400	---	B	260~ 410	480~ 900	---	A
	Yalagüina- El Espino	22.4	300~ 600	---	---	B	60~ 150	---	---	B
		221.9	~			A				A
NIC.3	Sébaco-Matagalpa	29.9	2,100~ 3,300	2,700~ 4,400	---	A	400~ 800	700~ 800	---	A
	Matagalpa-Jinotega	21.0	900~ 1,400	700~ 800	---	B	180~ 300	170~ 230	---	B
		50.9				A				A
NIC.5	Matagalpa- La Dalia	48.2	400~ 1,600	---	500~ 1,800	B	120~ 290	---	130~ 280	B
NIC.15	Yalagüina-Ocotal	24.0	900	1,200	---	B	250	400	---	A
	Ocotal-Las Manos	7.1	700	700	---	B	210	260		B
		31.1				B				A
NIC.24	Chinandega-El Guasaule	77.2	900~ 1,000	1,300~ 2,000	---	B	320~ 390	460~ 650	---	A
NIC.26	Telica- San Isidro	98.5	800~ 900	600~ 1,400	---	B	130~ 190	200~ 450	---	A

2.4 Road Disaster

2.4.1 Past Disaster Record

Nicaragua suffers from many natural disasters caused by topographical and meteorological conditions. Table 2.4.1 shows the record of past disasters in Nicaragua.

Table 2.4.1 Past Disaster Record (1/2)

No.	Year	Event	Place	Affectations
1	1609	Momotombo Volcano Volcanic Eruption	Old Leon	Evacuation of the population that inhabited the Old Leon City
2	1610	Earthquake	Old Leon	Evacuation of the population that inhabited the Old Leon City
3	1670	Masaya Volcano Lava Eruption (Lava falling down)	Masaya	The lava leakage coming from Nindiri Volcano covered an area from 2.12 kilometers. With a volume of 106x 10 mts.
4	1772	Masaya Volcano Lava Eruption	Masaya	From 16th to 23rd March, it produced the second lava eruption, that produced lava flow to the north and east of the volcano, covering a 7.51 kilometer area. And a volume of 22.5x10 mts, reaching around very near Sabanagrande.
5	1876	Hurricane Alluvion		From 2nd to 4th October, Managua city was covered by water and mud flows that came from ranges and the mountains located in the south of the city. The city remained semi destroyed.
6	1926	Earthquake Strong sysmic movement in Nicaragua	All the country	On Friday 5 November at 2:00 in the morning, a violent earthquake shaked all the country, Nicaragua. In Leon, the 80% of the building suffered breakdowns, and in Managua, the 50% of the buildings were damaged. In Managua also, the water dam from Ticuantepe was completely buried
7	1931	Earthquake	Managua	On March 31st, at 10:45 am, a shake of magnitude between 5.3 and 5.9 in the Ritcher scale destroyed the growing Managua city, causing losses in human lives. A thousand died and 2 thousand suffered injuries.
8	1968 and 1971	Cerro Negro Volcano		It caused 2 km long in lava flow during 53 days of activity. It expulsed big quantity of ashes, and brought up an eruptive column that affected an area from 5.7 km2, and destroyed a big quantity of acres of cultivated land.
9	1972	Earthquake	Managua	On December 23rd, there were three shakes of big magnitude, that caused the loss of lives to 10.000 persons. 20,000 were injured and 60,000 houses were destroyed. Estimate damages for 772 millions dollars.
10	1082	Hurricane Alleta	Pacific zone	In may affected la pacific zone, damaging road and bridges, infrastructure damages in the Occident, and also in agriculture. It were recorded 69 dead and estimate losses: 480 millions dollars.
11	1988	Hurricane Joan	Atlantic Coast	It destroyed the city of Blufields, Rama City and Corn Island. Results: 148 dead, 184 injured, 23,200 destroyed houses. Infrastructure damages: roads, bridges, power wires and communications. It affected more than 500,000 persons. Total losses: 840 millions dollars.
12	1991	Flood	Rama City	In July, the grow of the Escondido River caused flood in Rama City and La Esperanza Port, affecting around 20,000 persons, causing material damages in houses and animals
13	1992	Cerro Negro Volcano Eruption		XIV Cerro Negro Eruption, violent and short period. It forced to the evacuation of the peasant population. It expeled thousands cubic meters of ashes and sand, and the eruptive column height reached the 26 thousand feet. It affected 11,578 manz. of cultivable lands. 565 houses were semi destroyed and there were 100 injured. Estimated losses: 19 millions dollars.
14	1992	Pacific Coast Tsunami	Pacific coast	September 1st at 19:15 hrs, there was a shake in the button of the sea with a magnitude of 7.2 in the Richter scale, that affected the Pacific Coast. The tsunami caused waves from 8 and 15 mts height and affected the cost in 250 km length. 26 urban comunities suffered the consecuences from the phenomenom that left 116 dead, 63 dissapeared and 489 injured. Totally, there were 40,500 people affected. The estimated looses in damages: 25 millions dollars
15	1993	Tropical Storm Gert	South Atlantic Autonomous Region	On August 15th, at 12:00 hours, the tropical storm Gert whipped Blufields coasts with a speed of 17 km7hr., strongly affecting the South Atlantic Autonomous Region. It left13 dead, 24 disappeared, 62,192 injured, 252 destroyed houses and 292 damaged houses
16	1993	Tropical Storm Bret	North Atlantic Autonomous Region	In September, the North Atlantic Autonomous Region was affected by the Bret Tropical Storm, causing 1,138 destroyed houses, 1,530 damaged houses, and 65,029 people injured. The estimate losses are around 5.1 millions dollars.

Table 2.4.1 Past Disaster Record (2/2)

No.	Year	Event	Place	Affectations
17	1995	Flood	All the country	The intense rains that began on september 25th continued until october 11th. During those 18 days generated serious economic damages to the urban population an the rural population form the regions I, II, IV, and VI. 3,525 people were affected, 32 people died, 1,343 injured, 71 destroyed houses, 161 partially damaged, 1,214 affected wells , 1,050 floos latrines, 1,525.3 km of damaged roads and 13 destroyed bridges. Estimated economic losses of 17, 219,363.00 dollars. 11, 643,788.00 belonged to the agriculture production.
18	1995	Volcanic Eruption	León	On November 19th, the Cerro Negro Volcano's eruption affected an area from 9,839 manz. (1manz= 10,000mts2) with volcanic sediment (sand) covering
19	1996	Hurricane Cesar	North Atlantic Autonomous Region	On July 27th, Hurricane Cesar beat around 30 kms of the Atlantic Coast, aproximately to the north of Blufields, crossing the country in direction to the Pacific coast on the Padre Ramos Estuary, in Chinandega Department. It caused more than 100,000 affected, including 31,828 injured and economic losses for more than 29 millions dollars.
20	1998	Hurricane Mich	All the country	The worst natural disaster in the Nicaraguan history. Intense rains that began on october 22 and continued until october 31.The most critical period during the 27th and 31th october.The hurricane stay stacionary between the 21:00 hours on october 28th until the 19:00 hours from the 29th.Mitch go throw the land about 50 km south west from Trujillo city in Honduras. Mitch caused 870,000 victims, 2400 death, 287 hurts, 938 people disappear.US$1504 millions material loss(94% from de active, 6% production), 145,700 houses affected, 3,750 houses destroyed, 80% from the road network: 8000km road damage, 3800ml bridges damage, 42 bridges destroyed , 29 bridges semi destroyed.The total loss on the business area are consist on: US$ 14,4 millions in export (including the shrimp export), US$ 31,3 millions on agro products, US$ 8 millions on factory, US$ 18 millions on electric , US$ 20 millions on potable water, US$ 12 millions on connection , US$84 millions on the health area, US$ 51 millions on education.

2.4.2 Distribution of Road Damage by Disaster Type

The most serious disasters are hurricanes and floods caused by heavy rain. Less serious, but still major problems are volcanic eruptions and earthquakes.

1) Hurricane and Flood Damage

Table 2.4.1 reveals that the worst disaster for roads and bridges are hurricanes and floods. Nicaragua has been affected by 41 Tropical Cyclones between 1892 and 1996, of which 18 hurricanes, 50% were tropical storms and 5% were tropical depressions.

The Caribbean watershed or Atlantic Region, with its long rivers and high discharge, is most sensitive to overflowing owing to the topographic conditions, the humidity flow of the Caribbean Sea, and the occurrence of Tropical Storms.

The Pacific watershed has shorter rivers and less discharge, and so the potential to overflow are less than in the Atlantic region, but the effects are relatively greater bigger because of the population concentration. Hence impacts on the social and economic infrastructure tend to highest on this side.

The region with the highest impact of tropical cyclones is the North Atlantic Coast. However, the Pacific Ocean area is sometimes affected by hurricanes. In recent years the biggest hurricane was Mitch in October 1998 that caused severe damage to the north-western area of Nicaragua.

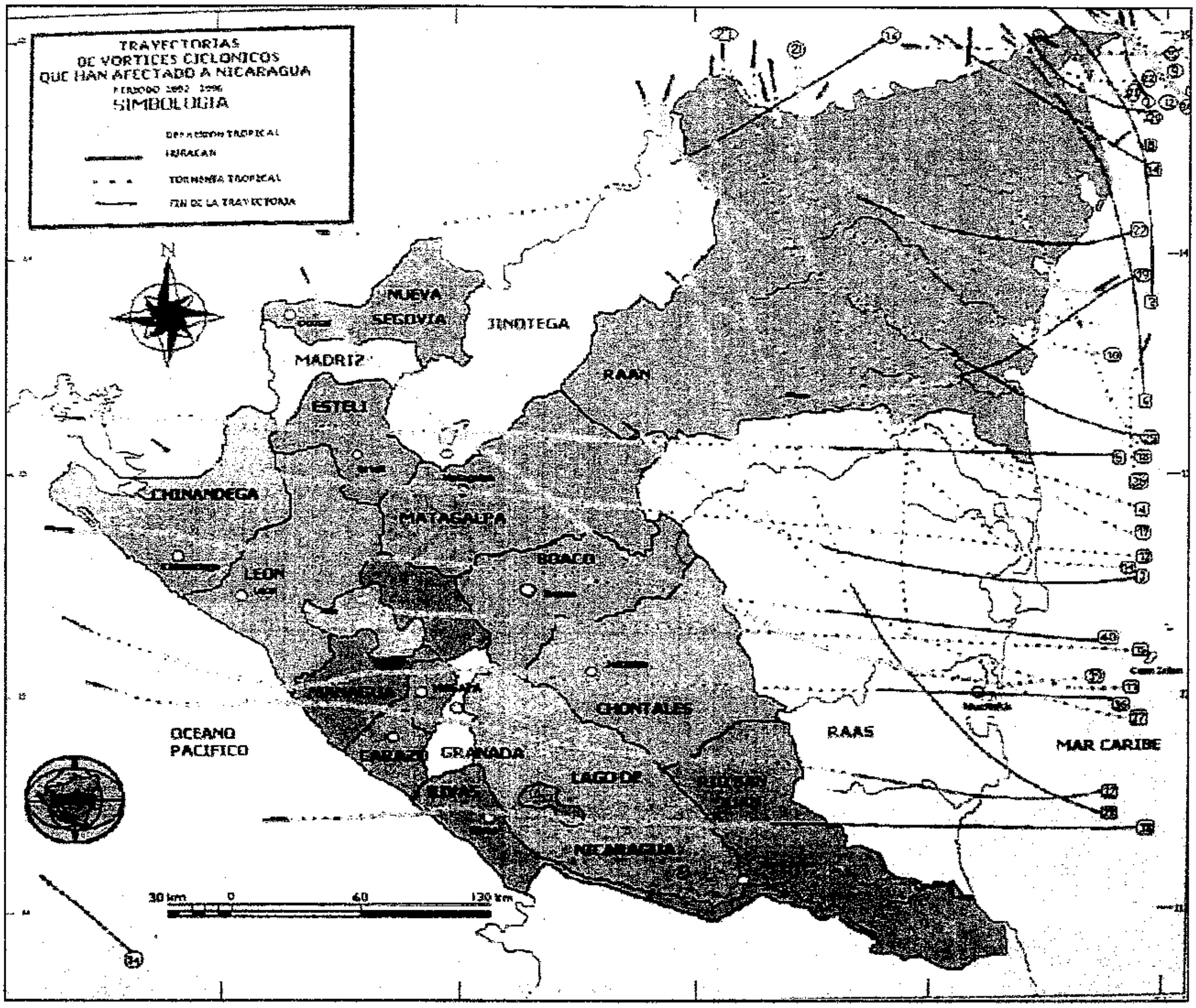


Figure 2.4.1 The Route of Past Cyclones

2) Seismic Damage

The National Seismic Network was established in 1975 to observe earthquakes. Although its work was interrupted between 1985 and 1991, it has collected data on almost 25000 seismic incidents. Figure 2.4.2 shows the distribution of seismic centers of activity in the Region, between 1993 and 2001.

Most seismic activity occurred in the Pacific Ocean, where the Coco and Caribbean tectonic plates meet. A second important seismic band lies along a narrow strip alongside the volcanic chain from Cosiguina to Ometepe Island. In the mountain area of Nicaragua there was very little seismic activity. There was activity detected off the Caribbean coast, near to Corn Island.

Nicaragua is divided into 6 seismic zones, which increase in severity from 1 to 6. These are shown in Figure 2.4.3. The "Reglamento Nacional de Construccion" allow this zonal classification to be applied to the study objective roads as shown in Table 2.4.2.

Table 2.4.2 Classification of Objective Roads by Seismic Zone

Road Name	Section	Zone
NIC.1	From San Benito to Las Maderas	4
	From Las Maderas to Ciudad Dario	3
	From Ciudad Dario to Sebaco	2
	From Sebaco to El Espino	2
NIC.3	From Sebaco to jinotega	2
NIC.5	From Matagalpa to La Dalia	2
NIC.15	From Yalaguina to Las Mands	2
NIC.24	From Cinandega to Estero Real	4
	From Estero Real to Guasaule	3
NIC.26	From Terica to El Jicalral	5
	From El Jicalral	3

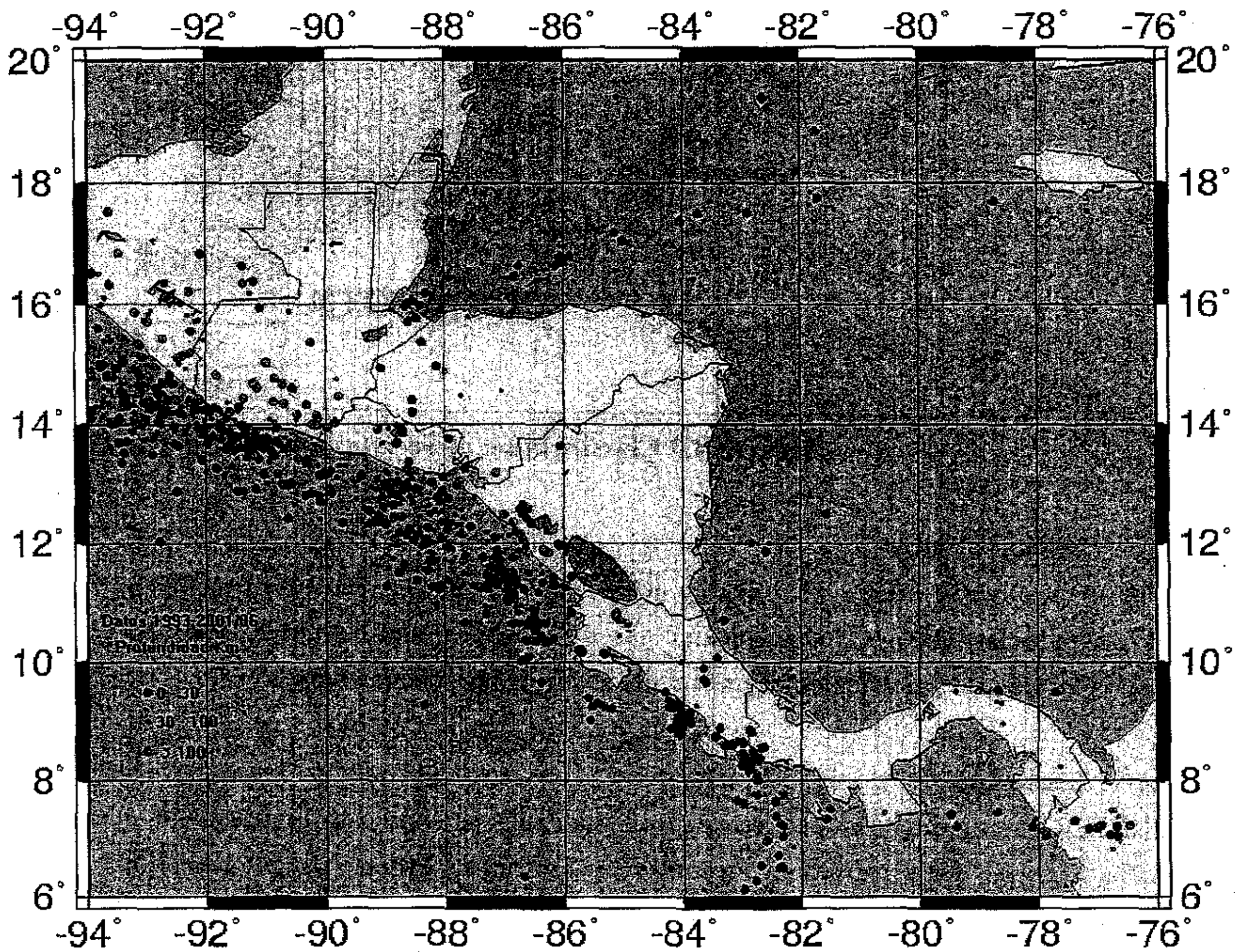


Figure2.4.2 Distribution of Seismic Center in Nicaragua (Source INETER)

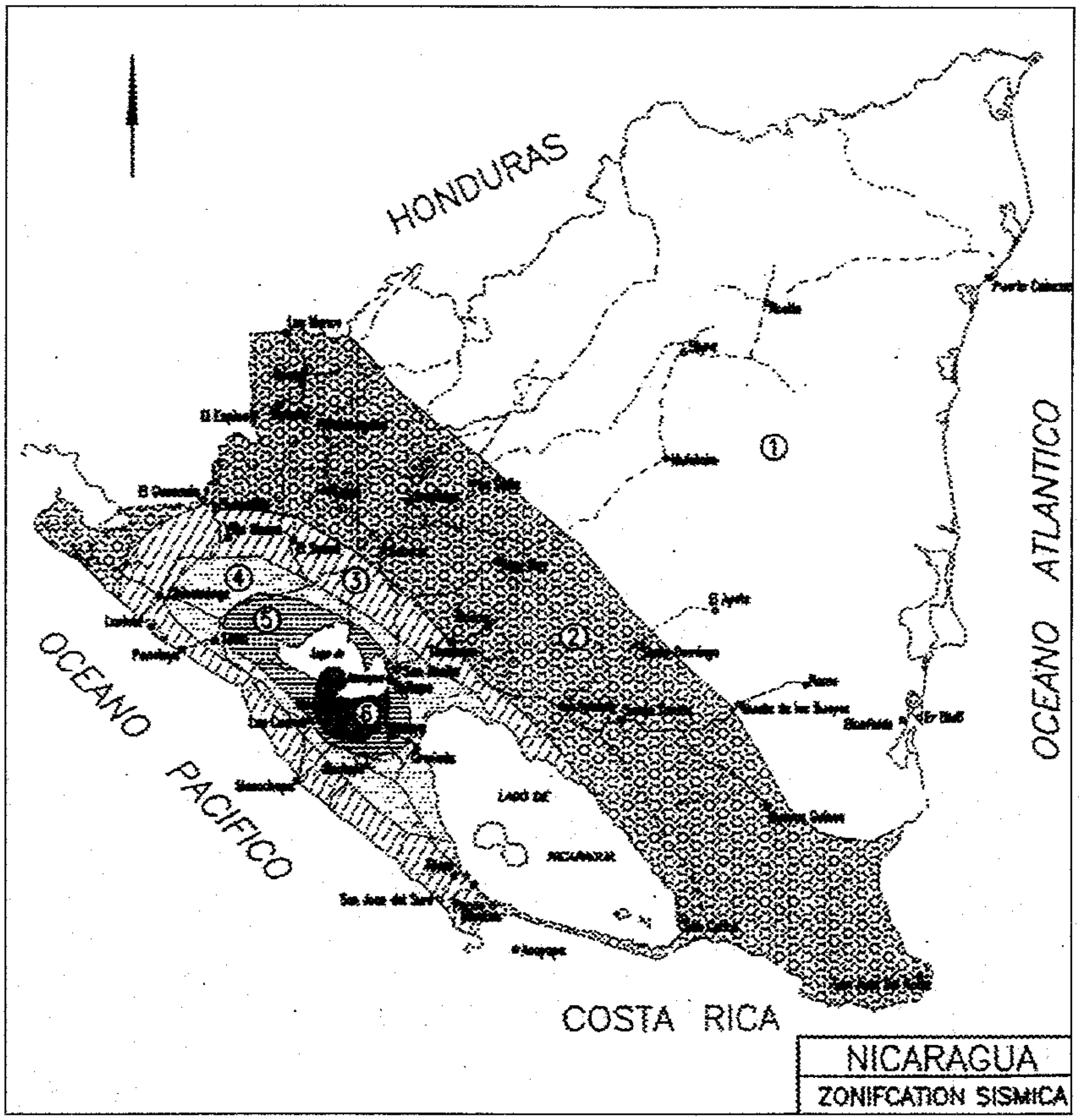


Figure2.4.3 Classification of Seismic (Source INETER)

3) Volcanic Danger

The main adverse effects of volcanic activity are : volcanic ash fall, pyroclastic fall, lava flows, pyroclastic flows, toxic volcanic gases, landslides, and collapses. The part of NIC.26 that is located on the volcanic chain is most at risk from volcanic danger.

4) Landslides

INETER has produced a location map of landslides as shown in Figure 2.4.4. More than 90% landslide were caused by occurred by Hurricane Mitch. Many landslides occurred between Matagalpa and Jinotega on NIC.3 and between Ocotal to Los Manos on NIC.15.

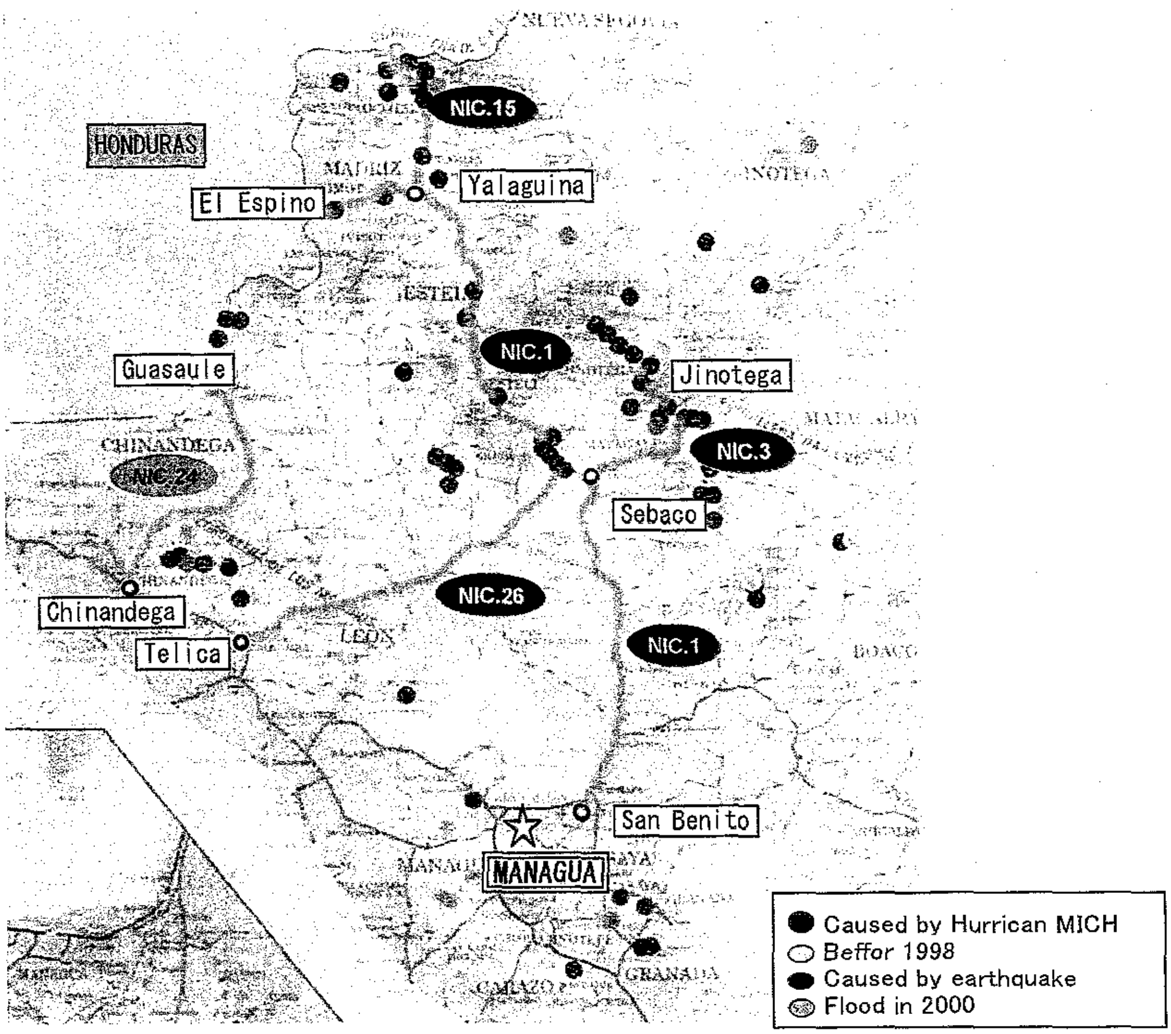


Figure 2.4.4 Location Map of Landslides (Source INETER)

2.4.3 Frequency of Traffic Interruptions

There are no detailed statistical data on the traffic impacts from natural disasters. However, in the case a lowland area like a section around Estero Real Bridge on NIC.24, typically hurricanes or tropical storms occur every 3 years. Floods that wash completley over the bridge are observed about once every 5 years.

It is rare for big floods, caused by tropical storms, to destroy bridges, but Hurricane Mitch destroyed many bridges and roads, and it has taken more than 3 years to effect repairs. Heavy rains can cause landslides and rock falling trouble in mountainous areas, for example around NIC.3 or NIC.15. These interrupt traffic flow. In the case of Hurricane Mitch, many landslides occurred, shown in Figure 2.4.4, and traffic was severely interrupted at these locations.

Other hurricanes and tropical storms, with less intensity than Mitch, tend occur about every 5 years and cause serious interruptions to traffic flow.

CHAPTER 3

NATIONAL DEVELOPMENT PLAN

CHAPTER 3 NATIONAL DEVELOPMENT PLAN

3.1 General

The Government operates on a five year planning cycle. In addition, MTI published a National Transport Plan in 2001. The study for this included the following;

Volume I ; Survey Profile
Volume II ; Demand of Transport
Volume III ; Inventory of Road Net
Volume IV ; Road Net Department
Volume V ; Water System
Volume VI ; Air System
Volume VII ; Road Diagnostic
Volume VIII; Model of Road Traffic
Volume IX ; Infrastructure Plan
Volume X ; Institutional Aspect
Volume XI ; Action Plan

The conclusions of the study were reported to the Government by MTI in January 2002.

3.2 Review of Past Development Plan

In 1965, Central American Bank of Economical Integration (CABEI), assisted by USAID, started the Central American Transport Study (CATS). These studies aim to achieve an important regional road network. Each participating country contributed survey data and financing for its.

CATS identified 13 routes for regional integration, including the Inter American Highway, (or Pan-American Highway). The construction of these roads was financed by CABEI. A second CATS was commissioned in 1974, and the third CATS is now underway.

In 1974, Nicaragua developed its own National Transport Plan for the next 10 and 20 years. The plan was reported to the Government on December 28 of 1976 by consultants from USA and Nicaragua. Early in 1976, the Government started to use its own resources to invest in transport, in line with the planes recommendations, but the civil war intervened and the plan was not able to be fully implemented. In 1990, the Government recognised the need to prioritise investment in transport and development plans. MTI was designated as the authority to administrate the implementation of urgent transport projects.

3.3 Future Perspective

3.3.1 Economic Perspectives 2000- 2020

The economic prognosis for the long term in Nicaragua reflects the last three years set of economic and financial reforms :

1. Structural reforms made between 1990 and 1999 within the framework of the overall Economic Program (ESAF),
2. Assistance from foreign countries in reducing external debt,
3. A reconstruction program to counter the massive destruction caused by Hurricane Mitch in 1998, and
4. The International Financial Help for the reconstruction of affected countries. National and foreign investment has been encouraged by the Government complemented by economical, political and social reforms.

3.3.2 Economic Projection Model

The long-term economic projection model is based on programs prepared by the International Monetary Fund. The model identifies three key determinants. The first is overall political and economic objectives and goals. The second is the permissible limit of macro-economic balance, which needs to be determined for each economic sector. The third is the external resources that will be provided foreign countries, and international funding institutions.

3.3.3 Economic Forecasts, 2000- 2020

The macro-economic projections are based on the hypothesis of economic growth up to 6 % per year to 2010 followed by growth of 5.0 % to 5.5 % in next decade. By controlling growth the government aims to keep inflation in the first decade to around 6.5%, falling in the second decade to an annual average of 3.7%. The annual average rate of total investment in the economy is forecast to increase to 33.2% of GDP during by 2010, decreasing thereafter to an annual average of 30.2% of GDP.

Almost 80% of the public sector debt is committed to multilateral organizations and the Paris Club. Debt exceeds GDP almost threefold in Nicaragua. In the future, loans and donations of around US$400 million per year are expected during the 2000-2010 period. In the following second decade, external resources are expected to rise US$590 million per year, comprising transfers and foreign investments and income from the privatization of ports, airports, roads, energy, drinking water and communications.

3.3.4 Production Forecasts

GDP is forecast to grow from US$2,516.2 million in 2000 to US$4,613.5 million by 2010. During the following ten years, growth will decline resulting in a GDP of US$7,695.3 million by 2020, as shown in Table 3.3.1.

The main sectors contributing to GDP are agriculture, cattle, handicraft industry, construction, commerce, transport and communications. GDP per capita is forecast to rise from US$491.7 in 2000 to US$656.5 by 2010, and to US$800.0 level by 2020.

Table 3.3.1 Production Forecasts 2000- 2020 (Million US dollars)

CONCEPT	2000	2005	2010	2015	2020
GDP (constant)	2,516.2	3,447.4	4,613.5	6,029.5	7,695.3
Primary Sector	737.2	1,013.5	1,370.2	1,802.8	2,324.0
Agricultural & farm	681.9	951.5	1,301.0	1,718.4	2,231.6
Secundary Sector	676.8	937.7	1,259.4	1,658.1	2,108.5
Handcraft industry	503.2	706.7	955.0	1,254.1	1,608.3
Construction	130.8	179.3	244.5	331.6	423.2
Tertiary Sector	1,102.2	1,496.2	1,983.9	2,568.6	3,262.8
Commerce	451.7	620.5	830.4	1,085.3	1,369.8
General Goverment	161.0	206.8	267.6	331.6	423.2
Transport & Communication	122.0	168.9	226.1	295.4	377.1
GDP per capita	**491.7**	**574.1**	**656.2**	**732.1**	**797.4**

Source: Own estimation

3.3.5 Balance of Payments

It is expected that the increase of GDP over s sustained period will allow 80% of foreign debt to removed by 2020, as shown in Table 3.3.2.

3.3.6 Fiscal Forecasts

The government expects savings to rise to around 10% of the GDP during the forecast period. Debt alleviation in combination with public investment should reduce the fiscal deficit, from 2.2% of GDP in 2000, to 1.0% of GDP by 2020. These forecasts are amplified in Table 3.3.3.

3.3.7 Monetary Perspectives

The regeneration of the financial system to support economic growth is forecast to be characterized by private sector credit rising from 44% of GDP in 2000, to 54.2% in 2010, and 60% by 2020, shown in Table 3.3.4.

Table 3.3.2 Payment Balance

(Million US dollars)

CONCEPTS	2000	2005	2010	2015	2020
Deficit of current account	-714,0	-611,2	-463,4	-189,2	132,0
Respect to GDP %	-27,9	-18	-10,6	-3,5	2
Deficit in commercial account	-745,0	-749,2	-736,4	649,2	-400,5
Respect to GDP %	-29,1	-22,1	-16,9	-11,9	6,0
Exports FOB	912,2	1500,6	2358,8	3651,9	5492,9
Referent to GDP %	35,6	44,2	54,2	67,0	82,1
Imports FOB	-1657,2	-2249,8	-3095,2	-4301,1	-5892,9
Respect to GDP %	-64,7	-66,3	-71,1	-79,0	-88,1
Exports of B & S 1/	1150,2	1874,6	2,933,8	4500,9	6514,9
Referent to GDP %	44,9	55,3	67,4	82,6	97,4
Imports of B & S 1/	-1944,2	-2584,8	-3095,2	-4301,1	-5892,9
Respect to GDP %	-75,9	-76,2	-80,6	-88,4	-97,8
Loans & Donations	515,0	420,0	300,0	300,0	300,0
Respect to GDP %	20,1	12,4	6,9	5,5	4,5
Private Capital 2/	510,0	627,0	602,0	597,0	602,0
Respect to GDP %	19,9	18,5	13,8	11	9
International Brute Reservs 1/	664,1	971,6	1508,1	2069,8	3076,3
Respect to GDP %	25,9	28,6	34,7	38,0	46,0
Memorandum:					
Current GDP	2560,8	3392,9	4351,5	5447,8	6689,4

1/: Non factorial services;
2/: Include transfers and capital investment;
3/: Remnants.

3.3.8 Economic sustainability

The ESAF programmes for the last three years relied on IMF, World Bank and the international community for financial assistance. In the future, the country needs to execute the full programme of structural reforms agreed with the above mulit-lateral organizations in a Policy Framework Paper (PFP).

From 1994, Nicaragua was admitted to the club of countries with ESAF programs. In 1998 second ESAF was signed.

The Nicaraguan economy has maintained some sustainability and stability since 1994. It is to be hoped that a reduction in the fiscal deficit can be achieved.

Table 3.3.3 Fiscal Forecasts (Million US dolars)

CONCEPTS	2000	2005	2010	2015	2020
Current Saving of NFPS 1/	256,1	339,3	435,2	544,8	668,9
Respect to GDP %	10,0	10,0	10,0	10,0	10,0
General deficit of PS 1/	-56,1	-50,6	-64,8	-56,1	-68,9
Respect to GDP %	-2,2	-1,5	-1,0	-1,0	-1,0
General income of NFPS	953,9	1229,9	1533,9	1920,4	2358,0
Respect to GDP %	37,3	36,3	35,3	35,3	35,3
General Expense of NFPS	989,5	1280,5	1598,7	1976,5	2426,9
Respect to GDP %	38,6	37,7	36,7	36,3	36,3
Public Investment	221,2	296,5	380,3	451,1	553,9
Respect to GDP %	8,6	8,7	8,7	8,3	8,3

1/: NFPS= Non Financial Public Sector; PS= Public Sector, include Central Bank.

Source: Own Estimation.

Table 3.3.4 Monetary Forecasts (Million US dollars)

CONCEPTS	2000	2005	2010	2015	2020
Credit for Private Sector	1125,5	1736,6	2357,0	3106,6	4036,1
Respect to GDP %	44,0	52,0	54,2	57,0	60,3
Ready Cash (M3A) 1/	1868,3	3081,4	4399,9	5836,7	7376,0
Respect to GDP %	73,0	90,8	101,1	107,1	110,3
Circulant	303,5	554,4	911,2	1391,6	2011,1
Respect to GDP%	11,9	16,3	20,9	25,5	30,1
Quasi Money	332,1	547,7	782,1	1037,4	1311,0
Respect to GDP %	13,0	16,1	18,0	19,0	19,6
Foreign Money deposits	1232,8	1979,3	2706,7	3407,7	4053,9
Respect to GDP %	48,1	58,3	62,2	62,6	60,6

1/: Include deposits of Public Sector. Source: Own estimations.

CHAPTER 4
ASSESSMENT OF ROAD DISASTER PREVENTION SPOTS

CHAPTER 4 ASSESSMENT OF ROAD DISASTER PREVENTIONSPOTS

4.1 Classification of Road Disaster

This study describes the stability of slopes in Nicaragua and the factors which affect stability. The routes studied are shown in Table 4.1.1.

Table 4.1.1 Route Studied for Road Disaster Prevention and Length

Name of Route	Section	Length
NIC.1	San Benito – El Espino	Approx. 205 km
NIC.3	Sebaco – Jinoteca	Approx. 58 km
NIC.5	The Site of 24.6 km from Matagalpa	-
NIC.15	Yalaguina-Las Manos	Approx.41 km
NIC.24	Chinandega – Guasaule	Approx. 73 km
NIC.26	San Isidro – Telica	Approx. 117 km
Total	6 Routes	Approx.495 km

Table 4.1.2 presents the geology and topography of each route.

Table 4.1.2 Geology and Topography of the Routes for Road Disaster Prevention

Name of Route	Topography	Geology
NIC.1	Gently-sloping hills at height of 120m-480 m for 120 km between San Benito and Sanisidin Between Sanisiden and Esteli there rise up to 1,040 m but the height is between 880-540 m until the border with Honduras of 117 km length(820 m height). Special feasure rests with lava plateau called Mesa.	Area of mainly volcanic rock belonging new Terti-ary era and andesite lava welded tuff, partly agglo- merate and pyroclastic rock are distributed. And- site is self-fracture and some are split into 20cm but some others are huge like 2 m in diameter. Conditions are varied.
NIC.3	Height is gradually raised at Sebaco (440 m height) and 700 m at Matagarupa, pass through the highest point at 1,480 m, and reach Jinotega with 960 m height.	Volcanic activities are seen in Matagarupa mainly, tuff, andesite- lava flow, sandstone of Palaeogene and Neogene are distributed.
NIC.5	This is a mountainous route along the river and is a part of spur. And it passes down to the river at a sharp cliff.	On the top is talus deposit with many rubbles, and thereunder are pyroclastic andesite. Boundary between them is not clear but it can be distinguished as andesite shows anti-dip slope and talus deposits is like rock debris falling down slope. Collapse happens at the boundary between them and partly involves bedrock weathered zone.

Name of Route	Topography	Geology
Nic.15	Height is raised at Yalaguina (650m height) and reach 1,200m at the border with Honduras. Old bedrock is distributed and the feature rests with fault topography.	Except that the volcanic rocks of Neogene are dis- tributed near Yalaguina, black schist, green schist, granodiorite have become decompose granite soil. Therefore, a vast amount of earth and sand are discharged into diluvium deposit. Recently, there does not happen such large debris flow like Mitch due to dry weather. But the slope still remains even though decomposed granite soil collapsed entirely.
Nic.24	This route passes through the northern mountain but all the route passes flat area of 20-55 m height. Only two slopes will be studied for road disaster prevention. Rather, being lowlands, some places will be covered with water at the time of flood.	Except that rocks with columnar joint of andesite exposed at around 10 km of Chinandega, many low outcrops of tuff are found. Traffic trouble is concerned due to eruption of Quaternary era volcano.
NIC.26	Height is 455 m at the junction of San Ishidro with NIC.1. This route goes west along the river at around 450 m height until the point of 28 km Height will be reduced gradually from that point and less than 20 m at Telica, the last point. Along the river, left lateral fault is predicted thereby east-northeast displacement will affect the stability of slope. This route is also under the influence of the Quaternary volcano.	Basically, andesite lave and tuff of Neogene volcano rocks exit. But alteration into green schist is also seen. Green tuff also found. Phenomena are varied like those blocked by fault or rhyolite intrude along the fault but some unstable factors are found which are not seen in other routes. This route is also concerned for traffic problem due to eruption of Quaternary volcano from Momotombo etc.

Based upon the above geological and topographical features and taking into account that Nicaragua has not changed its land conditions much artificially, the following examples are studied to distinguish geophysical features:

i) Where contour line is disordered especially low swampy area is changed into colluvial slope, there is a fear of collapse or landslide (NIC.1- NIC.26, NIC.24 are forecasted for volcanic debris flow.)

ii) There will be a fault where saddle topography are seen in straight line (NIC.15 and 26).

iii) Where slope angle is changed, frequent collapse are presumed (all the route).

iv) River meander is meant for intruding of mud. Landslide should be checked (NIC.3, around Matagalpa).

v) Debris flow, talus deposits and alluvial fan may be derived from loose sand and gravel layer. Gushing water and collapse should be pecular (NIC.15).

vi) Difference between the ecology and the surrounding area means the collapsed land. Recovery for vegetation takes time (NIC.15)

vii) Terrace, area under hill, Mesa-shaped mudstone, weathered zone of tuff might be feature for a big collapse (NIC.3 around Matagalpa).

viii) Weathered zone of tuff should be checked for collapse and landslide (NIC.3).

ix) Crack in slope shoulder is a sign of collapse. Old cracks have become small trails. Difference in grade should be checked (NIC.5, El Tuma).

x) Gully and piping can be a cause for collapse (NIC.15).

xi) The slope which has spring water in rainy season contains a danger of collapse (NIC.15).

xii) Continued falling-rocks from slope means a sign of collapse (NIC.5, ElTume).

xiii) Water system of lava plateau is complicated with wide catchment area. Points where water gathers should be checked. Collapse for embankment should be forecasted (NIC.1).

The slope collapse has also been studied under the following items taking into account the past weather records and actual damages:

i) Topography: Talus, collapsed land, knick line, tableland,erosion of the lower part of terrace scarp, over-hung, water-collecting slope, trace of debris flow, landslide, debris flow, and topography where embankment is laid.

ii) Geology: Collapsible geology, soil and structure prone to collapse (direction of crack and continuity, boundary of layer, weak line), conditions of surface layer, landslide geology prone to debris flow, foundation ground of embankment.

iii) Loose stone in surface soil, rolling stone, large loose part of rock mass which may cause rock collapse.

iv) Weak lines like fault on slope

In any cases, the topographic map has been utilized with utmost efforts and concluded as follows after adding the information obtained on the site and survey results on the slopes as stated in Sub-section 4.1.1.

4.1.1 Rock Fall Collapsing

Geological features indicating potential fall and collapse have been identified along the 6 routes as follows:

1) **Surface Heavy Weathering of Weathered Rock.** Most of weathered rocks are decomposed into sand and silt size including rubble stone. Thickness at the slope is less than 2 m.

2) **Weathered Zone Has Become Soil.** In the weathered substances which turned into

surface soil, fine stone of 5- 10 mm are left including the rubble stone of more than 10 mm and covering the whole slope with 2 m thickness.

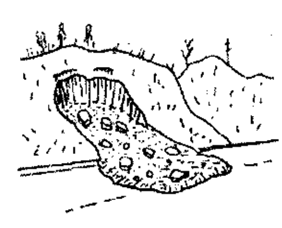
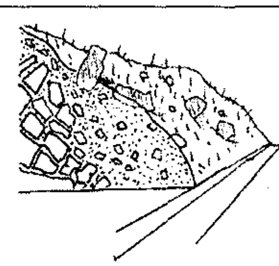
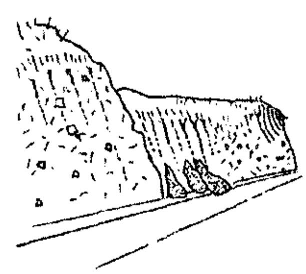
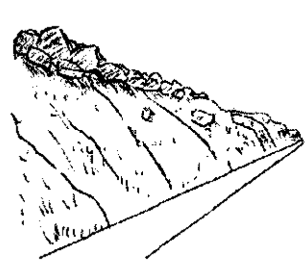
3) **Talus Deposits** in most of the study road, thickness is around 2 m.

4) **Decomposed Granite Soil** distributed mainly in northern area of Ocotal, NIC.15. Where turned into soil, the entire slope was collapsed at the time of Mitch, and they are left as yet.

5) **Others** Debris as sediments, terrace sand and ground layer, mud stone of Neogene, agglomerate, pyroclastic rock, tuff breccia etc.

6) **As a special Case**, conditions where Mesa-shaped and andesite lava is piled up as large blocks on the upper part of natural slope are included in this item.

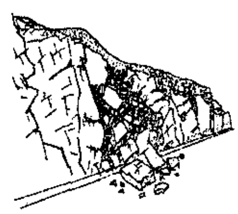
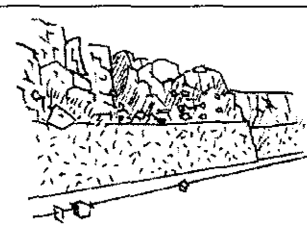
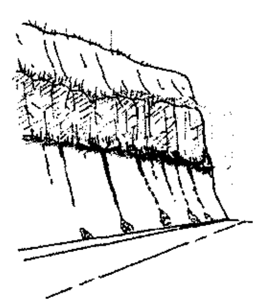
Table 4.1.3 Type of Rockfalls and Collapse on the Study Route

Failure Type	General Features	Schematic Illustration
1	Talus deposits, weathered zones turned into soil, especially tuff. Weathered zones of mud rocks, loose sand and stone layers, and decomposed granite soil. Failure caused by gushing water through penetration of rain. In many cases, the soil volume of collapse is less than 700- 1,200 m^3.	
2	Largely occurs in residual soil and weathered soil of former granites. Andesite lava can also display similar weathering. If there is no weak line like a clay joint or small fracture, no large collapses will happen, except for falling stones.	
3	Collapse will occur when granite is weathered creating decomposed granite soil, or in a weathered zone where fine and coarse tuffs are mixed. Collapse occurs when a surface layer flows down from the slope or when there are permeable rocks in a lava flow with many cracks. Gullies will be opened up at the boundary between them. Collapsed soil volume will be between 20 and 500 m^3 depending upon the conditions of collapse.	
4	If lava flows on the upper part of Mesa plateau become blocked a brick-like accumulation can occur. Some parts of this can be pushed out on a dip slope bedding plane. The natural slope angle of the plateau would be around 40 degrees. On occasions, stones fall due to hurricanes even on vegetated slopes. 2 or 3 stones will fall depending on crack conditions.	

4.1.2 Rock Collapse

All slopes, except those as discussed in Sub-section 4.1.1, are susceptible to rock collapse. The hard rocks of the Tertiary Era are widely distributed and many locations need to be checked for signs of collapse. The exception would be the decomposed grano-diorite soil and alluvial sand and ground layer to the north of Ocotal on NIC.15. Signs of potential rock collapse include : unusual conditions in the slope as the inclination direction and interval of cracks; falling stone conditions; visible signs of collapse, such as square crevices, and fresh stone falls; crack openings being larger than the slope; part of the slope is pushed out,; over-hanging rocks above the boundary of rock. These phenomena are typically fond after heavy rain. Table 4.1.4 shows the type of rock collapse along the study routes.

Table 4.1.4 Types of Rock Collapse on the Study Route

Failure Type	General Feature	Schematic Illustration
1	Rocks fall and collapse caused when weathering advances from the crack opening and when contact between rocks is loosened. Discontinuities in cracks of platy joints or dip slope structure are closely connected. Falls of the order of 20-300 m^3.	
2	Friction work between the blocks, due to toppling destruction, but collapse will occur when blocks themselves revolve. Typical falls of around 90 m^3.	
3	Same as the above collapse but more intact rocks usually result from lava flow, with many cracks. Falls of up to 200 m^3.	
4	Occurs when there is a lava flow with many cracks in the middle. Middle lava flows that are over-hung will fall when ground water flows out from the boundary of the strata, and gullies are formed in weathered rock in the lower bed. In many cases, the fall volume is small but 200 m^3 may result from a fall of decomposed granite soil.	

4.1.3 Collapse in Embankment Slope

Usually, embankment has no drainage ditch in its shoulder and rainwater flowing from the road surface falls down into the slope through shoulder on riverside or drainage facilities on mountain side do not function thereby erosion will be caused at the drain intake by rain water down from slope. In such a case, water penetrated into the embankment will gush out from the middle of the slope and cause collapse. Judging from the damage by the large hurricane Mitch, it goes without saying that the above damage should be suffered but it is also conspicuous that the road was largely scooped out through the erosion made by increased water in rivers. In such a case, they are protected by concrete retaining wall or spur dyke but this road passes through mountainous and hilly areas with danger of debris flow and flash flood depending upon the volume of rain. But there are only 3 locations where repeated collapse were recorded after Mitch. At the time of Mitch, many embankment and cut slope in mountainous area were damaged but such flat area like basin was also damaged by running water. Reviewing the water system through these facts reveals that in some cases embankment is preceding before the flowing direction has not been decided for wide catchment area in such place like lava plateau. Judging from the fact that the improvement works were carried out all-out after Mitch and no traffic trouble is seen with usual rainfall, the existing system would be acceptable. However, the following routes should be taken notice considering various factors especially at the time of hurricane:

i) NIC.1
ii) NIC.3
iii) NIC.15
iv) NIC.24
v) NIC.26

4.1.4 Debris Flowing

Debris flow was caused at the time of Mitch, it is judged that washout of embankment is large at NIC.3 and 15. As a special case, it is concerned that the section between Jose Del Obraza-Las Mercedes in NIC.24 will be affected when volcanic ash of Pleistocene Epoch is turned into mud flow. Similarly, NIC.26 section will also apply. The hazard map of volcanic eruption as officially published presumes falling of ash so the range is wider than the forecasted dangerous area of mud flow.

Name of Route	Locations
NIC.3	1 Spots
NIC.15	4 Spots

4.1.5 Bridge Foundation Scouring

Bridges on the objective roads tend to have the following characteristics

- River width is generally narrow at the bridge site (See figure 4.1.1),
- Both abutments are located in the river (see Figure 4.1.2),
- There is no protection around piers, and
- Backfill materials of the wing structure for abutments are scoured by the river flow.

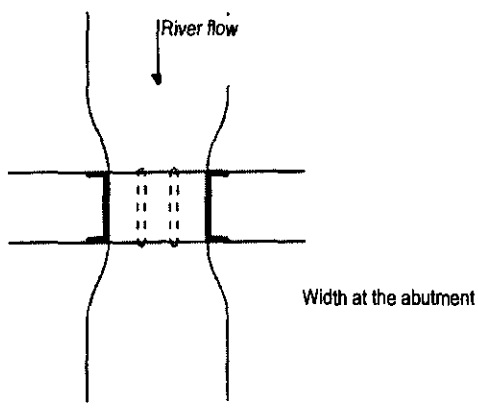


Figure 4.1.1 River Width at the Bridge

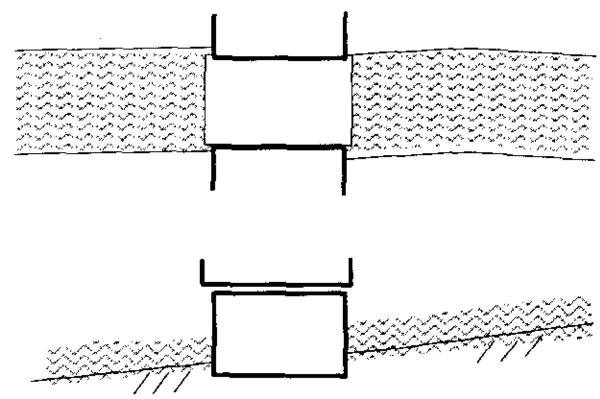


Figure 4.1.2 Both Abutments in the River

Furthermore, almost all the bridges are located at points where the river has a fairly gentle gradient. Therefore, at the time of heavy rains, the riverbed tends to be scoured by eddy and rapids around the abutments and the piers (See Figure 4.1.3).

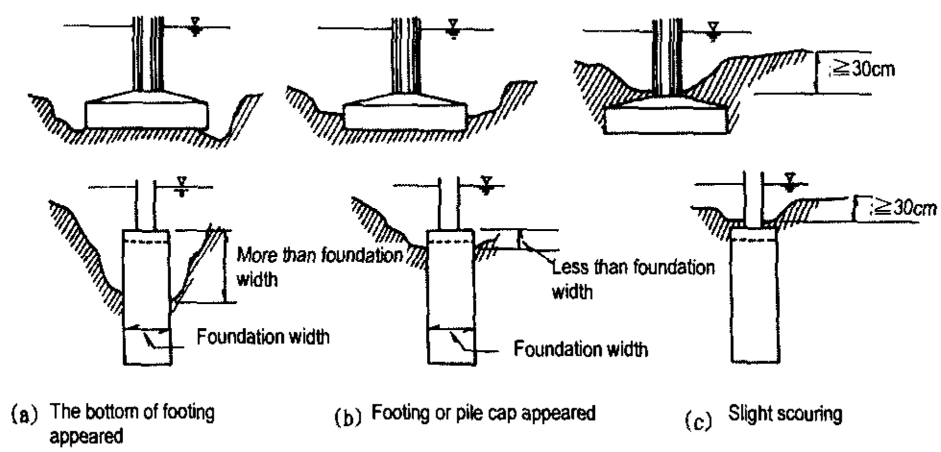


Figure 4.1.3 Pier Scouring

Inspections of bridges, for evidence of scouring, should focus on abutments and piers. Usually, there is no defined channel for the river at bridge sites, and water flow finds any route it can resulting in protection around the abutment being scoured by rapids.

4.2 Assessment Guideline of Road Disaster Prevention

4.2.1 Investigation Procedure of Road Disaster Prevention

In order to execute the most effective road disaster prevention and to maintain road safety, detailed plans should be produced as shown in Figure 4.2.1. The investigation of potential disaster spots should be carried out based on the ***Inspection Manual for Road Disaster Prevention : Road Management Technology Center, 1996,Japan*** (the "Inspection Manual").

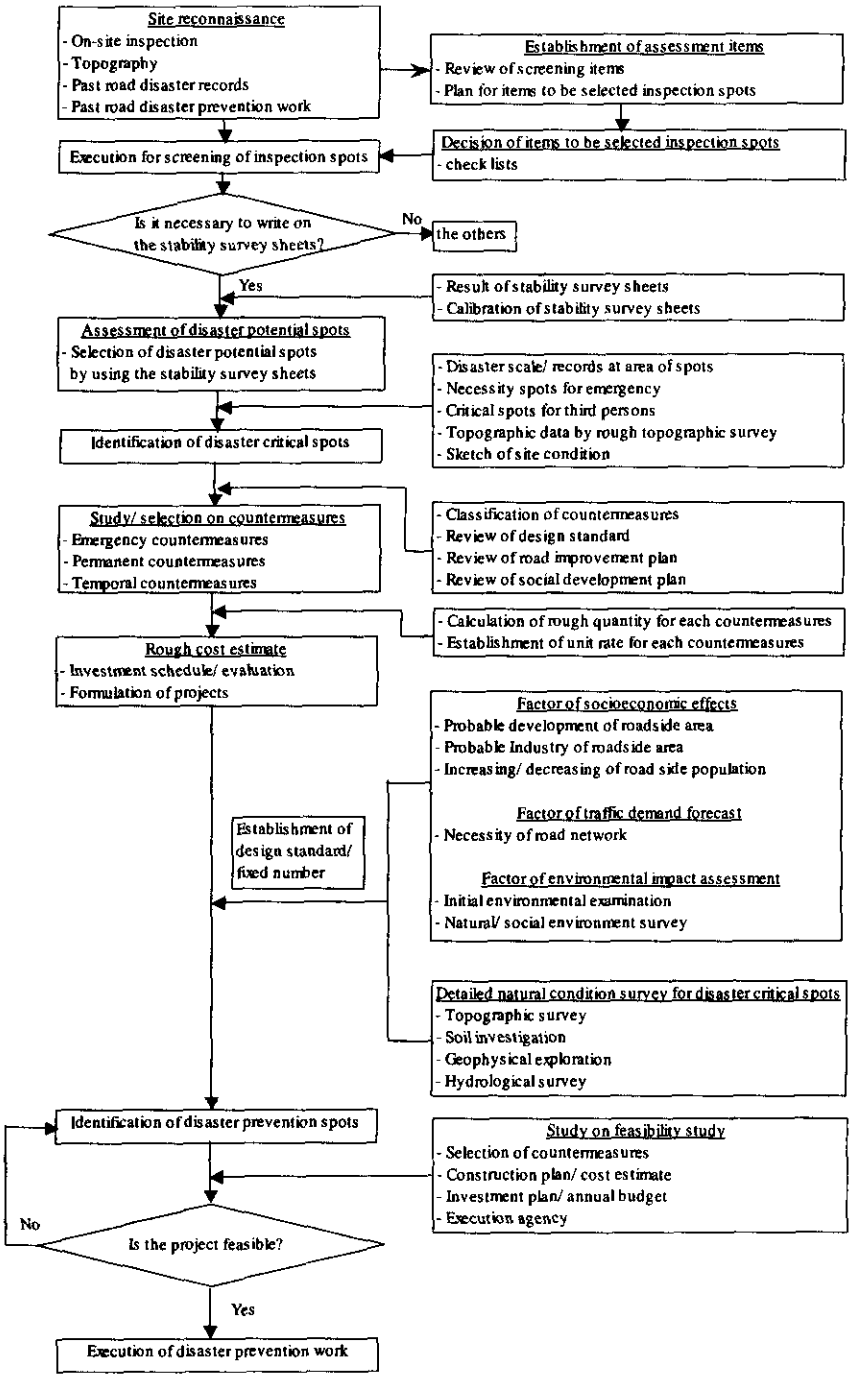


Figure 4.2.1 Investigation Procedure of Road Disaster Prevention

4.2.2 Site Reconnaissance

Site reconnaissance on objective roads should be carried out with sufficient team organization. In each team there should at least be an experienced engineer for suggesting vulnerable spots, and a technician to make drawings and fill out the stability survey sheets. Basic portable equipments should comprise road inventory data, a digital video camera, topographic maps (scale = 1/50,000), measuring tape, and geological hammer.

4.2.3 Screening

The objectives of screening are as follows:

- Objective inspection of all potentially vulnerable spots,
- Early detection of vulnerable spots, and
- Characteristic grasp of vulnerable spots.

In screening the engineer makes an objective assessment against inspection spots. The spots for screening are classified into the following disaster items.

- Rockfalls, collapsing
- Rock collapsing
- Slope slide
- Debris flow
- Scouring of bridge foundation

Screening items should be reviewed before establishing the assessment items of inspection spots. Selection of inspection spots should be planned for each disaster factor by using updated check lists.

1) Check List To Select Inspection Spots

The check list to select inspection spots covers :

- Locations where clear disaster potential is confirmed; and
- Spots where it is necessary to inspect against past disaster records.

2) Rockfalls, Collapsing

An engineer should inspect the following factors:

- Spots at a cutting or embankment with a natural slope of fifteen (15) meters height or more, or with a natural slope of more than forty-five (45) degrees;
- Spots where there are unfixed stones or boulder stones on slope surfaces,
- Spots where there are vulnerable mechanics of soil or rock mechanics, and
- Spots at old or deteriorated countermeasures or where countermeasures need to be

inspected.

3) Rock Collapsing

Engineers should inspect the spots at cuts and natural slopes of seven meters or higher.

4) Slope Slide

Engineers should inspect all potential slope slide spots with a view to identifying:

- Critical spots;
- Potential disaster sites; and
- Sites where disaster prevention measures are require

5) Debris Flow

The following locations should all be inspected:

- Spots where streams cross roads, bridges, and culverts (except where the stream is taken by a sunk tunnel, or where there is a clearance under the bridge deck height of 10 metres or more, or a span width of 20 meters over the stream;
- Spots with a basin area of 0.01 km2 or more,
- Spots where the stream bed above the road has a gradient of 10 degree or more; and
- Spots where the culvert gradient or stream bed beneath the road is 2 degrees or more.

6) Scouring of Bridge Foundation

Engineers should inspect all bridges taking into account the following factors.

- Where no scouring is evident at slow flowing rivers there is little risk;
- Simple span bridges without piers, with sturdy riverbank protection, and complete river improvements up and down stream are very low risk;,
- Where there is no damage at scouring protection around bridge foundations, and/or there is adequate scouring protection around the bridge foundations, then prevention measures adequate;
- There is little risk where there is adequate embedment depth, (15 meters or more) or it is eight times more than the pier width of the transverse direction, for pile and caisson foundation against either the deepest riverbed or design riverbed (the depth from riverbed to bearing stratum), and
- Bridges is less than 15 meters span have a high potential disaster risk

4.2.4 Stability Survey Sheets

1) Characteristics of Inspection Spots

In order to carry out field inspections efficiently, the following data should first be assembled.

- Past disaster records (disaster type, location, magnitude, circumstances, photograph, date, and cause)

- Records of past disaster prevention work (date, type of work, cost, life expectancy)
- Road inventory data
- Topographic map (scale = 1/50,000) (annotated with disaster locations, type and magnitude)
- Aerial photographs

Inspection spots should be selected by the engineer's objective judgement using the above criteria.

2) Execution of Stability Survey

Following screening, inspection spots should be subjected to a stability survey. Similar levels of engineering competence are required as for screening, and the same equipment.

The stability survey sheets should be filled in using the following procedure:

- Selection of disaster type for,
- Enter the relevant points for Factors A to G (except "total assessment item", as shown in Appendix – 1),
- To calibrate the result of stability survey sheets to reflect a balanced view of the team.

The calibration method is shown in below example.

Order	1	2	3	4	5	6	7
Inspection spot (score)	A (80)	F (80)	G (60)	B (55)	D (50)	C (40)	E (30)
Calibration result (re-score)	ditto	ditto	ditto	B (70)	ditto	C (60)	E (40)

After both engineers checked and discussed the survey results, the order of the stability survey results was changed as below.

Order	1	2	3	4	5	6	7
Inspection spot (score)	A (80)	F (80)	B (70)	G (60)	C (60)	D (50)	E (40)

Special attention should be given to calibration for possible "Rockfalls, collapsing of slope" and "Rock collapsing". This procedure is best carried out on site.

4.2.5 Assessment for Disaster Potential Spots

The stability survey sheets are prepared should be prepared in order after calibration. Scoring needs to take of :

- Topographical factors, soil/ rock mechanics, slope surface condition, its shape and transformation,
- Existing countermeasures,
- Disaster history.

Other data to be included are a rough topographic survey along with sketches.

Besides, the objective roads for this study have different traffic volumes with large increases to 2020. Therefore, in this section, traffic volume is not considered as the assessment factor.

The score of each spots is different against disaster type. Therefore, selection of disaster potential spots should be assessed in order of highest score first. Where scores are higher than the threshold indicated below for each disaster type below, then the site is deemed a potential disaster spot.

Furthermore, disaster potential spots are defined as the following items:

- To exist boulder on slope surface,
- To exist many cracks on rock surfaces,
- To exist small rocks falling, and
- To exist disaster records regarding rock-fall, rock collapsing, slope slide, scouring of bridge foundation, and so on.

Important : Total scores for each disaster type vary, and should be factored to a common total of 100. All scores should therefore be factored by the appropriate ratio

For Bridges: 70 score over

The score should be assessed from the following (on the stability survey sheet) : riverbed incline (15), bridge location (20), minimum span length (15), ratio of river flow blockage by piers (15), and clearance under the deck (10). The maximum score is 75 points. Therefore, the threshold for potential disaster spots for bridges is 70 score over. However, bridges with a score less than 70 should also be designated potential disaster spots where the bridge is located on a bend in the river, or where abutments protrude into the river, or where foundation piles are bent.

For Cut/ Embankment Slope : 60 score over

Rockfalls and Collapsing. The most important factors are soil or rock structure (8 or 12), vulnerable mechanics (14), unfixed stones or boulder stones of slope surfaces (12), slope incline or height (18), and slope transformation (12). The maximum score of each factor is 64 or 68 points. The threshold for potential disaster spots for rockfalls and collapsing is 60 score over.

Rock Collapsing. The most important factors are crack scale of rocks (30), continuous horizontal cracks (10), condition of soft or hard rocks (11 or 15),direction of bedrock (15), and steepest slope height (10). The maximum score is 76 or 80 points. However, as total score is 126 points, an equivalent to 100 scores is calculated by 0.79. Each maximum score will be converted 60 points or 63 points. The threshold for potential disaster spots for rock collapsing is 60 score over.

For Debris Flow : 60 score over

Scoring factors are area of basin (10), steepest mountain torrents incline (10), area of slope incline of 30 degrees or more (8), and area of meadow, or trees (8). The maximum score in this way is 36 points. However, as total score is 56 points, an equivalent to 100 scores is calculated by 1.78. The maximum score will be converted 64 points. The threshold score is 60 score over.

4.2.6 Identification for Disaster Critical Spots

1) Definition of Disaster Critical Spot

Disaster critical spots should be identified by considering the following items :

- Disaster scale/ records at area of spots,
- Spots where emergency treatment is required,
- Critical spots for third parties
- Topographic data by preliminary topographic survey, and
- Sketch of site conditions

The stability survey sheets should be filled as far the "total assessment item". As noted Sub-section 4.2.5, the definitions should be used.

a) Definition of Rockfalls/ Collapsing

[Factor A]

Item		Factor	Talud de corte Clasificación	Notas	Potencial Nota de Evaluación	Critico Nota de Evaluación
Topografía	Topografía que tiene factor del colapso	G1:Talud deterítico en cono G2:Huellas de desprendimiento	Uno corresponde G1	3		
		:Línea de mella (nick line) es clara	No corresponde G1	0		
		G3:Falda de terraza erosionada,	Varios corresponden G2,3	3		
		voladizo, talud que concentra agua,	Corresponde G2,3	2		
		huella de flujo de sedimentos	No corresponde G2,3	0		
		G4:En la cresta hay cumbre, voladizo	Corresponde a G4		(6)	(6)
Suelo, Geología, Estructura	Suelo que se degrada	Suelo que fácilmente se erosiona	Notable	8		
		(Suelo que pierde resistencia por	Algo notable	4	8	8
		absorver agua, otros)	No corresponde	0	(8)	(8)
	Calidad de roca erodable	Alta densidad de grietas o capa frágil	Notable	12		
		Rocas blandas facílmente erosionado	Algo notable	6	12	12
		Calidad de erosionarse rápidamente	No corresponde	0	(12)	(12)
	Estructura de colapso	Capa de dirección deslizable (estratificación o línea débil)	Corresponde	8		
			No corresponde	0		
		Suelos sobre rocas impermeables. (Roca dura en la parte superior la parte inferior blanda)	Notable	6		
			Algo notable	4		14
			No corresponde	0	(14)	(14)
Condición de la superficie del suelo	Condición del suelo superficial, roca desprendida y canto rodado		Inestable	12		
			Algo inestable	6		
			estable	0	12	12
	Roca desprendida y canto rodado son inestable-algo inestable		Corresponde		(12)	(12)
	Situación de agua manantial		Hay manantial	8		
			Se rezuma un poco	4		
			No hay	0	(8)	(8)
	Estado del cubrimiento del suelo		Tierra desnuda-vegetación	5		
			Compuesto (vegetación, estructura)	3		
			Estructuras	1	(5)	(5)
Forma	Inclinación(i), Altura		Suelo H>30m	18		
			Suelo H≦30, i>norma	15		
			Suelo i≦norma,15	10		
			Suelo i≦norma,15≦H<30	5		
			Roca H≧50m	18		
			Roca 30≦H<50m	16		
			Roca 15≦H<30m	12	18	18
			Roca H<15m	10	(18)	(18)
Deformación	Deformación de talud y pendiente (fisilidad, caída de rocas pequeñas, cárcavas, socavación, agujero de escorrentía, hundimiento, hinchamiento, árbol caída, grieta, grieta abierta, deformación de obras hechas)		Varios corresponden,algo claro	12		
			Corresponde, No tan clar	8	12	12
			No hay	0	(12)	(12)
	Deformación de talud y pendiente cercanas (caída de rocas, derrumbe, grieta, hinchamiento, otros)		Varios corresponden,algo claro	5		
			Corresponde, No tan clar	3		
			No hay	0	(5)	(5)
		Total	talud: Total de notas		62 (A1)	76 (A1)

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

b) Rock Collapsing

[Factor A]

Item	Factor	Clasificación	Nota	Potencial	Critico
Fenómeno, sintoma	Tamaño de grieta abierta	Grande	30	30 (30)	30 (30)
		Pequeño	15		
		No existe	0		
	Dirección de grieta continua horizontal	Hacia la dirección degradable	10	10 (10)	10 (10)
		Hacia la dirección estable	5		
		No existe	0		
	Derrumbe pequeño, caída de rocas	Existe	7	(7)	(7)
		No existe	0		
Estado de grietas	Roca dura	Existencia regular, distancia de cada una más de 1 m.	15	15 (15)	15 (15)
		Existencia regular, distancia de cada una menos de 1 m.	11		
		Irregular	7		
		No existe	0		
	Roca blanda	Existencia regular, distancia de cada una más de 1 m.	11	(11)	(11)
		Existencia regular, distancia de cada una menos de 1 m.	7		
		Irregular	4		
		No existe	0		
Composición de masa de roca	Parte superior es dura/parte inferior es blanda		7	(7)	(7)
	Parte superior es blanda/parte inferior es dura		5		
	Todo blanda		2		
	Todo dura		0		
Buzamiento	Buzamiento quebradizo (dip slope)		15	15 (15)	15 (15)
	Buzamiento estable		5		
	No existe		0		
Topografía	Inclinación de talud y pendiente	Voladizo	4	(4)	(4)
		Más de 60°	2		
		Menos de 60°	0		
	Altura de precipicio	Más de 100m.	10	10 (10)	10 (10)
		50-100m.	7		
		30-50m.	4		
		Menos de 30m.	2		
	Forma de pendiente	Pendiente de forma de cresta	4	(4)	4 (4)
		Pendiente de talud deterítico	3		
		Pendiente de forma de valle	1		
		Pendiente de forma intermedia de cresta y valle	0		
	Línea de mella (Nick line)	Claro	7	(7)	(7)
		irregular	4		
		No claro	0		
Agua freática, lluvia	Manantial	Existe manantial	4	(4)	4 (4)
		Después de lluvia se sale agua.	2		
	Sitio Donde Existe Manantial	Dentro de grietas verticales	2	(2)	(2)
		Límita de estratos horizontales	1		
		Casi no se observa	0		
		Total	(A)	80 (126)	88 (126)

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

c) Slope Slide

[Factor] (A)

Item		Punto de observación		Nota	Potencial	Crituco
Terreno formado por deslizamiento de tierra		Pendiente formada por deslizamiento de tierra, Terreno tipo meseta, Terreno de inclinación suave, Desorden de curva de nivel, Terreno fluido hacia el río, etc.	Claro	30		
			Algo claro	15	30	30
			No claro	7	(30)	(30)
Geología, etc.	Estructura geológica	Falla, Zona de trituración		18		
		Zona de alteración volcánica, Suelo solfatárico		18		
		Dirección deslizable de capa		14		
		dirección estable de capa		7		
		Forma de bloques (Estructura de roca intrusiva, de roca de cubierta)		3		18
		Otros		0	(18)	(18)
	Edad geológica y Calidad de roca madre	Estrato mesozóico y paleozóico (esquisto cristalino, roca sedimentaria)		7		
		Estrato terciario (roca sedimentaria)		7		
		Estrato cuaternario (Sedimentos no solidificados o roca sedimentaria)		3		
		Otros (Roca volcánica, Roca ígnea)		0	(7)	(7)
	Manantial	Hay (incluye huella)		10	10	10
		No hay		0	(10)	(10)
		Total		(A)	40 (65)	58 (65)

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of eac should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each ite should be 70 scores over at least.

d) Debris Flow

[Factor] (A)

Item	Factor	Clasificación	Nota	Potencial	Critico
Caracteristica de arroyo	Superficie de la cuenca dañada por alud de fango. Superficie que tiene más de 15° de inclinación de lecho	Más de 0.50km2	10		
		Más de 0.15km2 menos de 0.50km2	8	10	10
		Menos de 0.15km2	4	(10)	(10)
	Inclinación máxima del lecho	Más de 40°	10		
		Más de 30° menos de 40°	5	10	10
		Menos de 30°	0	(10)	(10)
Caracteristica de pendiente	Superficie del pendiente que tiene más de 30° de inclinación	Más de 0.20km2	8		
		Más de 0.08km2 menos de 0.20km2	6	8	8
		Menos de 0.08km2	2	(8)	(8)
	Superficie ocupada por hierbas y arbustos (menos de 10m. de altura)	Más de 0.20km2	8		
		Más de 0.02km2 menos de 0.20km2	4	8	8
		Menos de 0.02km2	0	(8)	(8)
	Existencia de obra de suelo con suelos inestables	Existe	5		
		No	0	(5)	(5)
	Existencia de grietas y pendiente formada por desplazamiento nuevas	Existe	5		
		No	0	(5)	(5)
	Historia de derrumbe de dimensión relativamente grande	Existe	10		10
		No	0	(10)	(10)
		Total	(A)	36 (56)	46 (56)

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

e) Scouring of Bridge Foundation

(Items comúnes de estribo y pila de puente)

Item	Factor	Clasificación	Nota	Potencial	Critico
Caracterí sticas de lecho y estructura de puente	Inclinación de lecho (es rápidos)	Más de 1/100	15	15	15
		Menos de 1/100 más de 1/250	10		
		Menos de 1/250	0		
	Sitio de construcción (Estribo y pila de puente existen en sitio de mayor impacto de aguas o en sitio socavado)	Corresponde	20	20	20
		No corresponde			
	Edad de puente	año≧50 años	10		
		30≦ año<50 años	5		
		año<30 años	0		
	Distancia mínima entre pilas	Menos de 10m.	15	15	15
		Más de 10m. menos de 20m.	10		
		Más de 20m.	0		
	Razón de bloqueo por pila	Más de 7%	15	15	15
		Más de 5% menos de 7%	5		
		Menos de 5%	0		
	Espacio libre debajo de viga	*Menos de 30cm.*	10	10	10
		Más de 30cm. menos de 60cm.	5		
		Más de 60cm.	0		

Item	Frecuencia (Promedio)	Nota (α)	Subtotal		(A)	(100-0)	(A) (100-0)
Rectificación por la frecuencia de ocurrencia de desastres	Los desastres ocurren más de 1 vez por cada 10 años alrededor del puente	15	(15)	Total		75	90
	Los desastres ocurren más de 1 vez por cada 5 años en el río	10	15				
	Los desastres ocurren más de 1 vez por cada 10 años *en el río*	5					
	Otros	0					

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 70 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 90 scores over at least.

2) Study/ Selection on Countermeasures

Countermeasures for disaster critical spots should be divided into the following three categories according to the disaster condition :

- Emergency Countermeasures
- Permanent Countermeasures
- Temporally Countermeasures

a) *Emergency Countermeasures*

Emergency countermeasures should be applied closing any road section to traffic or pedestrians. Therefore, at disaster critical spots, such as high critical rockfall sites, vulnerable rocks should be removed and at critical bridge foundations, gabion mats should be put in place.

b) Permanent Countermeasures

Permanent Countermeasures should be applied to the following cases.

- After an emergency or temporary countermeasures have been implemented,
- on important sections of the road network, to safeguard social and economic development.

c) **Temporary Countermeasures**

Temporary countermeasures should be implemented

- After an emergency or countermeasure has been implemented,
- At sites where physical limitations prevent appropriate machinery for permanent measures
- At times when there are budget constraints

Studies of countermeasures, should consider the following items:

- Classification of countermeasures to the critical spots,
- Review of design standard,
- Review of road improvement plan, and
- Review of social development plan, etc.

After selecting the appropriate countermeasure, rough quantities and costs should be estimated. The following should be considered to identify the disaster prevention spots.

- Socio-economic effects, such as development of the roadside area, local industries, and affects on residential property,
- Traffic forecasts and impacts on the road network,
- Environmental impacts, determined by an initial environmental examination, natural condition surveys, and social surveys.

A detailed natural condition survey should be carried out to establish the design conditions and should include :

- Topographic survey,
- Soil investigation,
- Geophysical exploration, and
- Hydrological survey.

4.2.7 Feasibility Study for Disaster Prevention Spots

After detailed survey and analysis, disaster prevention spots should be identified along with countermeasures, and the socio-economic factors relevant to the project. The project should then consider :

- The most applicable countermeasures,
- A construction plan and cost estimate,
- An nvestment plan/ annual budget, and
- The appropriate executing agency.

If the project is under the benefit/ cost ratio (B/C) and internal return ratio (IRR) criteria, the disaster prevention work should be carried out promptly. If schemes fail these tests then alternative disaster prevention spots and/or other countermeasures should be considered..

As a general rule, the identification of the disaster prevention spots should consider the whole range of factors : socioe-conomic, natural condition, road network and traffic, social and natural environment, and road development plans..

4.3 Survey Sheet

To help objective inspection, the survey sheets should always be fully and accurately completed. The survey sheets are presented in Appendix A1.