CHAPTER 9

SELECTION OF PRIORITY ROADS

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9.1 PRIORITIZATION CRITERIA

In order to provide a rating system to rank the project roads and to select roads for the Feasibility Study in the next stage, a prioritization criteria has been established based on the evaluation of technical, environmental and economic factors related to the improvement and rehabilitation of the Study Roads as described in the following sections.

9.1.1 Technical Evaluation

(1) National Plan

Roads included in the road plans under the national development plan of Grenada are given a higher ranking rate in order to support and realize the targets of such development plans. Such targets emphasize the need to maintain a high economic growth, decentralize development to regional areas, accelerate the development of human resources and upgrade the quality of life and natural resources management. In the two plans of: "Grenada Medium-Term Economic Strategy Paper, 1996 – 1998" and "Five Year Plan 1998 – 2002 for Road Improvement Projects" three roads, out of the seven Project Roads, are included to be improved.

(2) Network Requirements

Improvement works for individual roads and highways should have the more comprehensive target of improving the functionality and serviceability of the whole road network in the area. In this respect, road network requirements are investigated and evaluated from the following points of view:

- Road Class: The class of each road represents in general its importance as a link in the road network. This factor is important in establishing a priority ranking for the study roads.
- Major Role: The function of each road is investigated in such terms as the population and land-use coverage and its connections to major activity centers such as cities, towns, ports and airports.
- Traffic Volume: The number of beneficiaries either as number of vehicles or

number of passengers is estimated based on the forecast of future traffic volumes.

(3) Engineering Requirements

The engineering conditions of the candidate roads are assessed to investigate the existence of any technical problems at present which require urgent rehabilitation or improvement works. The assessment procedure is carried out from different dimensions either related to the structural or geometrical design of each road section with special attention to the following:

- Functionality and condition of pavement structure and drainage facilities.
- Hydrological problems related to the functionality and condition of bridges and other structures along the roads.
- Geometric design and safety level due to short sight distance, sharp curves and steep gradients as well as safety of pedestrians.
- Urgency for disaster prone areas, such as landslides or flooding if they exist, or other strategic planning.

(4) Development Effect

The agriculture and tourism sectors contribute high shares to the national income and they are planned to continue their role for years to come. Road improvement projects are directed to mainly support the two sectors as follows:

- Agricultural Production: High priority is given to roads which promote agricultural development and are used in product transportation.
- Agro-Industrial Production: Roads promoting agro-base industries have higher priority.
- Tourism Development: As the tourism sector will bear more responsibility in the near future, roads which support and promote tourism activities have higher priority.

9.1.2 Environmental Evaluation

The environmental issue is given a high importance in this Study as major construction activities may cause some negative impact on the natural or social environment. Based on the environmental survey and initial environmental examination, roads with no negative environmental impact have higher priority as follows:

- Natural Environment: The existing condition and impact of each road on the natural environment is examined (air and water pollution - flora – fauna - erosion -- drainage -- etc.).
- Socioeconomic Environment: The existing condition and impact of each road on the social environment is examined (population coverage – land use – etc.).
- Women in Development WID: Higher priority ranking is given to road projects which can provide facilities and opportunities to support the WID issue.

Table 9.1.1 presents a summary for the social and land-use characteristics along the study roads.

Table 9.1.1 Social Characteristics along Study Roads

Item	R-1	R-2	R-3	R-4	R-5	R-6	R-7
Length (km)	20.5	3.2	7.2	5.8	16.0	3.2	3.1
Population Coverage	1,180	540	604	628	1,384	188	180
Household	295	126	151	157	346	47	45
School	10	1	4	2	5	1	0
Church	9	1	3	2	12	1	0
Community Center	6	2	7	2	6	0	0
Tourism Spot	NP	Forts	-	Beach	NP	-	NP

NP: National Park

9.1.3 Economic and Overall Evaluation

The results of the preliminary economic analysis, presented in Chapter 8, form an important factor in the prioritization ranking of the Study Roads. The highest estimated values of the three economic parameters of B/C, EIRR and NPV under the three improvement options provides higher rating values in the overall evaluation for roads with high economic viability.

9.2 RATING PROCEDURE

Based on the established criteria, the selection procedure was conducted in such a manner as to include factors directly on a monetary basis in addition to factors promoting development in various sectors. Table 9.2.1 presents the procedure applied in utilizing the established criteria and the breakdown results of the evaluation of the study roads. A rating and points system is applied on all the items considered in the criteria and the overall evaluation for each road is based on the total number of concluded rating and points of the items, as follows:

Table 9.2.1 Evaluation of Study Roads

Evaluation Items		R-1	R-2	R-3	R-4	R-5	R-6	R-7	Remarks
Technical Evaluation									
National Plan		A (Yes)	C (No)	C (No)	A (Yes)	A (Yes)	C (No)	C (No)	
Net-work	Road Class	a (1)	c (2)	c (2)	a (1)	a (1)	c (2)	c (2)	
	Major Roles	a (main)	b (tourism)	c (secondary)	a (main)	a (main)	c (secondary)	b (local)	
	Traffic Volume(2005)	a (6194)	b (1478)	c (325)	a (4657)	b (2490)	c (946)	c (698)	
	Rating	A (3a)	B (2b+c)	C (3c)	A (3a)	A (2a+b)	C (3c)	C (b+2c)	
Engine ering	Functionality	b (fair)	a (bad)	a (bad)	b (fair)	b (fair)	a (bad)	a (bad)	
	Geometric (safety)	a (bad)	a (bad)	b (fair)	a (bad)	c (good)	c (good)	c (good)	
	Urgency	a	b	c	b	a	c	c	
	Rating	A (2a+b)	A (2a+b)	B (a+b+c)	B (a+2b)	B (a+b+c)	B (a+2c)	B (a+2c)	
	Agriculture	c	c	a	b	b	b	b	
	Agro-Industrial	a	c	b	a	a	b	b	
	Tourism	a	a	c	b	b	c	c	
	Rating	B (2a+c)	B (a+2c)	B (a+b+c)	B (a+2b)	B (a+2b)	B (2b+c)	B (2b+c)	
Subtotal		3A+B	A+2B+C	2B+2C	2A+2B	2A+2B	2B+2C	2B+2C	A=3, B=2, C=1
Technical Evaluation		A	B	C	A	A	C	C	A=12~10,B=9~7,C=6~4
Environmental Evaluation									
R.O.W Acquisition		B	A	B	B	B	A	A	
	Natural Environment	b	b	b	b	b	b	b	
	Socio-Economic Env.	a	b	b	a	a	c	c	
	Rating	A (a+b)	B (2b)	B (2b)	A (a+b)	A (a+b)	C (b+c)	C (b+c)	
Subtotal		A+B	A+B	2B	A+B	A+B	A+C	A+C	A=3, B=2, C=1
Environmental Evaluation		A	A	B	A	A	B	B	A=6.5, B=4.3, C=2
Economic and Overall Evaluation									
Technical Evaluation		A	B	C	A	A	C	C	
Environmental Evaluation		A	A	B	A	A	B	B	
Economic Evaluation		3A	A	C	2A	A	C	C	
Overall Evaluation		5A=15	2A+B=8	B+2C=4	4A=12	3A=9	B+2C=4	B+2C=4	A=3, B=2, C=1
Ranking		Rank "1"	Rank "2"	Rank "3"	Rank "1"	Rank "2"	Rank "3"	Rank "3"	"1"=15~12, "2"=11~7, "3"=6~3

Note: Point; a = 3, b = 2, c = 1

Rating; A = 9-8, B =7-6-5, C =4-3

Economic Evaluation; 3A = Over 12%, 2A = 12 ~ 8%, A = 8 ~ 4%, B = 4 ~ 3%, C = Less than 3% (EIRR)

(1) Technical Evaluation

1) National Plan

	A:	included
	B:	not included

2) Network Requirement

Road Class	a:	1st Class Road
	b:	2nd Class Road
Major Roles	a:	Main Road
	b:	Tourism / Local Road
	c:	Secondary Road
Traffic Volume	a:	more than 4,000
	b:	1,000 ~ 4,000
	c:	less than 1,000

3) Engineering Requirement

Functionality	a:	bad,
	b:	fair
	c:	good
Geometry	a:	bad
	b:	fair
	c:	good
Urgency	a:	urgent repair
	b:	rehabilitation
	c:	maintenance

4) Development Effect

Agriculture Production	a:	large scale
	b:	middle scale
	c:	small scale
Agro-Industrial Production	a:	large scale
	b:	middle scale
	c:	small scale
Tourism Promotion	a:	large scale
	b:	middle scale
	c:	small scale

(2) Environmental Evaluation

1) R.O.W Acquisition

	A:	none
	B:	a little
	C:	large

2) Environmental Acceptance

Natural Environment	a:	not affected
	b:	a little
	c:	affected
Socio-Economic Environment	a:	not affected
	b:	a little
	b:	affected
WID (Number of Women)	a:	many
	b:	middle
	c:	a little

9.3 RATING OF PROJECT ROADS

Based on the results presented in Table 9.2.1, the Study Roads were given the ranking as follows:

- Ranking "1":
  - R-1: Grand Etang Road
  - R-4: Mt. Gay / Springs Road
- Ranking "2":
  - R-2: Morne Jaloux Road
  - R-5: Eastern Main Road (Grenville / Sauteurs)
- Ranking "3":
  - R-3: Perdmontemps / St. David's Road
  - R-6: Paraclete / Mt. Horne Road
  - R-7: Dover Road (Windward / Cherryhill)

Table 9.3.1 presents the ranking and cost of the study roads. Based on the evaluation on prioritization, the four (4) roads under the rankings of "1" and "2" are recommended to be selected for the second stage of the Feasibility Study.

9.4 SELECTED ROADS FOR FEASIBILITY STUDY

Roads selected for the Feasibility Study in the next stage include those roads under the two high rankings of "1" and "2". The two ranks include four roads with lengths as follows:

R-1:	Grand Etang Road	20.5 km
R-2:	Morne Jaloux Road	3.2
R-4:	Mt. Gay / Springs Road	5.8
R-5:	Eastern Main Road (Grenville / Sauteurs)	16.0

In addition, it was agreed to include in the Feasibility Study the only other temporary Bailey bridge (Vineyard Bridge) on the Study Roads, to be replaced by a permanent bridge with new approaches as a minimum requirement for that class of roads in the country.

R-3: Perdmontemps / St. David's Road – Vineyard Bridge, L = 16.0m

Table 9.3.1 Ranking and Cost of Study Roads

Road No.	Name	Class	Length (Km)	Improvement Option	Cost (MEC $)			Ranking
					Construction	R-O-W	Total	
R-1	Grand Etang Road	1	20.5	II	27.70	0.21	27.91	"1"
R-2	Morne Jaloux Road	2	3.2	I	0.90	0.00	0.90	"2"
R-3	Perdmontemps / St. David's Road	2	7.1	I	3.06	0.00	3.06	"3"
R-4	Mt. Gay / Springs Road	1	5.8	II	3.37	0.16	3.53	"1"
R-5	Eastern Main Road (Grenville / Sauteurs)	1	16.0	II	9.15	0.07	9.22	"2"
R-6	Paraclete / Mt. Home Road	2	3.2	I	1.48	0.00	1.48	"3"
R-7	Dover Road (Windward / Cherryhill)	2	3.1	I	1.37	0.00	1.37	"3"

Total Cost:	Construction	R.O.W	Total	
Rank "1"	31.07 MEC$	0.37 MEC$	31.43 MEC$	(11.69MUS$)(1,344.7 M ¥)
Rank "2"	10.05	0.07	10.12	(3.76 MUS$)(432.4 M ¥)
Rank "3"	5.88	0.00	5.88	(2.19 MUS$)(251.9 M ¥)
Road 1,4,5	40.22	0.44	40.66	(15.13MUS$)(1,739.5 M ¥)
Road 1,2,4,5	41.12	0.44	41.56	(15.46MUS$)(1,777.9 M ¥)

PART IV

FEASIBILITY STUDY

CHAPTER 10 PRELIMINARY ENGINEERING DESIGN

CHAPTER 11 PROJECT COST ESTIMATE

CHAPTER 12 ECONOMIC EVALUATION

CHAPTER 13 ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 10

PRELIMINARY ENGINEERING DESIGN

CHAPTER 10

PRELIMINARY ENGINEERING DESIGN

In the second phase of the Study, the following field surveys were carried out on the selected Project Roads for the purposes of the preliminary design and cost estimation of the required rehabilitation and improvement works for the different road and bridge elements.

10.1 TECHNICAL SURVEY

The three different technical surveys of topographic survey, geotechnical survey and hydrological survey were carried out simultaneously in the field to provide data and information used during the preliminary design process.

10.1.1 Topographic Survey

The topographic survey generally included a route survey for a total length of about 46.3km, bridge site survey and slope topographic survey.

(1) Scope of Work

The route survey on the selected four Project Roads consisted of the following survey tasks:

- Traverse survey
- Centerline survey
- Profile section survey
- Topographic survey
- Preparation of topographic map, profile and cross section

Topographic surveys on bridges and slopes were enforced as below:

- Bridge site : 10 bridge sites (rehabilitation required bridges)
- Slope site : 10 slope sites (3 cut and 7 embankment sections)

(2) Final Output

Appendix 11 includes the Table of Coordination for each of the Project Roads. The final output of the topographic survey was presented as below:

1) Route Survey (46.3km)

- Topographic maps
- Profile drawings
- Cross section drawings

2) Topographic map of bridge sites

- 10 bridge sites (No.1 road, 5 sites. No.3 road, 1site.No.4 road, 1 sites. No.5 road, 3 sites).

3) Topographic map of cut and embankment sites

- 3 cut and 7 embankment slope sites at Grand Etang road.

10.1.2 Geotechnical Survey

The geotechnical survey consisted of highway boring for the pavement design, core boring for the bridge foundation design and test pitting for the construction materials sources.

(1) Scope of Work

1) Geotechnical Investigation for Pavement Rehabilitation

Highway boring of pavement structure investigation was carried out on 2.0km intervals at the four selected Project Roads. The estimated quantities of works for this investigation are as follows:

• Highway boring:	27 locations
• Laboratory test:	
Soil classification, Natural moisture content	81 samples
Sieve analysis, Atterberg limits Compaction	
and CBR test	27 samples

2) Geotechnical Investigation for Bridge Foundation Design

Geotechnical Investigation for bridge foundation design was carried out at 5 selected bridge sites for new construction and reconstruction works. The estimated quantities of works for this investigation are as follows:

- Number of bore holes: 5 bridge sites
- Total drilling length: 50 m
- Laboratory test:
  Soil classification, Natural moisture content 50 samples
  Sieve analysis, Atterberg limits

3) Materials Sources Investigation

Quality and quantity of material sources for the road construction were carried out on 2 course and 1 fine aggregate quarries for the asphalt and cement concrete pavement, for 2 sub base and base course materials. Estimated quantities of works for this investigation are as follows:

a) Course Aggregate Material Source

- Test pitting 2 locations
- Laboratory test
  Sieve analysis, Abrasion, Specific gravity, 2 samples
  Soundness test

b) Fine Aggregate Material Sources

- Test pitting 1 location
- Laboratory test
  Sieve analysis, Specific gravity, 1 sample
  Soundness test

c) Sub base / Base course Materials Sources

- Test pitting 2 locations
- Laboratory test
  Sieve analysis, Abrasion, Specific gravity, 2 samples
  Soundness test, Compaction and CBR test

(2) Final Output

An investigation reports were included sketch of location of investigation sites, photographs of operation of investigation works, all test results with computation sheets, test pit logs, boring logs. A summary of the Geotechnical survey results is presented in Appendix 12.

10.1.3 Hydrological Survey

The hydrological survey was carried out for the collection of rainfall data, calculation of catchment area and hearing of high water level of 17 bridge sites along selected Project Roads. The results of the survey are presented in Appendix 13.

The calculation results for discharge volume and discharge capacity of the three bridges of St. Syr Great River Bridge (Spillway) on R-1, Tempe Bridge on R-2 and Point Field Bridge (Spillway) on R-5 indicate the over flow by heavy rains.

The existing lateral and cross drainage facilities are V-Type concrete side ditch, R.C square side ditch and earth ditch. During the survey, it was not possible to check the discharge capacity of each drainage system because the catchment area of cut slope are not cleared. Instead of checking the drainage system, a monograph was done between maximum discharge length of concrete side ditch and gradient of side ditch. Appendix 13 presents the results of the hydrological analysis.

10.2 HIGHWAY DESIGN

10.2.1 Geometric Design Standards

The adopted design standards are based on AASHTO standards of " A Policy on Geometric Design of Highway and Street, AASHTO, 1994". For the improvement of the study roads, the major geometric design elements were established as presented in Table 10.2.1, recommended basic design standard based on the recommended highway classification and design concept.

(1) Major Design Elements

The highway should be so designed that vehicles can be operated in a safe and efficient manner. The geometric design of highways involves many design elements such as sight distance, horizontal alignment, vertical alignment and combinations of both alignments.

The following major design elements are discussed in the Study.

- Minimum radius
- Sight distance on horizontal curve
- Maximum grades

1) Minimum radius

The minimum radius is a limiting value of curvature for a given design speeds and is determined from the maximum rate of super elevation and maximum side friction factor selected for design.

Table 10.2.2 summarizes the minimum values for all-rural highways and high-speed urban streets.

Table 10.2.1 Recommended Basic Design Standard

	Functional Classification	General Definition	Characteristic	Level of Services	Design Speed (KM/h)	Min. Traveled Way (m)	Graded Shoulder (m)	Min. Radius (m)	Max Grades (%)	Highway Class in Grenada	Classification of Study Road
Rural	Principal Arterials	· Corridor movement with trip length and density enabled for substantial travel	· Movement between urban areas and large cities	B (F,R) C (M)	(Over 2000 ADT) 110 (F) 100 (R) 80 (M)	Lane width more than 3.3	More than 2.4	(80 km/h) 195-280	(100 km/h) 3 (F) 4 (R) 6 (M)		
Rural	Minor Arterials	· Corridor movement reasonable trip length and travel densities	· Movement between cities, large towns and other traffic generators	B (F,R) C (M)	(Over 2000 ADT) 110 (F) 100 (R) 80 (M)	Lane width more than 3.3	More than 2.4	(70 km/h) 150-215	(80 km/h) 4 (F) 5 (R) 7 (M)		
Rural	Major Collector	· Linkage of large towns and traffic generators such as consolidated schools, country parks and important agricultural areas	· Linkage of nearby large towns or cities	C (F,R) D (M)	(Over 2000 ADT) 100 (F) 80 (R) 60 (M)	(Over 2000 ADT) 7.2	2.4	(60 km/h) 105 - 150	(60 km/h) 7 (P) 8 (R) 10 (M)	Class 1A	
Rural	Minor Collector	· Linkage of all developed areas from local roads	· Linkage of locally important traffic generators with their rural hinterland	C (F,R) D (M)	(400-1500 ADT) 80 (F) 60 (R) 50 (M)	(400 – 1500 ADT) 6.0 (30 – 50 km/h) 6.6 (60 – 110 km/h)	1.5 (0.6)*	(50 km/h) 70 - 100	(50 km/h) 7 (F) 9 (R) 10 (M)	Class 1	1) Grand Etang Road 5) Eastern Main Road
Rural	Local Road	· Service for traffic relatively short distances	· Access to land adjacent to collector net work	D	(250-400 ADT) 60 (F) 50 (R) 30 (M)	(Lessthan400ADT) 5.4 (30 – 60 km/h)	0.6	(30 km/h) 25 - 35	(30 km/m) 8 (F) 11 (R) 16 (M)	Class 2	3) Perdmontemp /St. David's 6) Paraclete/Mt. Home 7) Dover
Urban	Principal Arterials	· Carry most of the trip	· Significant intra-area travel · Inter city bus routes	B (F,R) C (U)	60-100	Lane width 3.0 – 3.6		Same as Rural Roads	(100 km/h) 5 (F) 6 (R) 8 (M)		
Urban	Minor Arterials	· Land access, lower traffic mobility and intra-community	· Urban connections to rural collector roads · Local bus routes	B (F,R) C (U)	60-100	Lane width 3.0 – 3.6	1.5 (0.6)	Same as Rural Roads	80 km/h) 6 (F) 7 (R) 9 (M)		
Urban	Collector Street	· Land access service and traffic circulation within residential neighborhoods and commercial and industrial areas	· Collect traffic from local street in residential neighborhoods and channel into arterial system	C (F,R) D (U)	Over 50	Lane width 3.0 – 3.6		Same as Rural Roads	(60 km/h) 4 (F) 10 (R) 12 (M)	Class 1A Class 1	4) Mt. Gay to Springs
Urban	Local Street	Direct access to abutting lands connection to the higher order system	· Lowest level of mobility · No bus route	D	30-50	Lane width 2.7 – 3.6		Same as Rural Roads	(30 km/h) Less than 15	Class 2	2) Morne Jaloux
	Special Purpose Road	· Recreational . Resource Development roads . Local Service Roads	1) Two lane roads; or 2) Two directional one-lane roads	--	(1) (2) 60, 50 (F) 50, 30 (R) 30, 15 (M)	(1) 5.4 - 6.0 (2) 3.6	(1) 0.6 (2) 0.3	(30 km/h) 25 - 35	(20 km/h) 8 (F) 12 (R) 18 (M)	Class 3 Class 4	

Note:
F ; Flat
R ; Rolling
M ; Mountainous
U ; Urban
* : Special Case

Level of Service: Level A Free flow; speed controlled by driver's desires, speed limits, or physical roadway conditions
Level B Stable flow; operating speeds beginning to be restricted; little or no restrictions on maneuverability from other vehicles
Level C Stable flow; speeds and maneuverability more closely restricted.
Level D Approaches unstable flow, tolerable speeds can be maintained but temporary restrictions to flow
Level E Volumes near capacity; speed typically in neighborhood of 30 mph; flow unstable; stoppages of momentary duration. Ability to maneuver severely limited.
Level F. Forced flow, low-operating speeds, volumes below capacity; queues formed.

Table 10.2.2 Minimum Radius

Design Speed (km/h)	Maximum Values (%)	Limiting Values f	Radius (cm)
30	4	0.17	35
	8	0.17	30
	12	0.17	25
40	4	0.17	60
	8	0.17	50
	12	0.17	45
50	4	0.16	100
	8	0.16	80
	12	0.16	70
60	4	0.15	150
	8	0.15	125
	12	0.15	105

Notes: e - Rate of Superelevation 4% only for urban condition

f - coefficient of friction between lines and roadway

2) Sight Distance on Horizontal Curve

The ability to see ahead is of the utmost importance in the safe and efficient operation of a vehicle on a highway. Sight distance is the length of roadway ahead visible to the driver, it involves stopping sight distance, decision sight distance, passing sight distance and distance on horizontal curves.

Discussed here is sight distance on horizontal curve where there are sight obstructions (such as walls, cut slopes, and longitudinal barriers) on the inside of the curves. Adjustments in the normal highway cross section maybe required for providing adequate sight distance.

AASHTO, 1994 provides the " Range of Upper values and Lower values " which is the relationship between the radius and the value of the middle ordinate necessary to provide adequate stopping sight distance on horizontal curves. Figure 10.2.1 shows the "Range of Lower values ".

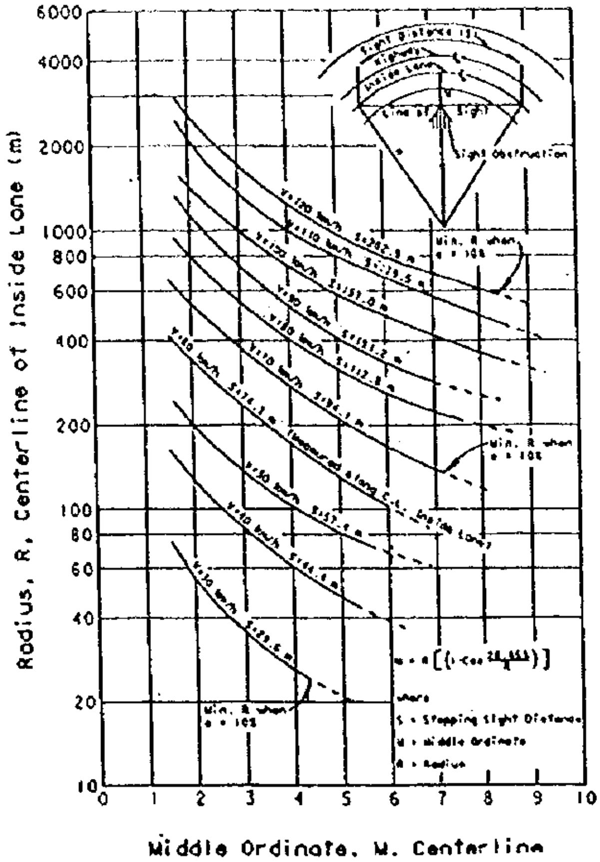


Figure 10.2.1 Range of Lower Values for Sight Distance [relation between radius and value of middle ordinate necessary to provide stopping sight distance on horizontal curves.]

3) Maximum Grades

The topography of the land traversed has an influence on the alignment of the roads and streets. Topography does not affect horizontal alignment, but it is more evident in the effect on vertical alignment. Maximum grades have been determined based on vehicle operating characteristics particularly speed, as shown in Table 10.2.3.

Topography is classified into the following:

Level terrain:	Condition where highway sight distances, as governed by both horizontal and vertical restrictions, are generally long or could be made to be so without construction difficulty or major exposure.

Rolling terrain:	Condition where the natural slope consistently rise above and fall below the road or street grade and where occasional steep slopes offer some restriction to normal horizontal and vertical roadway alignment.
Mountainous terrain:	Condition where longitudinal and transverse changes in the elevation of the ground with respect to the road or street are abrupt and where benching and side hill excavation are frequently required to obtain acceptable horizontal and vertical roadway alignment.

Table 10.2.3 Maximum Grades (%), AASHTO, 1994

Highway Classification	Design Speed (km) Terrain	30	40	50	60	70	80	90	100	110	120
Rural Local Roads	Level	8	7	7	7	7	6	6	5	-	-
	Rolling	11	11	10	10	9	8	7	6	-	-
	Mountainous	16	15	14	16	12	10	10	-	-	-
Rural Collectors	Level	7	7	7	7	7	6	6	5	4	-
	Rolling	10	10	9	8	8	7	7	6	5	-
	Mountainous	12	11	10	10	10	9	9	8	6	-
Rural Arterials	Level	-	-	-	5	5	4	4	3	3	3
	Rolling	-	-	-	6	6	5	5	4	4	4
	Mountainous	-	-	-	8	7	7	6	6	5	5
Urban Local Street	-	Less than 15% (Less than 8% for commercial/industrial areas)									
Urban Collectors	Level	9	9	9	9	8	7	7	6	5	-
	Rolling	12	12	11	10	9	8	8	7	6	-
	Mountainous	14	13	12	12	11	10	10	9	7	-
Urban Arterials	Level	-	-	8	7	6	6	5	5	-	-
	Rolling	-	-	9	8	7	7	6	6	-	-
	Mountainous	-	-	11	10	9	9	8	8	-	-

Note: For rural urban collectors, maximum grades shown for rural and urban condition of short lengths (less than 150m), on one-way down grades and low-volume rural collectors may be 2% steeper.

The adopted design standards are summarized in Table 10.2.4.

10.2.2 Standard Cross Section

Standard cross section of selected roads is shown in Figure 10.2.2 to Figure 10.2.7. The width of lane, for the recommended sight distance, is as specified on the adopted standard. The applied minimum shoulder is 0.6m.

Table 10.2.4 Adopted Design Standard

Item		Unit	Class I Road (Rural Minor Collector) Grand Etang, Eastern Main			Class 2 Road (Rural Local Street) St. David's, Paraclete,Dover			Class 1 Road (Urban Collector Street) Mt. Gay, Grand Etang			Class 2 Road (Urban Local Street) Morne Jaloux *			Remarks
Terrain			Flat	Rolling	Mountain	Flat	Rolling	Mountain	Flat	Rolling	Mountain	Flat	Rolling	Mountain	
Design Speed		km/hr	80	60	50	60	50	30	Over 50	Over 50	Over 50	30 ~ 50	30 ~ 50	30 ~ 50	
Lane Width		m	3.0	3.0	3.0	2.7	2.7	2.7	3.0	3.0	3.0	2.7	2.7	2.7	
Traveled Way Width		m	6.0	6.0	6.0	5.4	5.4	5.4	6.0	6.0	6.0	5.4	5.4	5.4	
Shoulder Width		m	1.5	1.5	1.5	0.6	0.6	0.6	1.5	1.5	1.5	0.6	0.6	0.6	
Crossfall of Traveled Way		%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	AC Pavement
Crossfall of Shoulder	Gravel	%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
	Pavement	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Maximum Grade		%	7	8	10	7	10	16	9	11	12	Not	Exceed	15	
Maximum Superelevation		%	8	8	8	8	8	8	4	4	4	4	4	4	
Minimum Radius of Horizontal Curve		m	195	135	80	125	80	30	100	100	100	60	60	60	
Minimum Radius of Vertical Curve Crest			40	16	10	16	10	3	10	10	10	3 ~ 10	3 ~ 10	3 ~ 10	
(K Value)	Sag		28	16	10	16	11	4	11	11	11	6 ~ 17	6 ~ 17	6 ~ 17	
Minimum Stopping Sight Distance	Vertical Curve	m	120	80	60	80	60	30	60	60	60	30 ~ 60	30 ~ 60	30 ~ 60	
Minimum Passing Sight Distance	Vertical Curve	m	540	410	345	410	345	220	Urban Section Not Applicable			Urban Section Not Applicable			
Sight Distance on Horizontal Curve		m	115	75	60	75	60	30	60	60	60	45	45	45	
Horizontal Curve Radius, Centerline of Inside Lane **		m	550	200	110	300	150	40	110	110	110	100	100	100	
Vertical Clearance		m	4.45	4.45	4.45	4.45	4.45	4.45	4.45	4.45	4.45	4.45	4.45	4.45	

Note: * Classified Special Road
** Middle Ordinate : Class 1 Road + 3.5m, Class 2 Road = 2.45m

10.2.3 Special Purpose Roads

Some types of roads is different from the roads under the functional classification because of its special purposes and does not fit into any of the noted classifications. This type of roads is referred to as a special purpose road, which includes the followings:

- Recreational Roads
- Resource Development Roads
- Local Services Roads

The principal design factors of special purpose roads are discussed in the following sections of the Study.

(1) Design Speed

1) Recreation Roads

- Primary access roads; 60 km/hr
- Circulation roads; 50 km/hr
- Area roads; 30 km/hr

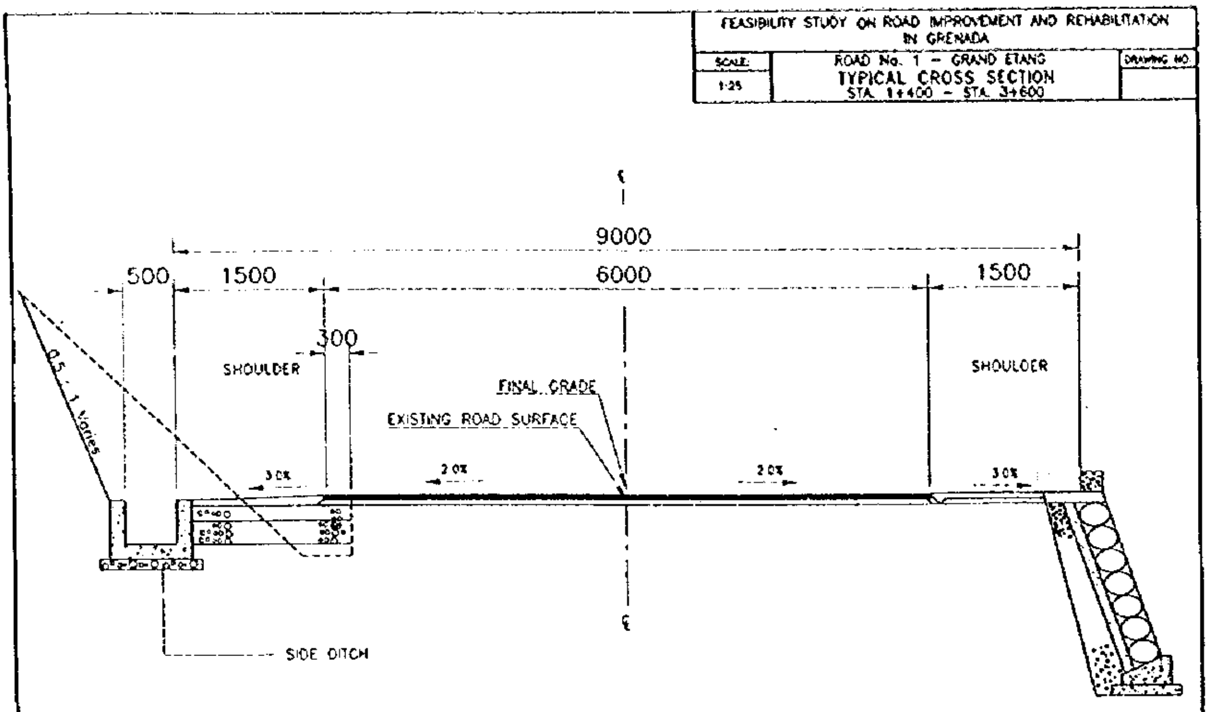
2) Resource Development and Local Services Roads

The minimum design speeds of resource development and local service roads are presented in Table 10.2.5.

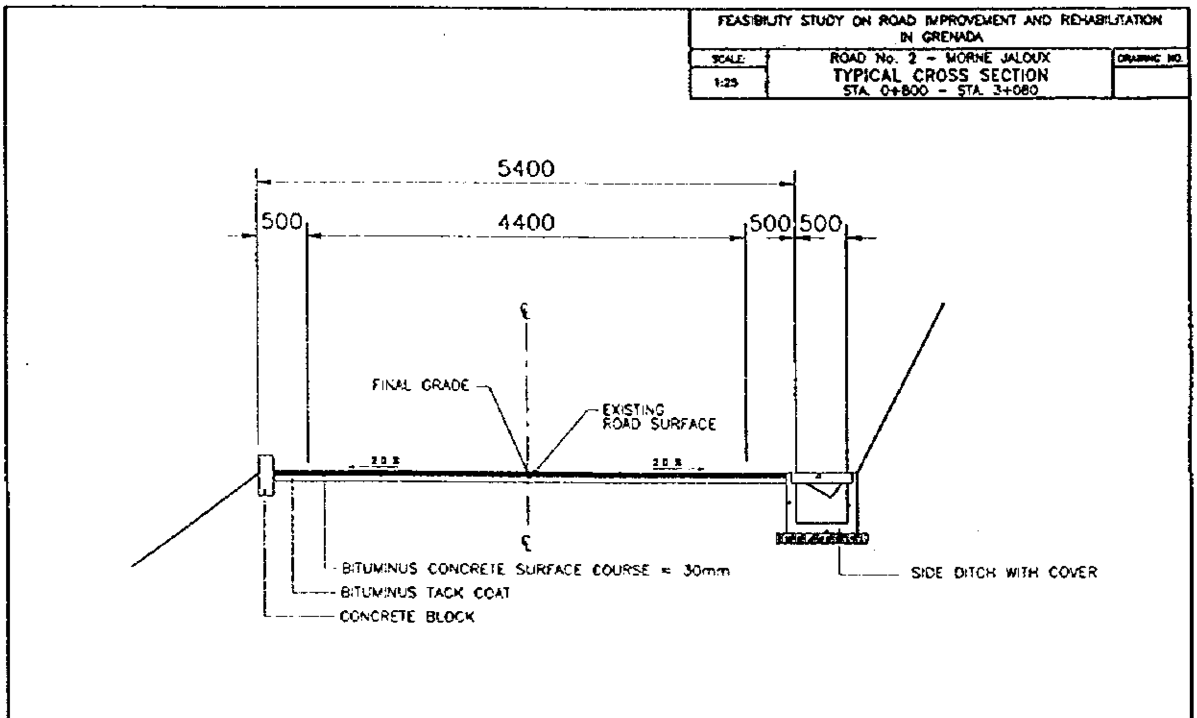
Table 10.2.5 Minimum Design Speed

Terrain	Single Lane 100 VPD Maximum (km/hr)	Tow Lane
Level	50	60
Rolling	30	50
Mountainous	10	30

Source: A policy on geometric design of highway and street, AASHTO, 1994.

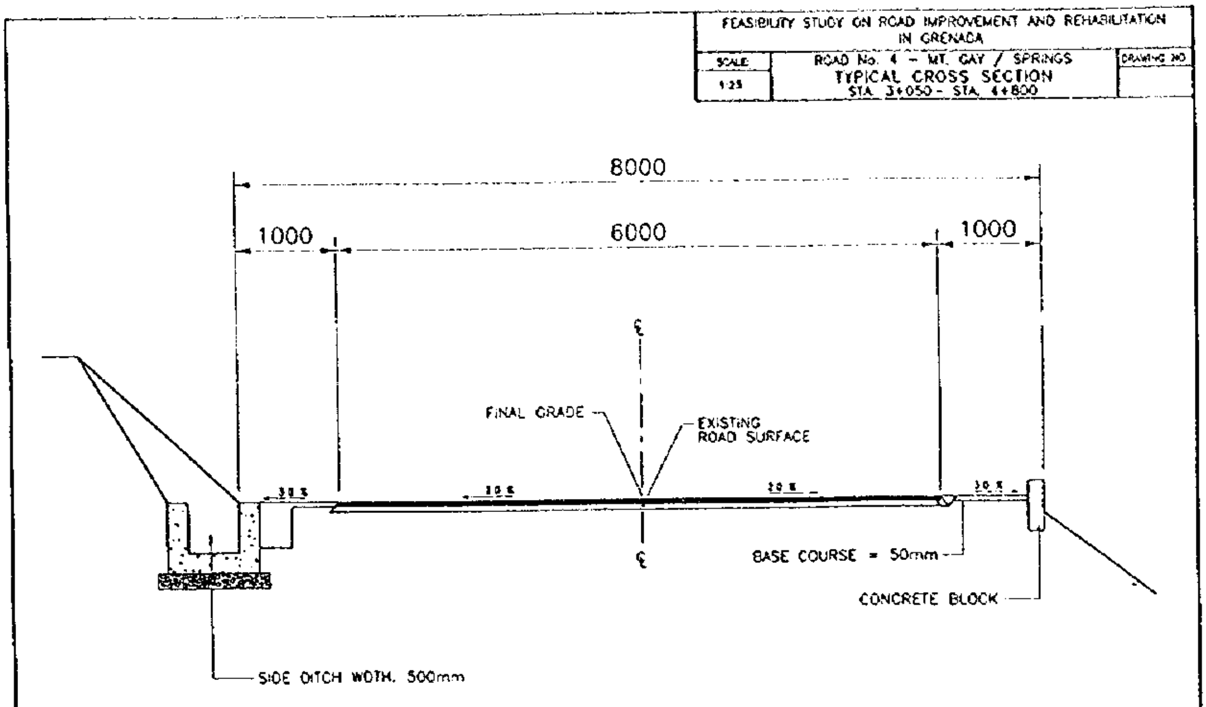


Road-No.1 Grand Etang Road

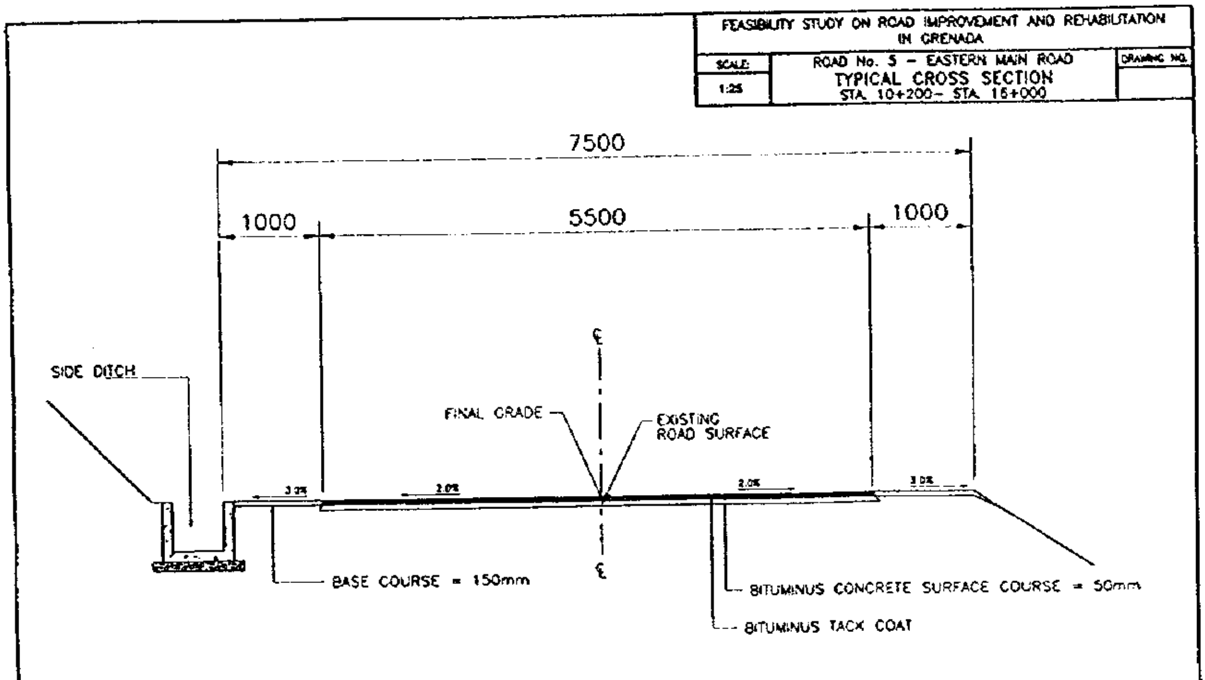


Road-No.2 Morne Jaloux

Figure 10.2.2 Standard Cross Section (1)



Road-No.4 Mt. Gay / Springs



Road-No.5 Eastern Main Road (EMR) -Grenville /Sauteurs

Figure 10.2.3 Standard Cross Section (2)

(2) Width of Roadway

1) Width of Traveled Way and Shoulder

Recommended widths of traveled way and shoulder are shown in Table 10.2.6.

Table 10.2.6 Recommended Width of Traveled Way and Shoulder

Type	Traveled Way Width (km /hr) [a]	Shoulder Width (m)
Primary access roads (two lanes)	6.6 – 7.2	0.6 – 1.2
Circulation roads (two lanes)	6.0 – 6.6	0.6 – 1.2
Area roads (two lanes)	5.4 – 6.0	0.0 – 0.6
Area roads (two lanes) [b]	3.6	0.0 – 0.3

Note: a - Widening on the inside of sharp curves should be provided. Additional width equal to 3.5 divided by the curve radius in meters is recommended.

b - Roadway width greater than 4.2m should not be used because of the tendency for drivers to use the facility as a two lane road.

Source : A policy on geometric design of highway and street AASHTO, 1994.

(2) Turnouts

In some cases where traffic volumes are less than 100 vehicles per day, it may be feasible to use a two-directional one-lane roadway. When one-lane roadway with two-directional traffic is used, turnout for passing should be provided. Traffic convenience requires that turnouts be visible from both directions, provided on all blind corners, and supplemented as necessary so that the maximum distance between turnout is not more than 300m.

The turnout should be a minimum of 3.0m width for a length of 15m and should have an approach of 8.0m on each end. Figure 10.2.4 presents the standard type of turnout.

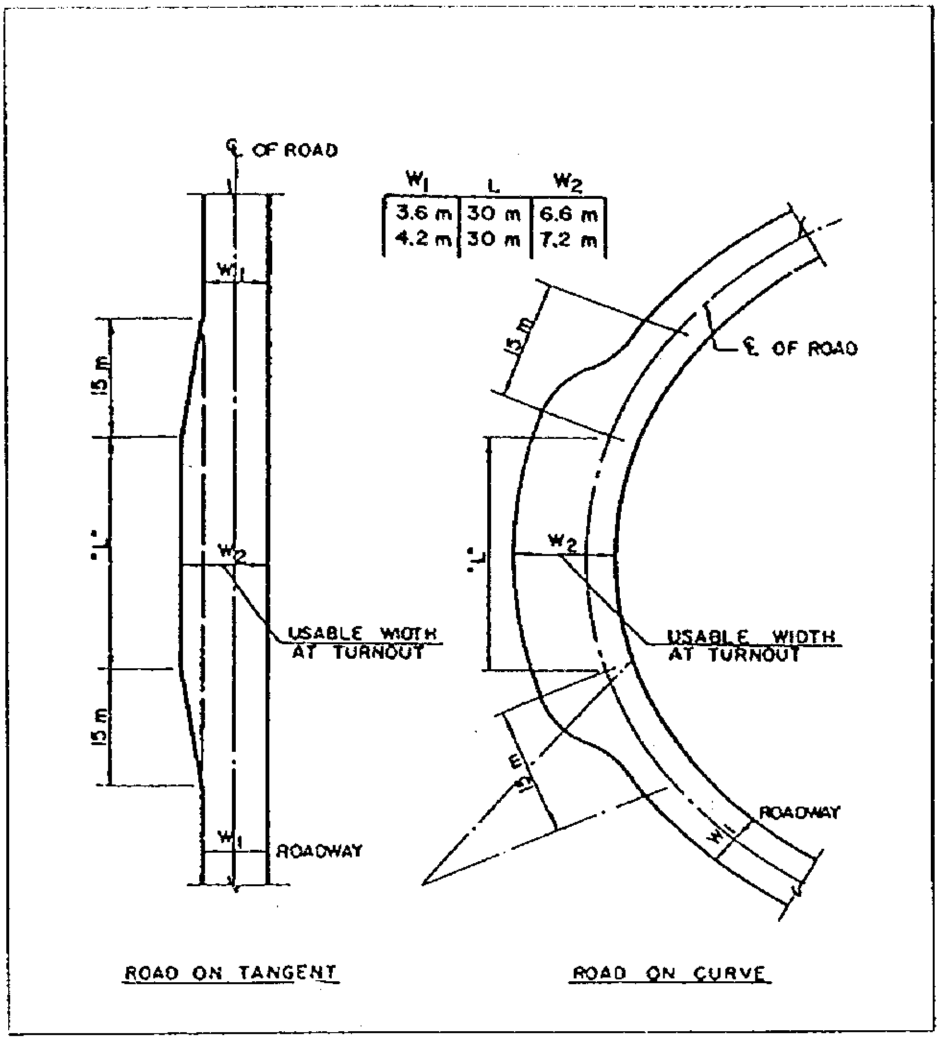


Figure 10.2.4 Turnouts

(3) Sight Distance

Minimum stopping sight distance and passing sight distance are a direct function of the design speed.

The two-directional one-lane roads must provide enough sight distance for one vehicle to reach a turnout or for both to stop before colliding. Therefore, the stopping sight distance for a two-directional one-lane road is approximately twice the stopping sight distance for a two-lane road. Suggested stopping sight distances are given in Table 10.2.7.

Table 10.2.7 Minimum Stopping Sight Distance

Design Speed (km/hr)	20	30	40	50	60
Two-lane roads and single-lane roads (one-direction)					
Stopping Sight Distance (m)	20	30	45	60-65	75-85
K value* for:					
Crest vertical curve	0.3	3	5	9	14-18
Sag vertical curve	0.7	4	8	11	14-18
One-lane road (two directional)					
Stopping Sight Distance (m)	40	60	90	115-125	150-170
K value* for:					
Crest vertical curve	1	3	6	10	17-22
Sag vertical curve	3	6	7	17	24-29

Note: * K value is a coefficient by which the algebraic difference in grade is multiplied to determine the length in meters of the vertical curve, which will provide minimum sight distance.
Source : A policy on geometric design of highway and street, AASHTO, 1994.

(4) Grades

Vehicle operating speeds on special purpose roads are relatively low, and large speed reductions on grade are not anticipated. Table 10.2.8 identifies suggested maximum grades for given terrain and design speed, based primarily on the operational performance of vehicles.

Table 10.2.8 Maximum Grades for Special Purpose Roads

Type of Terrain	Design Speed (km/hr)				
	20	30	40	50	60
Level	8	8	7	7	7
Rolling	12	11	10	10	9
Mountainous	18	16	15	14	12

Source : A policy on geometric design of highway and street, AASHTO, 1994.

10.3 BRIDGE DESIGN

10.3.1 Design Criteria

(1) Under Clearance of Bridge

Clearance under the bottom of superstructures and design flood level will be more than the minimum height of 1.5 meter

- Length and height

Sufficient waterway opening should be provided. Size of waterway opening is determined based on hydrological analysis. Bridge length and height are determined depending on the maximum flood water level (MFWL), freeboard and depth of girders as shown in Figure 10.3.1. Freeboard (vertical clearance between MFWL and bottom of the lowest member of the superstructure) shall not be less than 1.50m for stream carrying debris and 1.00m for others.

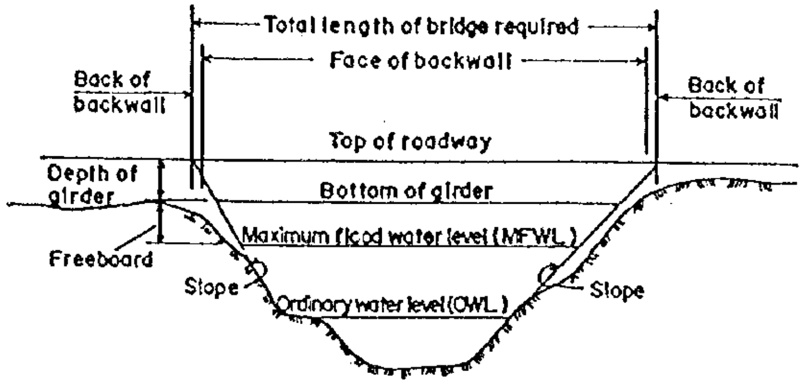


Figure 10.3.1 Determination of Bridge Length and Height, Sources : AASHTO

(2) Location of Abutment

- Abutment should be located at the place where the abutment does not disturb the stream flow.
- Abutment should be located at the place where bridge length is more than length of existing bridge length.

(3) Loading

Structure should be designed to carry the following load:

- Dead load
- Live load
- Impact or dynamic effect of the live load

The dead load consists of the weight of the entire structure including the roadway and sidewalks. The live load consists of the weight of the vehicles and pedestrians. The loads being adopted in the Feasibility Study are adopted from the standard of AASHTO (Design load of HS20).

10.3.2 Bridge Types

(1) Bridge Type and Span Length

Selection of the type of bridge and span length is presented in Figure 10.3.2.

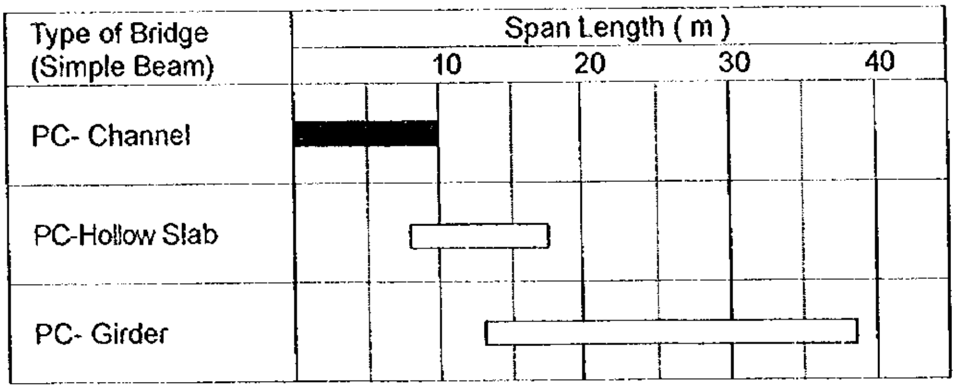


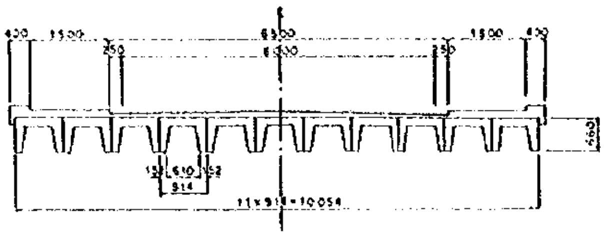
Figure 10.3.2 Bridge Type and Span Length

(2) Standard Bridge Width

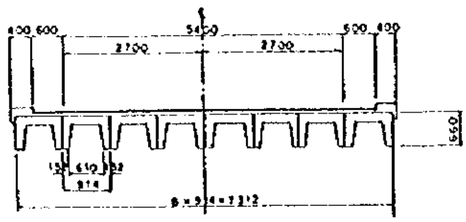
The bridge width applied in this study consists of the road width (Motorized lane) and side walk width on both side of the bridges, as presented in Table 10.3.1 and Figure 10.3.3.

Table 10.3.1 Standard Bridge Width

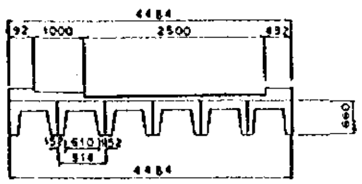
Rehabilitation Method	Road No.	Bridge Width (m)	Name of Bridge
New Construction	1	1.0 + 3.5	Birch Grove
	1	1.5 + 6.0 + 1.5	Balthazar
	1	1.5 + 6.0 + 1.5	St. Cyr Great River
	3	0.6 + 5.4 + 0.6	Vineyard
	5	1.0 + 3.0	Dunfermiline
	5	1.5 + 6.0 + 1.5	Point Field
	5	1.5 + 6.0 + 1.5	Madeys
Widening of Bridge	1	1.5 + 2.9	St. Margaret
	4	2.6	Tempe
Repair	1		Beaulieu



(1) Class 1 Road



(2) Class 2 Road



(3) Class 1 Road, One Lane Additional

Figure 10.3.3 Cross Section of Bridges for New Construction

(3) Sub-structure

The sub-structure consists of abutments, piers and foundations. Figures 10.3.4 and 10.3.5 shows the applicable sub-structure types in accordance with the required structural height of a bridge. The selection of substructure types is based not only on specified figures but also on the following considerations:

- Reinforced concrete structures;
- The cross section of pier in the river is ellipse or rectangular in shape with no restricted conditions;
- Non sliding of the back-fill materials behind abutment is considered in the selection of the abutment type to approach settlement;

The abutment used is a RC (Reinforced Concrete) reversed-T-type abutment as shown in Figure 10.3.4. As for the standard pier, RC pier is selected considering local materials condition, execution ability and economical construction, as shown in Figure 10.3.5. River condition shows danger for the scouring to steep gradient of riverbed. Therefore, applied pier type in this Study is ellipse column which is protected from the scouring caused by swirl stream.

TYPE		Height (m) 0 10 20 30	Remarks
A-1	Chair Type	3	
A-2	Gravity Type	4	
A-3	Semi Gravity Type	4 6	
A-4	Inverse T-Type	6 10	
A-5	Buttressed Type	10 15	
A-6	Box Type	10 30	
A-7	Sustaining Wall Type	10 15	

Figure 10.3.4 Applicable Type of Abutment

TYPE		Height (m) 0 10 20 30 40	Remarks
P-1	Column Type	0 15	
P-2	Rigid Frame Type (1 storey)	5 15	
P-3	Rigid Frame Type (2 storey)	15 25	
P-4	Wall Type	10 30	
P-5	Wall Type II section	25 40	

Figure 10.3.5 Applicable Type of Pier

(4) Type of Foundation Work

Figure10.3.6 shows the applicable foundation types in accordance with the required effective depth to sustain the upper structures. The following types are considered in selecting the foundation type:

- Possible construction depth in consideration of soil conditions.
- The prefabricated pile types are advantageous when the bearing stratum is within a shallow range.

Depth Type	Depth (m)					Soil Condition		
	10	20	30	40		Clayey	Sandy	Boulder
Spread Foundation	━					O	O	O
RC – Pile	━	━				△	△	X
PC – Pile		━	━			△	△	X
Steel Pile	- -	- -	━	━	━	O	O	O

Note: O ; Applicable, △ ; Considerable, X ; Not Applicable

Figure 10.3.6 Applicable Type of Foundation

10.4 PAVEMENT DESIGN

Pavement rehabilitation methods for the seven Study Roads were new construction of asphalt concrete pavement and asphalt concrete overlay, which were adopted based on pavement condition survey results.

10.4.1 Asphalt Concrete Pavement Design

The basic design equation for new construction of asphalt concrete pavement on serviceability – performance concept for flexible pavement in AASHTO Guide1993 is as follows.

(1) Basic Design Equation for Flexible Pavement;

$$Log_{10}(W_{18}) = Zr \times So + 9.36\ log_{10}(SN + 1) - 0.20 + [Log_{10}\ \Delta PSI / (4.2 - 1.5)] / [0.4 + 1094 / (SN + 1)^{5.29} \times 2.32 \times Log_{10}(Mr) - 8.07$$

Where:

W_{18}	;Predicted number of 18-kip equivalent single axle load application,
Zr	;Standard normal deviate,
So	;Combined standard error of the traffic prediction and performance prediction,
ΔPSI	;Difference between the initial design serviceability index, Po The design terminal serviceability index, Pt
Mr	;Resilient modulus (psi), and
SN	;Structural number

The design nomograph to solve the equation is prepared in Figure 10.4.1.

(1) Layer Thickness

The design based on identifying a flexible pavement structural number (SN) to withstand the project level of axle load traffic.

Once the design structural number for an initial pavement structure is determined, it is necessary to set up pavement layer thickness. The following equation provides the basis for converting SN into actual thickness of surfacing, base course and sub-base course:

$$\log_{10}W_{18} = Z_R{*}S_o + 9.36{*}\log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2 - 1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32{*}\log_{10}M_R - 8.07$$

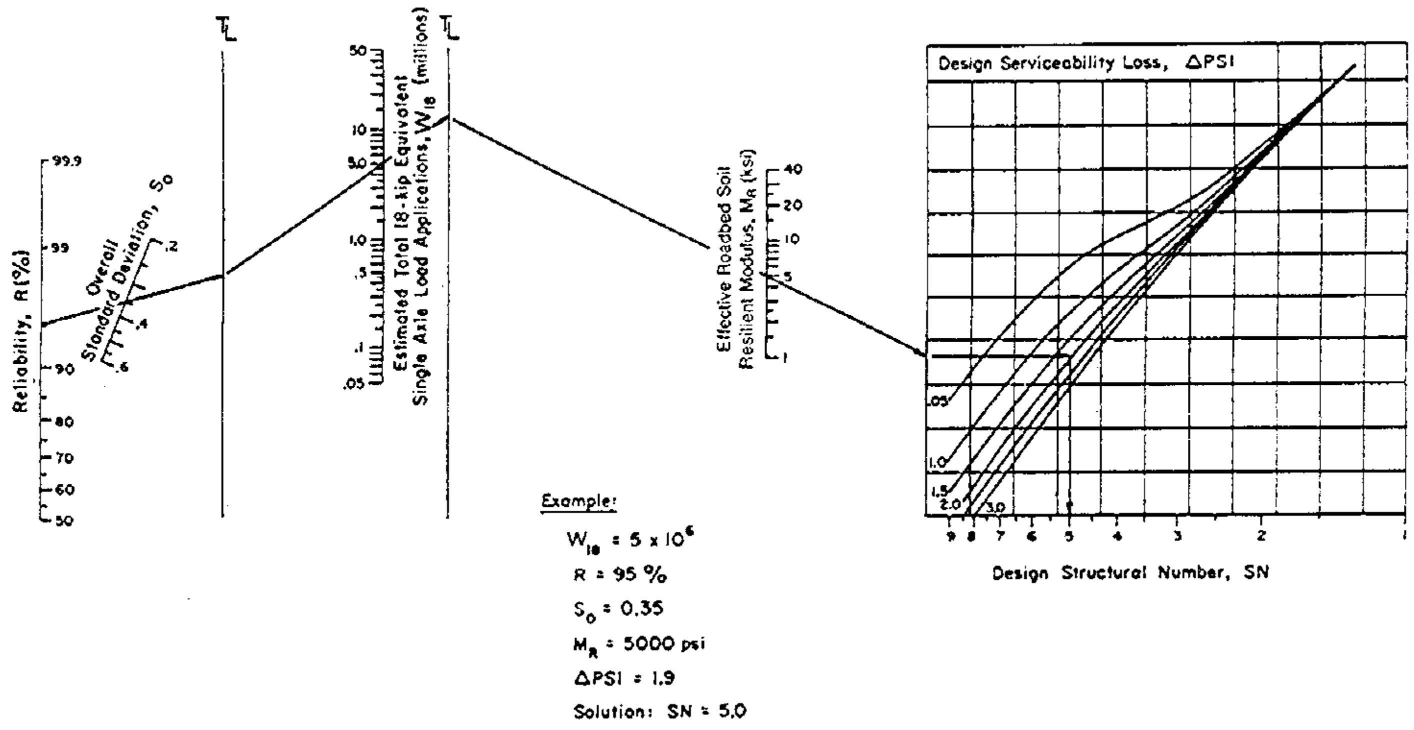


Figure 10.4.1 Design Chart for Flexible Pavements (Based on Using Mean Values for Each Input, Source: AASHTO Guide for Design of Pavement Structure 1993. P.II-32)

$$SN = a_1d_1 + a_2d_2m_2 + a_3d_3m_3$$

Where:

a_1, a_2, a_3	:	Layer coefficients representative of surfacing a_1=0.42, base course a_2= 0.14,sub-base course a_3= 0.11
d_1, d_2 ,d_3	:	Actual thickness (in inches) of surfacing, base course, sub-base course
m_2,m_3	:	Drainage coefficients for surfacing, base course, sub-base course

Since it is generally impractical and uneconomical to place surfacing, base course and sub-base course less than the minimum thickness, the values shown in Table 10.4.1 are provided as the minimum practical thickness for each pavement layers.

Table 10.4.1 Minimum Thickness (inches)

Traffic, ESAL's	Asphalt Concrete	Aggregate Base
Less than 50,000	1.0(or surface treatment)	4
50,001 to 150,000	2.0	4
150,001 to 500,000	2.5	4
500,001 to 2,000,000	3.0	6
2,000,001 to 7,000,000	3.5	6
Greater than 7,000,000	4.0	6

10.4.2 Overlay Pavement Design

(1) Preparation

Before overlay design, the following repairing works are involved in the placement of an AC overlay on an existing pavement.

- Repairing deteriorated areas and making sub-drainage improvement (if needed)
- Correcting surface rutting by milling or placing a leveling course
- Constructing widening (if needed)
- Applying tack a coat
- Placing the AC overlay (including a reflective crack control treatment, if needed)

(2) Thickness Design

The overlay thickness is a function of the structural capacity required to meet future traffic demands and the structural capacity of the existing pavement. The overlay thickness from future traffic is determined by the following equation.

$$SN_{ol} = a_{ol} \times D_{ol} = SN_f - SN_{eff}$$

Where:

SN_{ol} = Required overlay structural number
a_{ol} = Structural coefficient for the AC overlay
D_{ol} = Required overlay thickness, inches
SN_f = Structural number required to carry future traffic
SN_{eff} = Effective structural number of the existing pavement

$$SN_{eff} = SN_1 d_1 + SN_2 d_2 + SN_3 d_3$$

Where:

SN_i = Layer coefficient for existing AC pavement layer materials from Table 10.4.2
d_i = Thickness of existing pavement structure

(3) Structural Number Required to Carry Future Traffic

1) Traffic Volume

Future traffic volume was forecasted in the Study based on the existing traffic volume of the collected traffic survey data. Traffic volumes for the project roads are presented in Table 10.4.3.

Table 10.4.2 Suggested Layer Coefficient for Existing AC Pavement Layer Materials

Material	Surface Condition	Coefficient
AC Surface	Little or no alligator cracking and/or only low-severity transverse cracking	0.35 to 0.40
	<10% low-severity alligator cracking and/or <5% medium- and high-severity transverse cracking	0.25 to 0.35
	>10% low-severity alligator cracking and/or <10% medium-severity alligator cracking and/or >5 to10% medium-and high-severity transverse cracking	0.20 to 0.30
	>10% medium-severity alligator cracking and/or <10% high-severity alligator cracking and/or >10% medium-and high-severity transverse cracking	0.14 to 0.20
	>10% high-severity alligator cracking and/or >10% high-severity transverse cracking	0.08 to 0.15
Granular base or subbase	No evidence of pumping, degradation, or contamination by fines	0.10 to 0.14
	Some evidence of pumping, degradation, or contamination by fines	0.00 to 0.10

Note: Source; AASHTO Guide for Design of Pavement Structure 1993, pp-III 105

Table 10.4.3 Future Traffic Volume

Road No.	Road Name	2005 Total	2005 Car/Bus	2005 Truck (L)	2005 Truck (H)	2015 Total	2015 Car/Bus	2015 Truck (L)	2015 Truck (H)
1	Grand Etang Road	6,194	4,522	1,053	619	8,257	6,027	1,404	826
2	Morne Jaloux Road	1,478	1,271	163	44	2,244	1,930	247	67
3	St David's~ Perdmontemps	325	234	65	26	433	312	87	35
4	Mt. Gay ~ Springs	4,657	3,492	838	326	6,482	4,861	1,167	454
5	Eastern Main Road	2,490	1,980	336	174	3,254	2,587	439	228
6	Paraclete ~ Mt Horne Road	946	652	246	47	1,434	989	373	72
7	Dover Road	698	422	192	84	931	564	256	112

2) Equivalent 18kip Single Axle Load (ESAL)

Equivalent 18kip single axle load was calculated based on axle load survey data and accumulated traffic volume. Computation results are shown in Table 10.4.4.

Table 10.4.4 Equivalent 18kip Single Axle Load (ESAL)

Road No.	Road Name	ESAL $x10^6$			
		2001~2005	2001~2010	2001~2015	2001~2020
1	Grand Etang Road	0.398	0.928	1.259	1.989
2	Morne Jaloux Road	0.048	0.121	0.194	0.266
3	St.David's~Perdmontemps	0.027	0.062	0.098	0.134
4	Mt. Gay ~ Springs	0.215	0.514	0.813	1.112
5	Eastern Main Road	0.113	0.260	0.408	0.555
6	Paraclete Mt Horne Road	0.012	0.094	0.175	0.257
7	Dover Road	0.088	0.182	0.298	0.415

Note; ESAL = Daily Traffic Volume x 365 x year x Axle Load Factor x L(d)
Axle Road Factor Truck (L) = 0.02
Truck (H) = 0.67
ESAL ; Equivalent 18kip Single Axle Load
L (d) ; Lane Distribution Factor 2 – Lane Road 0.50 1 – Lane Road 0.80

3) Structural Number (SN)

Structural number of the Project Roads is computed based on ESAL in Figure 10.4.1 of the Design Chart for Flexible Pavement based on using mean values for each input and assumed conditions. Calculation result of structural number for the study roads is presented in Table10.4.5.

Table 10.4.5 Structural Number

Road No.	Road Name	Structural Number (SN)			
		2001~ 2005	2001~ 2010	2001~ 2015	2001~ 2020
1	Grand Etang Road	2.80	3.30	3.40	3.70
2	Morne Jaloux Road	1.70	2.10	2.20	2.40
3	St. David's~ Perdmontemps	1.70	1.80	2.00	2.10
4	Mt. Gay ~ Springs	2.50	2.80	3.00	3.20
5	Eastern Main Road	2.30	2.60	2.90	3.00
6	Paraclete~Mt.HorneRoad	1.50	2.00	2.20	2.30
7	Dover Road	2.00	2.20	2.30	2.50

Note: SN ; Reliability R : 95%
Overall Standard Division So : 0.35
Effective Roadbed Soil Resilient Modulus Mr : 8,000 psi (CBR = 10%)
Design Serviceability Loss, 2.0

(3) Overlay Thickness

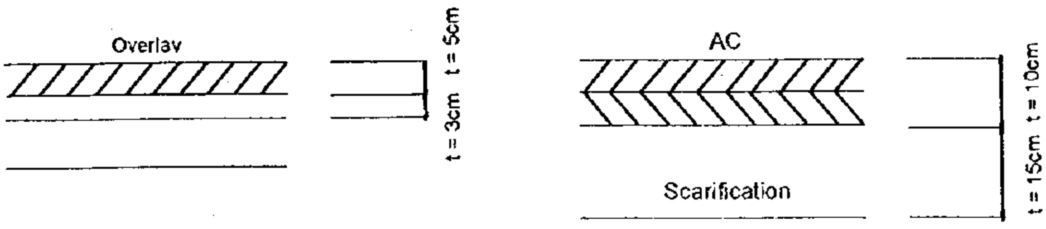
Layer coefficient of existing pavement for selected roads were assumed by the field survey results and CBR test result. Overlay thickness of the selected roads are presented in Table 10.4.6.

Table 10.4.6 Overlay Thickness

Road No.	Road Name	Overlay Thickness(cm)			
		2001~2005	2001~2010	2001~2015	2001~2020
1	Grand Etang Road	2.0	5.0	6.0	8.0
2	Morne Jaloux Road	2.0	5.0	5.0	7.0
3	St. David's~ Perdmontemps	4.0	4.0	5.0	6.0
4	Mt. Gay ~ Springs	4.0	5.0	7.0	8.0
5	Eastern Main Road	4.0	5.0	7.0	8.0
6	Paraclete~Mt.HorneRoad	2.0	5.0	7.0	7.0
7	Dover Road	5.0	6.0	7.0	8.0

Note: Overlay thickness (cm) = $\{(SN_f - SN_{eff}) / A_{ol}\} \times 2.54$

Thickness of overlay was applied for 10 years period for economical and easily considerations execution of works. Pavement structure applied in this project is presented Figure 10.4.2.



(1) AC Overlay, t = 5cm, t=3cm (2) Scarification, t = 10cm

Figure 10.4.2 Overlay Thickness

10.5 DRAINAGE DESIGN

The drainage facilities required for surface water are classified as facilities for road surfaces water, slope water and adjoining land drainage. The functions of these facilities are as follows:

- Road Surface water discharge facility
  Surface water is collected by a lateral ditch and discharged by cross drainage or vertical ditch

- Slope face water discharge facility
  Collection and discharge water uses side ditch at berm and toe of the slope.

- Road adjoining land discharge facility
  Rainfall on the adjoining land is discharged by means of a lateral ditch at the boundary of road and road crossing structure (reinforced concrete pipe culvert RCPC or reinforced concrete box culvert RCBC).

10.5.1 Surface Drainage Design

Design of surface water discharge facility is calculated using the probable rainfall intensity and allowable discharge area, as presented in Appendix 13.

(1) Design of Surface Water Discharge Facility
Rainfall intensity for calculation of design discharge volume is applied as classified below:

- Road surface water — 2 years probability rainfall intensity
- Slope face water — 2 years probability rainfall intensity
- Road adjoining land — 10 years probability rainfall intensity

(2) Rainfall Intensity
Calculated method of Rainfall intensity is shown in Appendix 13

(3) Calculation of Design Discharge Volume
Design discharge volume is calculated by applying empirical and theoretical formula in Grenada.

(4) Road Crossing Structure
In case of design discharge volume of 3-20 cm^3/sec, reinforced concrete box culvert (RCBC) should be applied. Details of RCBC are shown in Drawing No. D-1. In case of design discharge volume less than $3m^3/sec$, an RCPC with a

minimum diameter of 600mm should be applied, as shown in Table 10.5.1.

The average interval between cross drainage facilities on the road is about 170m.

Table 10.5.1 Type of Drainage Structure

Classification of Drainage Structure		Type
Drainage structure of road surface	Toe and top of shoulder	Side ditch (Rip rap)
Drainage structure of road adjacent area	Design volume $3 \sim 20m^3/sec$	Reinforced Concrete Box Culvert
	Design ditch volume Less than $3m^3/sec$	Reinforced Concrete Pipe Culvert

10.5.2 Subsurface Drainage Design

Groundwater, spring water and seepage water near ground surface permeating into slope shall be drained in order to protect the stability of the slope. Subsurface drainage facilities usually used in such case are classified as follows:

For groundwater in shallow stratum (2 – 3m deep):

- Closed Conduit
- Closed Conduit with open ditch
- Gabion (Wire Cylinder)
- Horizontal Drain Hole

For groundwater in deep stratum (deeper than 3m):

- Horizontal Drain Hole
- Vertical Weep Hole
- Horizontal Drainage Layer

These subsurface facilities shall be systematically arranged with effective combination of conduit and channel.

Closed conduit and close conduit with open ditch are most suitable facilities to collect and drain groundwater in shallow stratum (about 3m below ground surface). These facilities are effective particularly to groundwater in soils with small coefficient of permeability.

These conduits are constructed in such a way that a fascine or gabion is installed in the ditch excavated to a predetermined depth. Vinyl cloth or asphalt board is laid below them to prevent any leakage. Gravel is placed with filter around and above them to prevent clogging. Where the amount of collected water is large, perforated pipes are sometimes used. Catch basins or manholes are normally installed at every 20 to 30m of conduit and are connected to surface water channel or draining conduit.

10.6 SLOPE DESIGN

10.6.1 Classification of Countermeasures for Slope Disasters

Slope disasters for road are classified into the following five (5) main types.

- Cut Slope Failure
- Embankment Slope Failure
- Fall
- Landslide
- Debris Flow

The works for the countermeasures to protect, control or restrain slope disasters are defined and classified in several ways in accordance with: i) places where these works are applied, ii) purposes of works acting against disasters iii) materials to be used, and iv) shapes of works. In general, the countermeasures are classified in the following eleven (11) types:

- Drainage Work
- Protection Work
- Earth Work
- Structural Work
- Fixing Work
- Catch Work
- Rock Shed
- Hillside Work
- Torrent Work
- Sabo Work
- Avoiding Problem Work

Table 10.6.1 summarizes countermeasures for cut slope failure and embankment slope failure, which were mainly used for the Study Roads.

Table 10.6.1 Countermeasures for Each Type of Slope Disaster

Countermeasures \ Slope Disaster			Cut Slope Failure	Embankment Slope Failure
Drainage Work	Surface Drainage		O	O
	Subsurface Drainage		O	O
Protection Work	Vegetation		O	O
	Spraying		O	
	Pitching		O	O
	Crib		O	O
Earthwork	Removal		O	
	Recutting		O	
	Refilling			O
	Earth Removal Counterweight			
Structural Work	Retaining Wall	Stone	O	O
		Gravity	O	O
		Support	O	O
		Gabion	O	O
	Anchoring		O	
	Foot Protection			O
	Piling			

10.6.2 Criteria for Selection of Protection Works

Slope protection works should be carefully selected taking into consideration peculiarities of each protection work, considerations of slope, etc., Table 10.6.2 shows the general criteria in the selection of protection works.

Table 10.6.2 General Criteria for Selection of Protection Works

Condition of Soil		Condition of Slope		Slope Protection Work
Typical	Example			
Alluvial Deposit Strongly Weathered Materials Clayey Soil	• Volcanic Mudflow • Loam • Cohesive Soil	Extensive Spring Water	Slope Steeper than 1:1 Slope gentler than 1:1	Mat Gabion, Crib Gabion, Crib work filled gravel
		A Little Spring Water	Slope steeper than 1:1	Stone Masonry, Block Masonry
			Extensive spring water Vegetation spring water	Vegetation, if necessary, Crib work with filling gravel, Block Pitching
Sandy Soil (easily errodable)	• Weathered Granite • Volcanic Ashes • Loose Sandstone	Cut	Extensive spring water Vegetation spring water	Gabion, Crib work with filled cobblestones, wicker work Vegetation, if necessary, Crib work with filled sediment, Wicker Work
	• Sand of Diluvial Epoch	Embankment	Ordinary height Very high	Vegetation Vegetation with Wicker Work on Concrete Block Crib Work
Hard Soil	• Dense Sandy Soil • Hard Clayey Soil • Hard Clay • Soft Rock			Vegetation with Dressed Soil by growing of Digging
Rock Fall – Prone Area	• Sediment with Gravel • Weathered Soft Rock	Small Rock Fall	Ordinary Cases Many Fissures, No water fissures	Rock Fall Prevention Net, Fence, if possible, Seed Mud Spray Concrete Spraying
	• Soft and Hard	Big Rock Fall	Many joints distribution widely	Concrete Spraying
	• Soft and Hard	Cracks in Bedrock		Anchoring Work
		Unstable Pumice Stone		Rock Bolt, Removal of Rock
Rock quickly weathered after cutting	• Tertiary Mudstone • Shale • Tuff	Gentle Slope, Few Possibility of Failure after progress of weathering		If possible, Vegetation, Otherwise Crib work with filled Sediment or Cobblestone
	• Rhyolite • Igneous Rock	Steep Slope, considerable Possibility of Failure after progress of weathering		Concrete Spraying, Concretee Block Crib, Crib work with Block Pitching, Supported Retaining Wall

10.6.3 Countermeasures For Cut Slope Failures

Countermeasures for cut slope failures are classified into the following six types:

- Drainage Work
- Protection Work
- Earth Work
- Structural Work
- Catch Work
- Avoiding Protection Work

(1) Standard Gradient

1) Standard Gradient of Cut Slope

Gradient of cut slopes vary with the types and condition of the soil and with the height of the cut. Table 10.6.3 shows the standard gradients of cut slopes, empirically established, assuming no treatment or provision of slight protection work such as sodding or netting.

Table 10.6.3 Standard Gradients of Cut Slopes

Soil or Rocks		Height of Cut	Gradient
Hard Rock			0.3:1 to 0.8:1
Soft Rock			0.5:1 to 1.2:1
Sand	Not dense, and poorly graded		1.5:1 or above
Sandy Soil	Dense	Less than 5 m 5 to 10 m	0.8:1 to 1.0:1 1.0:1 to 1.2:1
	Not dense	Less than 5 m 5 to 10 m	1.0:1 to 1.2:1 1.8:1 to 1.2:1
Sandy Soil mixed with gravel or rock masses	Dense, or well graded	Less than 10 m 10 to 15 m	0.8:1 to 1.0:1 1.2:1 to 1.1:5
	Not dense, or poorly graded	Less than 10 m 10 to 15 m	1.0:1 to 1.1:1 1.0:1 to 1.2:1
Cohesive Soil		Less than 10 m	0.8:1 to 1.2:1
Cohesive Soil mixed with rock masses or cobble stones		Less than 5 m	1.0:1 to 1.2:1
		5 to 10 m	1.2:1 to 1.5:1

Note: (1) Silt is classified as cohesive soil.
(2) Soil not shown in the above table shall be designed with special care.

2) Standard Gradients of Embankment Slopes

Gradients of embankment slopes should be designed in accordance with the kind of embankment materials, geological condition of embankment foundation, height of embankment and other conditions.

Standard gradient of embankment slope shown in Table 10.6.4 is generally adopted in accordance with the type and height of embankment materials used.

Table 10.6.4 Standard Gradients of Embankment Slopes

Filling Materials	Height of Fill (m)	Gradient
Sand with well grading, gravel and sand mixed with gravel	Less than 5 m	1.5:1 to 1.8:1
	5 to 15 m	1.8:1 to 2.0:1
Sand with poor grading	Less than 10 m	1.8:1 to 2.0:1
Sand with masses (including muck)	Less than 10 m	1.5:1 to 1.8:1
	10 to 20 m	1.8:1 to 2.0:1
Sandy soil, hard clayey soil, hard clay (hard clayey soils and clay of alluvium)	Less than 5 m	1.5:1 to 1.8:1
	5 to 10 m	1.8:1 to 2.0:1
Soft clayey soil	Less than 5 m	1.8:1 to 2.0:1

Note: (1) Silt is classified as cohesive soil.
(2) Soil not shown in the above table shall be designed with special care.

(2) Selection of Countermeasures

In selecting proper countermeasures, the following elements should be taken into consideration:

1) Causes of failure

- Primary Causes (topography, geology, others)
- Inducement Causes (surface water, groundwater, precipitation, others)

2) Characteristics of Countermeasures

- Purpose and Effectiveness
- Stability and Durability
- Construction
- Maintenance
- Others

3) Impact

- Traffic
- Social
- Environmental
- Others

In many cases, several countermeasures may be proposed in one disaster spot and thus the combined use of two or three measures is rather common.

(3) Drainage Work

The causes of cut slope failure by the effect of water may be divided into two: first, erosion and scouring due to surface water running down on slope surface; and second, sliding of the slope due to decrease of shearing strength and increase of pore water pressure because of the existence of groundwater. Cause of failure is mostly on the first case. Thus, drainage work (especially surface drainage) is considered vital for slope protection. Ditching is the most common method used for surface water drainage.

- Top Slope Ditch
- Berm Ditch
- Vertical Ditch

(4) Protection Work with Vegetation

Protection work with vegetation is relatively cheap and contributes to aesthetics in the environment. For this reason, whenever possible, vegetation should be fully utilized as a protection measure. Seed spraying with equipment may be recommended because of the following reasons:

- Environmental aspect
- Cut and short construction period
- No disruption of traffic during construction

10.6.4 Countermeasures for Embankment Slope Failures

Countermeasures for embankment slope failures are classified into the following four types:

- Drainage Work
- Protection Work
- Earth Work
- Structural Work

Each of these works is sub-classified into several types of works as listed in Table 11.1 indicating the purpose, application and typical illustrations.

(1) Selection of Countermeasures

The elements for the selection of countermeasures for embankment slope failures are basically the same process to that of selecting countermeasures for cut slopes described in Section 10.6.3.

(2) Drainage Work

1) Surface Drainage

Generally, deterioration of embankment slope is often attributed to scouring due to concentration of surface water on the roadway. Drainage system, therefore, should be planned with the following considerations:

- Side Ditch
- Berm Ditch
- Vertical Ditch

2) Subsurface Drainage

Embankment can easily fail due to the effect of groundwater. When constructing new embankment or planning the re-filling, horizontal drain layer should be always provided to drain seepage water.

10.6.5 Countermeasures for Fall

Countermeasures for fall are classified into the following six types.

- Drainage Work
- Protection Work
- Earth Work
- Fixing Work

(1) Selection of Countermeasures

In selecting countermeasures for fall, following factors should be considered:

1) Cause of Failure

- Primary Causes (Topography, Geology, Others)
- Inducement Causes (precipitation, Wind, Others)

2) Characteristics of Countermeasures

- Purpose and Effectiveness
- Stability and Durability
- Construction
- Maintenance

3) Impact

- Traffic
- Social
- Environmental

In many cases, several countermeasures may be selected for spot and thus the combined use of two or three measures is rather common.

(2) Drainage Work

For slopes suspicious of fall due to surface water, drainage work such as top slope ditch, berm ditch and vertical ditch should be applied. However, where slopes are composed of hard rock, these may not be required because hard rock may not be eroded and scoured due to water.

10.6.6 Design of Retaining Walls

(1) General

Retaining walls are structures to support and retain earth in order to prevent failure of sediment in the places where stability of slope can not be assured by normal ground conditions (earth alone) or by other slope protection works.

Retaining walls are classified into the following types in accordance with the shapes and characteristics.

- Stone Masonry Retaining Wall
- Gravity Type Retaining Wall
- Supported Type Retaining Wall
- Cantilever Beam Type Retaining Wall
- Counterfort Type Retaining Wall
- Gabion Retaining Wall

To select a most appropriate type of retaining wall, a comparative analysis is recommended among several alternative types. In the analysis, topography, geology and conditions for construction should be taken into consideration.

Types of retaining walls generally adopted are presented in Table 10.6.2 in accordance with the height.

Table 10.6.5 Recommended Types of Retaining Wall in Accordance with Height

Type	Height of Retaining Wall (m) 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Stone Masonry	Special case Only for cut slope
Gravity	
Support	Special case
Cantilever Berm	Special case
Counterfort	

(2) Stone Masonry Retaining Wall

Stone masonry retaining wall is used to protect a slope from small-sized failure near the toe of slope. This type is effective only for small earth pressure acting on a retaining wall slope with gradient steeper than 0.5:1 (generally 0.3:1 – 0.6:1) and with firm soil cover. The height of the structure is normally less than 5m for embankment and 7m for cut slope.

10.7 SAFETY DEVICES

The Study Roads are characterized with sub-standard geometric design with short sight distances and low safety level.

The driving safety facilities and protection devices for the road users and resident along the road, such as road signs, road markings, information signs, guardrails and side walk etc., are not existed or in a very poor condition at the rural sections. The Grand Etang Road located in mountainous terrain especially needs to have more driving safety devices where there are many sharp curves with steep gradient.

According to the traffic forecast on the Project Roads, traffic volume will increase every year by about 5%. After completion of the road improvement project, car accidents may increase than now because cars can keep high speeds due to the road improvement.

The road management should reduce car accidents by applying road safety and control devices, such as:

- Markings and center line at 2-lane roads.
- Warning signs should be placed before and after at pedestrian crossings, populated areas and school zones.
- Regulation sign are required along the roads.
- Warning signs should be placed more than 10% steep gradient sections.
- Curve mirror should be installed at sharp curve section.
- Guardrail should be installed in cliff more than 3 meter height at populated areas and curved sections.
- Delineators should be used at dangerous sections of the roads.
- Guiding signs are required for unfamiliar drivers and tourists.

10.8 CONSTRUCTION METHOD

A summary of the proposed improvement works on the Project Roads under this Study is presented graphically as a straight diagram in Figure 10.8.1.To implement such improvement works, the proposed construction method is presented in the following sections.

10.8.1 Construction Method Type

There are two types of construction methods, namely labor-based and equipment-based construction methods. In the selection of a construction method, following factors should be assessed:

- Project type and quality required
- Construction period
- Economic aspect

The project for the improvement and rehabilitation of existing roads has basically the following requirements:

- Good quality of work is required to ensure the structural stability and durability under the continuously increasing traffic loads.
- Construction period should be as shorter as possible to avoid disturbance to existing traffic.

In view of above, labor-based construction method is not appropriate for this project and adoption of equipment-based construction method is recommended.

Major work items included in this Project are presented in Table 1 of Appendix 16. All works can be done by usual equipment-based construction method used in Grenada.

10.8.2 Traffic Management during Construction

Traffic management plan during construction is summarized as below:

(1) Roadway Rehabilitation(including drainage work)

In principle, roadway rehabilitation works are executed side by side of the road. During the construction of one side, the other side is open to traffic in one-way operation controlled by a signal (by mobile signal or manually). Construction length of each segment is determined depending on the traffic volume. Assumed construction length of each segment is as follows:

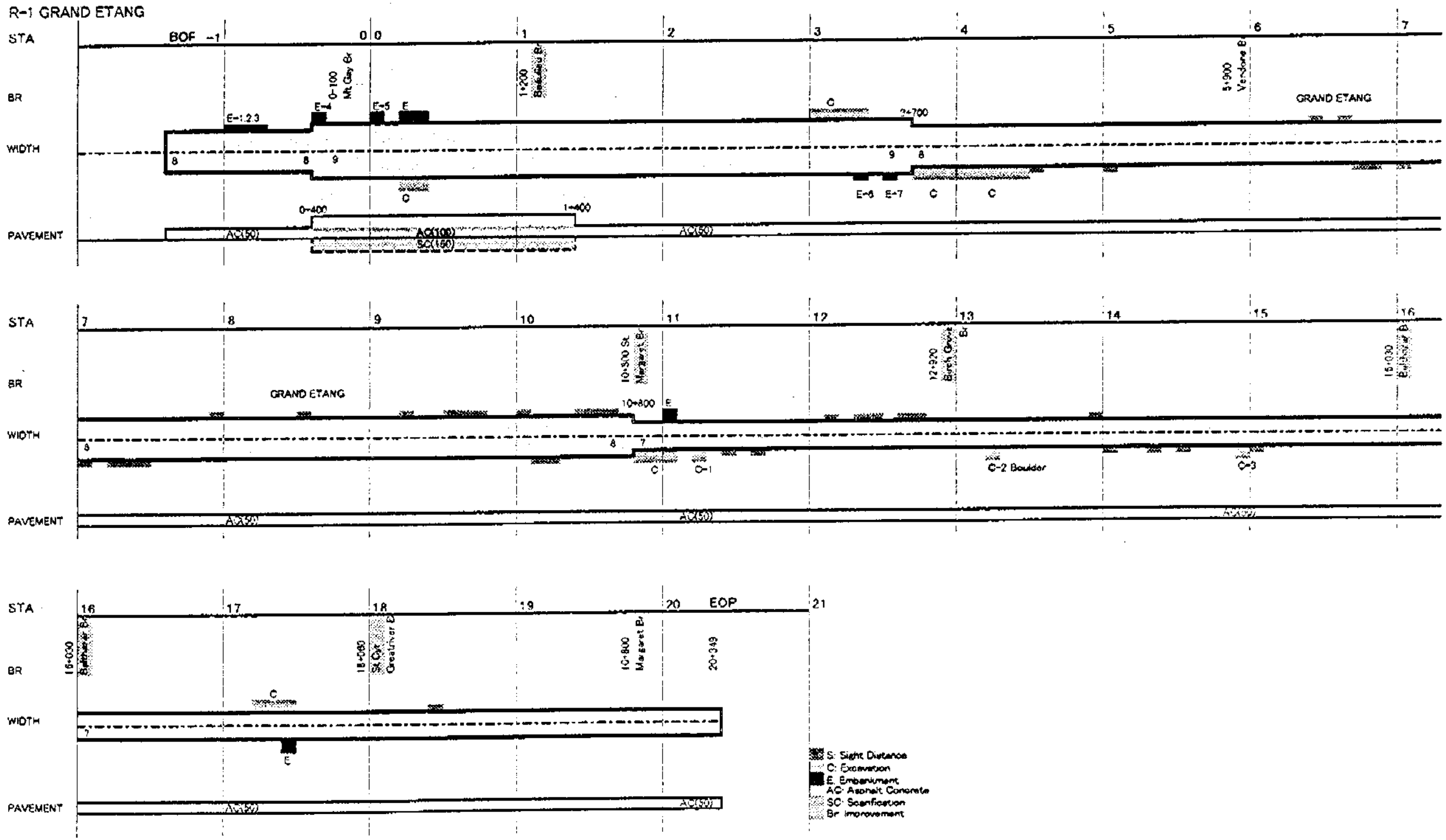


Figure 10.8.1(1) Proposed Improvement Works

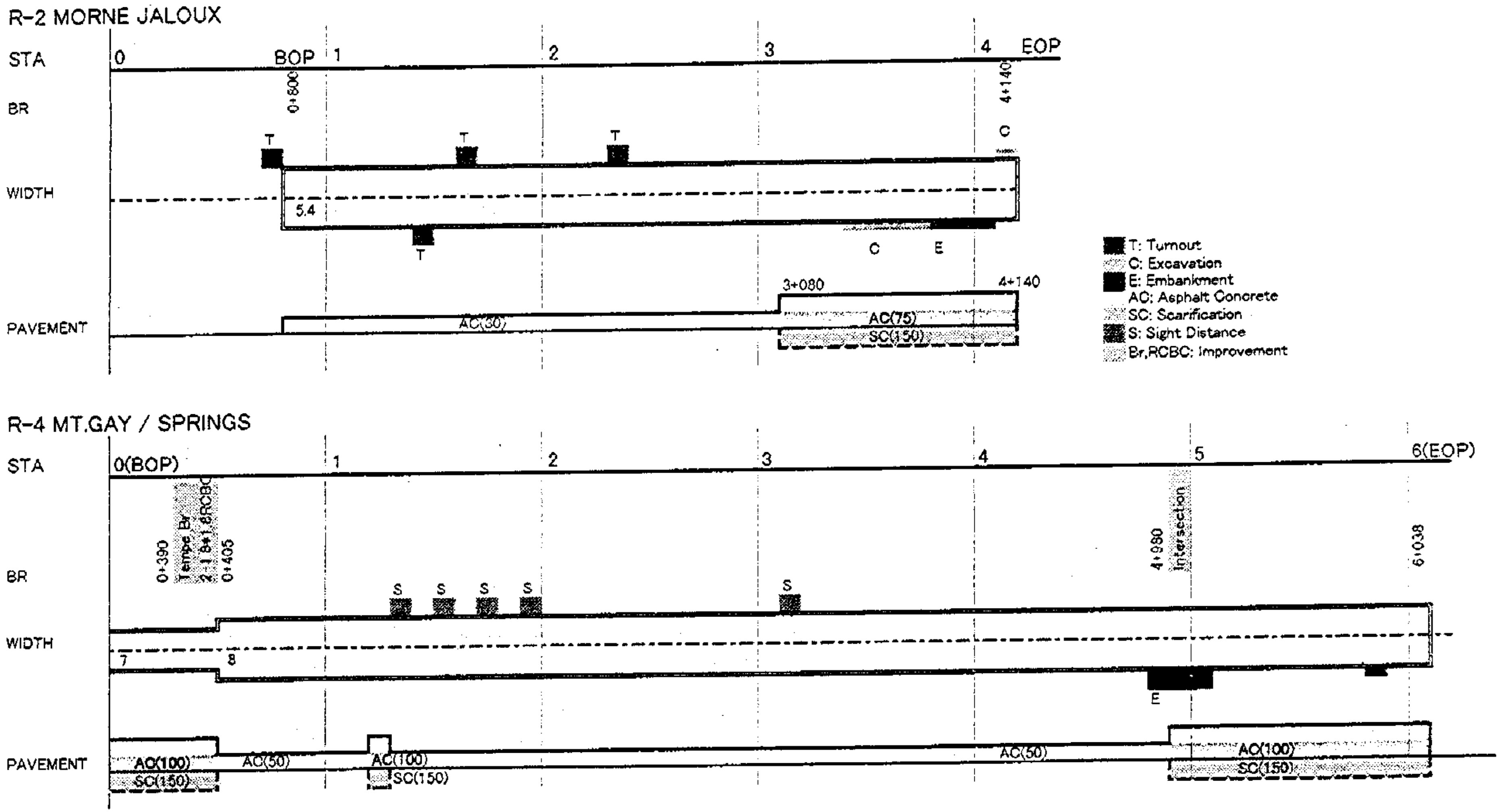


Figure 10.8.1(2) Proposed Improvement Works

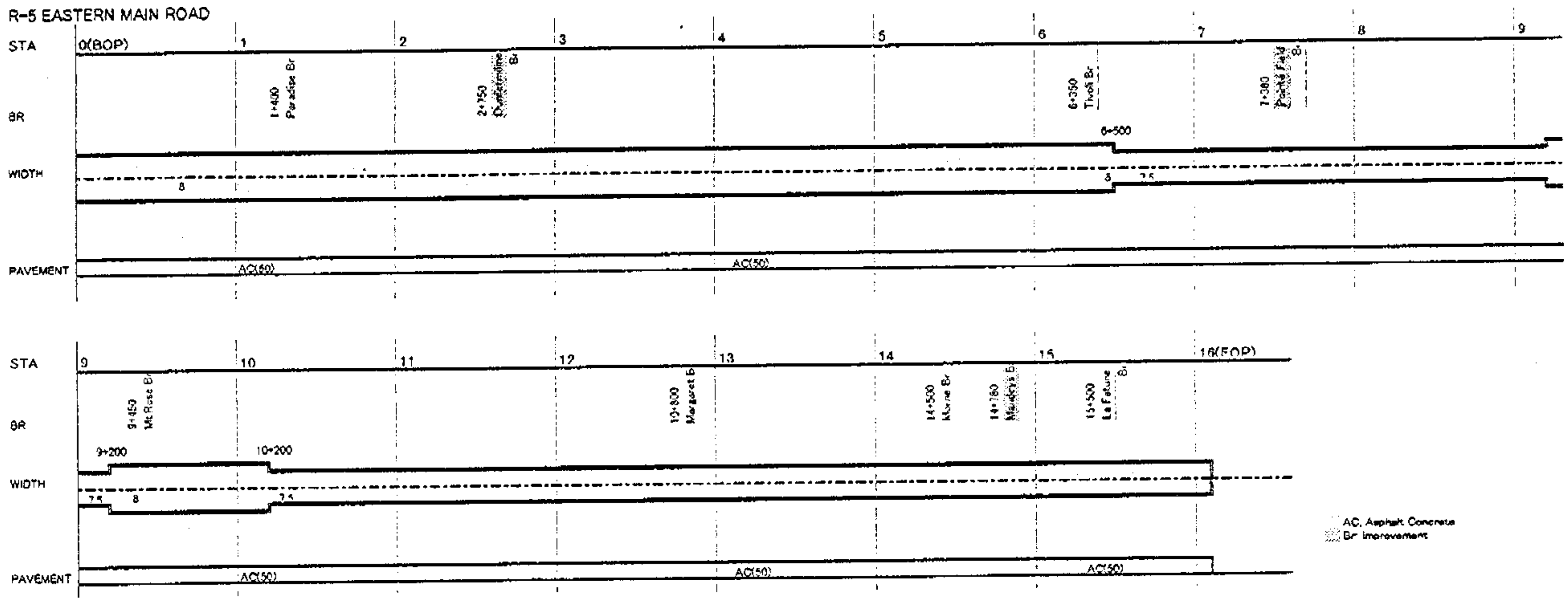


Figure 10.8.1(3) Proposed Improvement Works

ADT	Construction Length (m)
Less than 1,000	500
1,000 to 3,000	400
More than 3,000	300

(2) Bridge Rehabilitation

There are two construction methods for bridge rehabilitation as follows:

Method A : Detour road construction

Prior to the rehabilitation/reconstruction works, a detour road is constructed including a temporary bridge, usually adjacent to the existing bridge.

Method B : Using existing road in full width

If rehabilitation/reconstruction work does not affect the traffic at all, existing road is used for detour road (including change of road alignment).

Accordingly, the applied method for each bridge project is as follows:

- New and reconstruction
  Method A : Point Field bridge
  Method B : Birch Grove bridge, Balthazan bridge, St. Syr Greatriver bridge, Vineyard bridge, Dumfermiline bridge and Madeys bridge.

- Partial reconstruction
  Method B : Beaulieu bridge

- Widening
  Method B : St. Margaret bridge and Tempe bridge

(3) Slope Protection

Traffic management during the execution of slope protection works is as follows:

- Cut Slope Failure
  In case of Grand Etang Road, there is a few shoulder width possible to use for construction. Mostly, cut slope work areas need to extend a part

of traveled way, and one-lane operation controlled by a signal is required.

- Embankment Slope Failure
  In most cases, work area extends to a part of traveled way. Therefore, one-way traffic operation is required.

- Falling Rock
  Same as in cut slope failure.

10.8.3 Working Days

According to the rainfall data and national holidays in Grenada, net working-day ratio is about 64%. Details of the calculation of working days are as presented in Table 10.8.1.

Table 10.8.1 Net Working Days

Items	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Calendar's Days	31	28	31	30	31	30	31	31	30	31	30	31	365
Sundays	5	4	4	5	4	4	5	4	4	5	4	5	53
National Holidays	1	1	2	0	3	0	0	4	0	1	0	2	14
Non-work Days by Rain	2	2	3	4	4	6	8	9	9	8	7	6	68
Total Non-work Days	8	7	9	9	11	10	13	17	13	14	11	13	135
Net Working Days	23	21	22	21	20	20	18	14	17	17	19	18	230

Note: Average Month = 230 / 365 x 100 = 63.9% , 19days / Month
Dry Season (Jan to May) = 123 / 214 x 100 = 57.5%, 17 days / month
Rain Season (Jun to Dec) = 107 / 151 x 100 = 70.9%, 21 days / month

10.8.4 Equipment and Material Requirements

(1) Equipment

Based on the volume and components of work for the Project, major equipment required are estimated as is listed in Table 10.8.2. All the necessary equipment is the one commonly used in Grenada.

(2) Materials

Major materials required for this project are listed in Table 10.8.2. Materials required for the project are mostly imported from Trinidad and Tobago. Location of local product materials sources such as aggregate for asphalt concrete and base course material are presented in Figure 10.8.2 and Table 10.8.4.

Table 10.8.2 Equipment List for the Construction

Equipment Name	Type/Capacity	Number of Equipment
1) Earth Work / Base Course		
Vibratory Roller	10ton to 13ton	2
Vibratory Compactor	3.5ps to 5.0ps	2
Motor Grader	100ps to 120ps	2
Tired Roller	10ton to 15ton	2
Back Hoe	$0.4m^3$	3
Water Truck	$8.0m^3$	2
Dump Truck	$7.0m^3$	10
Bulldozer	142ps to 160ps	2
Crawler Drill	130ps to 170ps	4
Wheel Loader	$1.3m^3$	2
2) Pavement Work (AC Pave.)		
Bitumen Distributor	2,000l to 3,000l	1
Paver	2.4m to 4.5m	1
Tired Roller	10ton to 15ton	1
Steel Roller	8ton to 12ton	1
Vibratory Roller	5ton to 8ton	1
Vibratory Roller	3ton to 4ton	1
Concrete Cutter	20ps	1
3) Bridge Work		
Truck Crane	15ton to 20ton	2
Concrete Pump		1
4) Others		
Generator	65ps to 80ps	2
Air Compressor	30ps to 50ps	2
Concrete Mixer	0.1cm	
Trailer	12tone	1

Table 10.8.3 Bill of Quantities

Item		Unit	R-1	R-2	R-3	R-4	R-5	Total
Earthwork	Excavation / Embankment	m^3	34,568	954	165	4,299	1,720	41,706
	Back Fill	m^3	4,910	-	284	535	2,101	7,830
	Scarification	m^2	10,800	5,508	-	11,583	-	27,691
Pavement	Sub-base Course	m^3	8,886	58	-	402	3,901	13,247
	Asphalt Concrete Hot Mix	ton	27,335	1,830	-	5,914	11,992	47,071
Retaining Wall	RW-M (H = 2 – 5m)	m	919	300	60	257	60	1,596
Drainage	Side Ditch	m	22,223	1,700	-	1,650	6,050	31,623
	RCPC	m	68	6	-	26	-	100
	RCBC	m	-	-	-	15	-	15
Bridge Construction	New Construction 2-Lane	No.	2	-	1	-	2	5
	New Construction 1-Lane	No.	1	-	-	-	-	1
	Widening	No.	1	-	-	1	1	3
	Rehabilitation	No.	1	-	-	-	-	1
Incidental Construction	Safety Facilities	LS	1	1	-	1	1	4
	Concrete Blocks	m	11,000	4,100	-	2,400	10,500	27,200

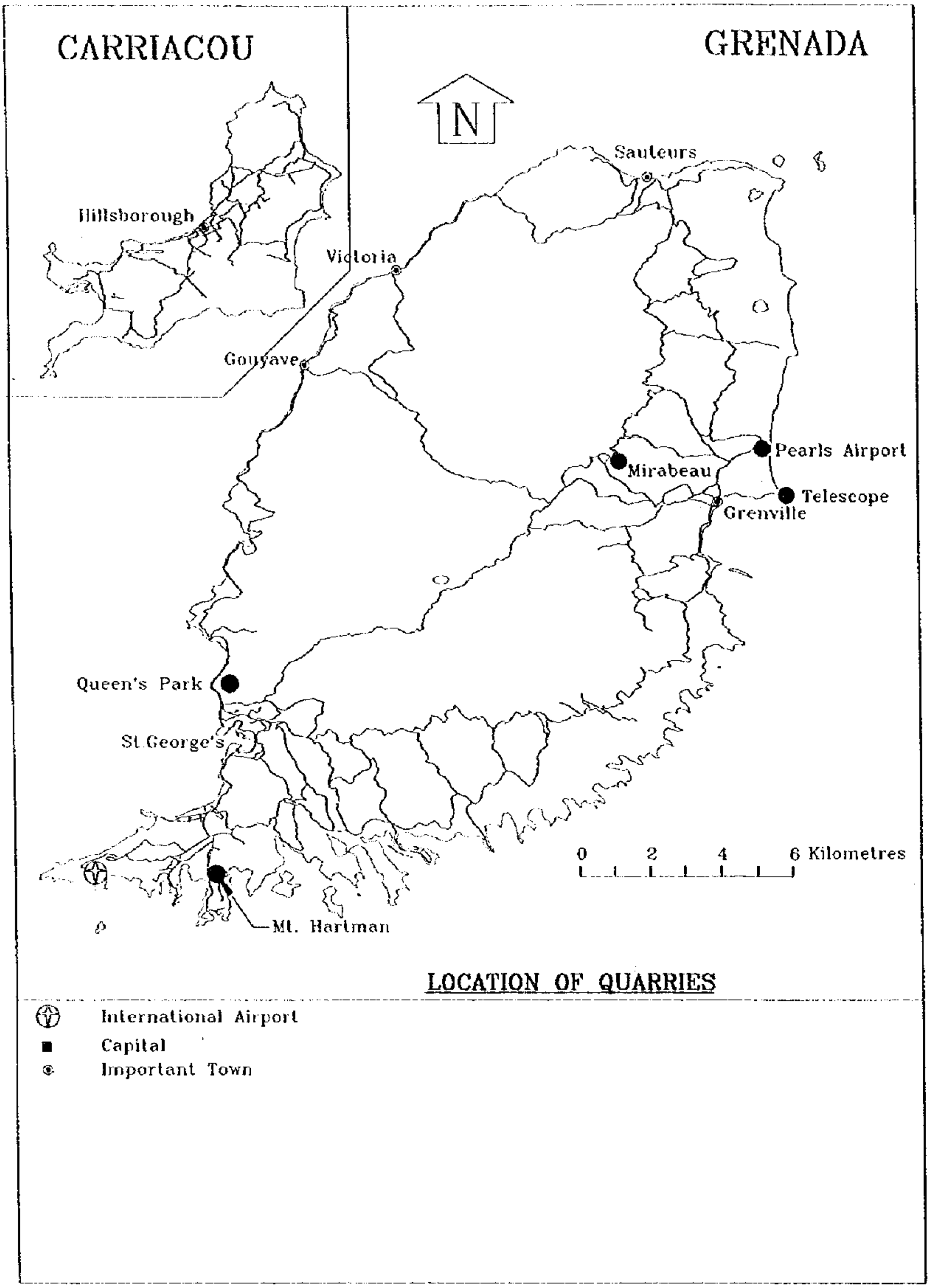


Figure 10.8.2 Location of Quarries

Table 10.8.4 Materials Sources of Aggregate and Base Course

Quarry Name	Location	Company Name	Main Equipment	Production Capacity (tone/day)	Deposit	Test Results	Application	Remarks
Mt. Hartman	Mt. Hartman St. George's	Consolidated Contractors International	Crashing Plant Bulldozer Wheel Loader	400	unlimited	SG=2.925 Abrasion= 14% Soundnes s=1.45% CBR=68%	AC Aggregate Concrete Aggregate Base Material	
Queen's Park	Queen's Park St. George's	Gravel Concrete & Emulsion Production Co.,op	Bulldozer Wheel Loader Bach Plant	240	unlimited	SG=2.404	Base Material Concrete Aggregate	
Telescope	Telescope St. Andrew	Gravel Concrete & Emulsion Production Co.,op	Crashing Plant Wheel Loader	150	unlimited	SG=2.905 Abrasion= 21% Soundnes s=1.3% CBR=71%	AC Aggregate Concrete Aggregate Base Material	
Arena	Pearls Airport St. Andrew	Government of Grenada MOW	Wheel Loader	--	unlimited	SG=2.741	AC Sand Concrete Sand	
Miribeau	Miribeau Estate St. Andrew	Government of Grenada MOW	--	--	unlimited	SG=2.205 Abrasion= 21% Soundnes s=12% CBR=26%	Base Material Borrow Material	

10.8.5 Construction Period

A rough estimation for the required construction period of each roads is shown in Chapter 15 Table 15.3.1. This estimation is based on the assumed high performance for such important project under international bidding system and in due consideration to the national target required by the government.

CHAPTER 11

PROJECT COST ESTIMATE

CHAPTER 11

PROJECT COST ESTIMATE

11.1 CONSTRUCTION COST

The project cost consists of land acquisition, compensation, materials, labor, construction, maintenance and engineering consultancy costs. Most of these costs are estimated based on the unit cost of work items obtained from a unit price analysis and in comparison with costs of similar projects in the country.

The costs are preliminary estimated in Chapter 8 for each of the seven Study Roads under the three improvement options for the purpose of road prioritization. Roads selected for the Feasibility Study are subject to more detailed cost estimate procedure in this Chapter.

11.1.1 Construction Unit Cost

The unit cost data of most of the items required to implement the road improvement project were collected from different resources including those of other similar road projects being undertaken recently in Grenada. As some of the construction materials are not available in Grenada, unit costs of such items were estimated as imports from Trinidad. The data collected includes the unit cost of each of the construction materials, labor by classification, and equipment. The unit cost of major work items was also obtained.

The material costs are presented in Table 11.1.1 which clarifies the source of each material either local or from Trinidad. Table 11.1.2 includes the labor cost for all local workers required to implement the Project.

The cost of equipment to be used in the project is presented in Table 11.1.3 on a rental basis. Table 11.1.4 gives the cost of major work items to be implemented during the course of the project. Foreign, Local and Tax component of construction labour, materials and equipment is shown in Table 11.1.5.

11.1.2 Construction Cost

The construction cost is estimated for each of the selected four Project Roads, as well as a bridge on R-3, as shown in Table 11.1.6. The breakdown of construction cost for the four roads and one bridge is presented in Appendix 15.

Table 11.1.1 Material Cost

Material	Unit	Cost (EC$)	Source
Diesel Fuel (Duty Free)	kl	672.00	Trinidad
Gasoline, Leaded	kl	850.00	Trinidad
Unleaded	kl	953.00	Trinidad
60 / 70 Bitumen	kl	744.32	Trinidad
Emulsion	l	0.90	Trinidad
Reinforcing Steel 9mm~16mm	kg	0.40	Trinidad
Structural Steel	ton	1,700.00	Trinidad
Wire Mesh	m^2	7.40	Trinidad
Cement	ton	375.00	Trinidad
25.4mm Base Course	ton	25.00	Local
20mm crushed rock	ton	28.00	Local
Concrete Aggregate	ton	55.00	Local
Beach Sand	m^3	25.00	Local
Concrete Block 20.3cm	each	3.50	Local
20mm crushed rock	ton	28.00	Local
Lumber, Yakal or Apitong	m^2	36.50	Trinidad
Form Lumber	m^2	37.50	Trinidad
50mm PVC Conduit	m	1.25	Local

Source: Nevis – Long Point project (Kuwait Fund), May 4, 1997

11.2 LAND ACQUISITION COST

Land acquisition cost is estimated based on the proposed improvement option of the Study Roads. The affected land is classified by the result of the geometric design and field visual inspection. Resettlement and compensation costs for the affected houses by road widening are estimated based on land prices of other similar projects.

As the improvement options do not involve realignment of the roads and are limited to minor improvements or widening, the land acquisition cost does not represent a high share in the total cost. Table 11.2.1 presents the estimated Land Acquisition cost for each study road.

11.3 ENGINEERING COST

Engineering cost consists of the international and local consultancy cost required for the Detailed Design and Construction Supervision of the project implementation. The engineering costs are estimated based on the billing rates of similar international projects. The engineering cost of the detailed design stage is approximately equivalent to 5.5% of the total cost, and for the construction supervision stage is about 6.5%, with a total engineering cost of 12.0% of the construction cost.

Table 11.1.2 Labour Cost

Classification	Class	Description	Basic Pay (EC$)	Remarks
1.Working Foreman	1	Supervises more than 5 workers; is able to safely operate all	120.00	Operator
		of the equipment assigned to his crew.		
2.Working Foreman	2	Supervises more than 5 workers	110.00	Mech/Const. Trades
3.Machine Operator	1	Able to efficiency and safely operate construction equipment	100.00	
		rated in excess of 100hp or 15 ton lifting capacity.		
4.Machine Operator	2	Able to efficiency and safely operate construction equipment	80.00	
		other than Class 1 and 3.		
5.Operator	3	Operates small plant, compressor, drill, roller, etc,.	55.00	
6.Tradesman	1	Skilled and experienced in mechanical, electrical, or hydraulic	80.00	
		repairs and maintenance.		
7.Tradesman	2	Skilled and experienced in construction trades, including	70.00	
		masonry, steelfixing and carpentry.		
8.Tradesman	3	Limited skills and experience in construction trades or	50.00	
		mechanical, electrical or hydraulic repairs and training.		
9.Tradesman Improve / Helper		Limited skills and experience but expected to gain such in	45.00	
		on-the-job training.		
10.Driver	1	Fully licenced, experienced and skilled driver of Heavy	75.00	
		Goods Vehicle in excess 20 ton GVW.		
11.Driver	2	Fully licenced, experienced and skilled driver of Heavy	60.00	
		Goods Vehicle in excess 20 ton GVW.		
12.Driver / Messenger	3	Fully licenced, experienced and skilled driver of Pickup	50.00	
		Truck or other personal vehicle.		
13.Labourer	1	Skilled and experienced in the construction industry.	40.00	
14.Labourer	2	Unskilled Labour	37.00	
15.Office Worker	1	Skilled and experienced in office procedures, book-keeping or	70.00	
		secretarial duties. Fully conversant with computer applications.		
16.Office Worker	2	Limited skills and experience in office procedures,	50.00	
		book-keeping or secretarial duties. Basic computer knowledge.		
17.Technician	1	Skilled and experienced in Surveying, or Materials Testing.	80.00	
18.Technician	2	Limited skills and experience in Surveying, or Materials Testing.	50.00	
19.Watchman / Security		Rate includes 12 hr., shift and premium for night or weekend work.		
20.Misellaneous		Office cleaner, office trainee.	37.00	
21.Labour Crew Ganger		Supervise labourer crew	50.00	
22.Scale Clerk		Operates weigh scales	60.00	
23.Certified Welder		Holds current Class 1 Certificate	80.00	

Source: Agreement between Janin Caribbian Contractors LTD., with The Grenada Technical and Allied Workers Union Issued by the Minister of Labour, 4 Feb. 1997

Table 11.1.3 Equipment Rental Cost

Equipment	Type	Rental Cost (EC$ / hr)
Mobile Crane	20 ton	80.00
Crawler Crane	60 ton	100.00
Mobile Crane	60 ton	120.00
Hydraulic Backhoe	235	120.00
Hydraulic Backhoe	225	51.00
Bulldozer	D7	51.00
Airtrack Drill		30.00
Compressor	750 CFM	35.00
Compressor	175 CFM	17.00
Grader	140 G	51.00
R/T Loader	966	60.00
R/T Loader	936	32.00
Tracked Loader	953	30.00
Backhoe / Loader JCB		25.00
Dumper	0.5 ton	12.75
Pickup Truck		2.55
Boom Service Truck		17.00
Fuel/Water Truck		17.00
Truck	12 ton	26.00
Truck	15 ton	34.00
Vibratory Steel Roller		22.00
Roller	Rubber Tyred	20.00
Asphalt Paver		32.00
Bitumen Heater / Sprayer		17.00
Power Broom - Towed		13.00
Mixer Truck	$5m^3$	34.00
Lowbed / Tractor	37 ton	50.00
Hydraulic Crane	20 ton	60.00
Backhoe	CAT 322	85.00
Rock Truck	15 ton	50.00
Rock Truck	25 ton	90.00
Crushing Plant		200.00
Asphlt Plant		200.00
Washing Plant		50.00
Concrete Plant		150.00
Truck	$7m^3$	112.50
Vibro Hammer		50.00
Dumper	4 ton	50.00

Source: Nevis - Long Point project (Kuwait Fund), May 4, 1997

Table 11.1.4 Unit Cost of Major Work Items

Work Item	Unit	Unit Cost EC$	Component (%)		
			Foreign	Local	Tax
1. Earth Work					All Government projects are exempted from taxes and import duties. Only Customs handling and storage charges are required.
Excavation Common Soil (Waste)	m3	38.00	70	30	
Excavation Common Soil (Embankment)	m3	36.00	75	25	
Excavation Hard Rock (Waste)	m3	117.00	80	20	
Excavation Hard Rock (Embankment)	m3	175.00	80	20	
Structural Excavation Common Soil	m3	56.00	80	20	
Structural Excavation Hard Rock	m3	272.00	80	20	
Borrow Materials	m3	46.00	30	70	
Backfill	m3	88.00	30	30	
Scarification	m2	1.50	75	25	
2. Aggregate Course					
Subbase Course	m3	90.00	75	25	
Base Course	m3	152.00	75	25	
3. Asphalt Pavements and Surface Treatments					
Hot Asphalt Concrete Pavement	tone	426.00	75	25	
Dense-Graded Emulsified Asphalt Pavement	tone		75	25	
Asphalt Prime Coat	m2	6.00	75	25	
Asphalt Tack Coat	m2	1.40	75	25	
Cold asphalt Mix	tone		75	25	
4. Portland Cement Concrete Pavement					
Portland Cement Concrete Pavement t =15cm	m2	133.00	65	35	
5. Structural Embankments					
Riprap	m3	58.00	45	55	
Gabions	m3	138.00	60	40	
Concrete Retaining Wall (Gravity Type)H = 2.0m	m	773.00	60	40	
Concrete Retaining Wall (Gravity Type)H = 3.0m	m	1,288.00	60	40	
R.C Concrete Retaining Wall H = 3.0m	m	1,582.00	65	35	
R.C Concrete Retaining Wall H = 5.0m	m	2,590.00	65	35	
Stone Masonry Type Retaining Wall H = 2.0m	m	300.00	45	55	
Stone Masonry Type Retaining Wall H = 3.0m	m	510.00	45	55	
Stone Masonry Type Retaining Wall H = 4.0m	m	840.00	45	55	
Stone Masonry Type Retaining Wall H = 5.0m	m	1,150.00	45	55	
Stone Masonry Type Retaining Wall H = 7.0m	m	1,770.00	45	55	
6. Bridge Construction					
Structural Concrete 35MPa,Hauling 10km	m3	331.00	60	40	
Structural Concrete 30MPa,Hauling 10km	m3	274.00	60	40	
Cement Mortar	m3		60	40	
Prestressed Concrete Girder U-Type L=16.0m	m	6,060.00	90	10	
Reinforcing Steel	kg	1.30	80	20	
Form Work	m2	36.80	75	25	
H- Pile Driven and H- Pile	m		90	10	
7. Incidental Construction					
R.C Pipe Culvert 600mm dia.	m	624.30	70	30	
R.C Pipe Culvert 900mm dia.	m	1659.30	70	30	
R.C Pipe Culvert 1,000mm dia.	m	1971.40	70	30	
Under drain	m	184.00	55	45	
Guard Rail	m	375.00	80	20	
Road Sign	each	450.00	80	20	
Lane Marking, Broken Line w=10cm	m	1.85	80	20	
Lane Marking, Broken Line w=10cm	m	2.75	80	20	

Source: Ministry of Communications, Works and Public Utilities, April,1997 Sea Defense and Road Rehabilitation Project.

Table 11.1.5 Foreign, Local and Tax Component of Construction, Labor, Material and Equipment

Item	Component(%)		
	Foreign	Local	Taxes
Heavy Equipment	75	25	0
Portland Cement	85	15	0
Reinforcing Steel	85	15	0
Lumber	75	25	0
Asphalt	85	15	0
Diesel Fuel	65	35	0
Engine Oil	65	35	0
Tires	85	15	0
Improvement Miscellaneous Materials	80	20	0
Locally Produced Misc. Materials	35	55	10
Skilled Foreign Labor	92	0	8
Skilled Local Labor	0	92	8
Unskilled Labor	0	92	8

Note: Component are obtained from MOW
Taxes are applied on national insurance scheme for the local labors and VAT

11.4 MAINTENANCE COST

To estimate the maintenance cost of the Study Roads, a criteria is established based on the applied practice in maintenance works for similar road conditions. It is assumed that during each year of the first 5 years a length of 2% of the road will require 3cm overlay and for the following 5 years a length of 4%. After that, the whole length of the road will require 3cm overlay works.

The same procedure will be applied for the following ten years with 5cm overlay's instead of 3cm. Based on the estimated costs for 3cm and 5cm overlay in Grenada, the maintenance financial costs applied for the two types of overlay are as follows:

Overlay 3cm cost : 0.19 MEC$/km (Pavement width 6.0m)
Overlay 5cm cost : 0.32 MEC$/km (Pavement width 6.0m)

Table 11.4.1 presents the estimated maintenance cost for each road segment under the three improvement options which were basically used in the preliminary evaluation of the seven Study Roads and partially applied on the four selected Project Roads.

Table 11.1.6 Construction Cost

Road No.	Road Name	Length (km)	No. of Bridges	Road Cost (M EC$)	Bridge Cost (M EC$)	Mobilization Demobilization (M EC$)	Total Cost (M EC$)
R-1	Grand Etang Road	21.7	5	22.22	3.60	1.29	27.11
R-2	Morne Jaloux Road	4.1	0	1.86	0.00	0.09	1.95
R-3	Vineyar Bridge	0	1	0.00	0.57	0.03	0.60
R-4	Mt. Gay to Springs Road	6.0	1	3.93	0.22	0.21	4.36
R-5	Eastern Main Roads	16.5	3	7.16	1.39	0.43	9.72
Total		48.3	10	35.17	6.49	2.08	43.74

Table 11.2.1 R.O.W Acquisition Cost

Road No.	Road Name	Length (km)	R.O.W Acquisition Coat			Compensation				Total (EC$)
			Residential (EC$)	Plantation (EC$)	Forest (EC$)	Affected Houses		Plantation		
						No. of Houses	Cost (EC$)	No. of Trees	Cost (EC$)	
R-1	Grand Etang Road	21.7	7,100	36,963	68,808	7	0	264	26,400	139,271
R-2	Morne Jaloux Road	4.1	0	540	5,630	0	0	6	0	6,170
R-3	Vineyard Bridge	0	2,700	0	0	0	0	0	0	2,700
R-4	Mt. Gay to Springs Road	6.0	2,067	972	7,680	0	0	11	1,100	11,819
R-5	Eastern Main Roads	16.5	0	6,120	0	0	0	102	10,200	16,320
Total		48.3	48.3	44,595	82,118	7	0	383	37,700	176,280

Note : R.O.W acquisition is presented in Appendix 15
House Cost is based on MOW Recommendation
Plantation Compensation is calculated by applying the following formula:
Compensation Cost = Affected area of plantation (m^2) / 10 m^2 x 100EC$

Table 11.4.1 Maintenance Cost

Road No.	Road Name	Station	Length (km)	Option I Traveled Way(m)	Option I Overlay (MEC$) 3cm	Option I Overlay (MEC$) 5cm	Option II Traveled Way(m)	Option II Overlay (MEC$) 3cm	Option II Overlay (MEC$) 5cm	Option III Traveled Way (m)	Option III Overlay (MEC$) 3cm	Option III Overlay (MEC$) 5cm
R-1	Grand Etang Road	0+000 ~ 1+300	1.300	6.00	0.25	0.41	6.00	0.25	0.41	6.00	0.25	0.41
		1+300 ~ 2+800	1.500	5.50	0.26	0.43	6.00	0.29	0.47	6.00	0.29	0.47
		2+800 ~ 5+000	2.200	5.50	0.39	0.64	6.00	0.42	0.69	6.00	0.42	0.69
		5+000 ~ 7+000	2.000	4.50	0.29	0.47	5.00	0.32	0.53	6.00	0.38	0.63
		7+000 ~ 9+000	2.000	5.50	0.35	0.58	5.50	0.35	0.58	6.00	0.38	0.63
		9+000 ~ 11+500	2.500	5.00	0.40	0.66	5.00	0.40	0.66	6.00	0.48	0.79
		11+500~12+300	0.800	4.50	0.12	0.19	5.00	0.13	0.21	6.00	0.15	0.25
		12+300~15+000	2.700	6.00	0.52	0.85	6.00	0.52	0.85	6.00	0.52	0.85
		15+000~16+300	1.300	5.50	0.23	0.38	5.50	0.23	0.38	6.00	0.25	0.41
		16+300~18+500	2.200	5.50	0.39	0.64	5.50	0.39	0.64	6.00	0.42	0.69
		18+500~20+500	2.000	6.00	0.38	0.63	6.00	0.38	0.63	6.00	0.38	0.63
	Subtotal		20.50		3.58	5.87		3.69	6.04		3.94	6.46
R-2	Morne Jaloux Road	0+000 ~ 0+800	0.800	4.20	0.11	0.18	4.20	0.11	0.18	5.40	0.14	0.23
		0+800 ~ 2+650	1.850	4.20	0.25	0.41	4.20	0.25	0.41	5.40	0.32	0.52
		2+650 ~ 3+000	0.350	3.50	0.04	0.06	5.40	0.06	0.10	5.40	0.06	0.10
		3+000 ~ 4+000	1.000	3.50	0.11	0.18	5.40	0.17	0.28	5.40	0.17	0.28
	Subtotal		4.000		0.51	0.83		0.59	0.97		0.69	1.13
R-3	St. David's / Perdmontemps	0+000 ~ 1+600	1.600	3.00	0.15	0.25	3.50	0.18	0.29	5.40	0.28	0.45
		1+600 ~ 3+400	1.800	3.00	0.17	0.28	3.50	0.20	0.33	5.40	0.31	0.51
		3+400 ~ 6+100	2.700	3.50	0.30	0.50	3.50	0.30	0.50	5.40	0.47	0.77
		6+100 ~ 7+200	1.100	4.00	0.14	0.23	4.00	0.14	0.23	5.40	0.19	0.31
	Subtotal		7.200		0.77	1.26		0.83	1.35		1.25	2.04
R-4	Mt. Gay / Springs	0+000 ~ 0+500	0.500	6.00	0.10	0.16	6.00	0.10	0.16	6.00	0.10	0.16
		0+500 ~ 3+050	2.550	7.00	0.57	0.94	7.00	0.57	0.94	6.00	0.49	0.80
		3+050 ~ 4+800	1.750	6.00	0.34	0.55	6.00	0.34	0.55	6.00	0.34	0.55
		4+800 ~ 5+800	1.000	6.00	0.19	0.32	6.00	0.19	0.32	6.00	0.19	0.32
	Subtotal		5.800		1.20	1.96		1.20	1.96		1.12	1.83
R-5	Eastern Main Road (Grenville / Sauteurs)	0+000 ~ 1+700	1.700	6.00	0.33	0.54	6.00	0.33	0.54	6.00	0.33	0.54
		1+700 ~ 3+000	1.300	5.00	0.21	0.34	6.00	0.25	0.41	6.00	0.25	0.41
		3+000 ~ 5+000	2.000	5.00	0.32	0.53	6.00	0.38	0.63	6.00	0.38	0.63
		5+000 ~ 6+500	1.500	6.00	0.29	0.47	6.00	0.29	0.47	6.00	0.29	0.47
		6+500 ~ 9+200	2.700	5.50	0.48	0.78	5.50	0.48	0.78	6.00	0.52	0.85
		9+200 ~10+200	1.000	5.50	0.18	0.29	5.50	0.18	0.29	6.00	0.19	0.32
		10+200 ~16+000	5.800	5.50	1.02	1.68	5.50	1.02	1.68	6.00	1.12	1.83
	Subtotal		11.000		1.96	3.22		1.96	3.22		2.12	3.47
R-6	Paraclete / Mt Horne	0+000 ~ 1+500	1.500	4.50	0.22	0.35	4.50	0.22	0.35	5.40	0.26	0.43
		1+500 ~ 2+000	0.500	2.50	0.04	0.07	5.40	0.09	0.14	5.40	0.09	0.14
		2+000 ~ 3+000	1.000	3.50	0.11	0.18	4.50	0.14	0.24	5.40	0.17	0.28
		3+000 ~ 3+200	0.200	3.00	0.02	0.03	5.40	0.03	0.06	5.40	0.03	0.06
	Subtotal		3.200		0.39	0.64		0.48	0.79		0.55	0.91
R-7	Dover (Windward / Cherryhill)	0+000 ~ 0+400	0.400	4.00	0.05	0.08	4.00	0.05	0.08	5.40	0.07	0.11
		0+400 ~ 0+900	0.500	3.00	0.05	0.08	4.00	0.06	0.11	5.40	0.09	0.14
		0+900 ~ 2+000	1.100	4.50	0.16	0.26	4.50	0.16	0.26	5.40	0.19	0.31
		2+000 ~ 3+100	1.000	4.00	0.13	0.21	4.00	0.13	0.21	5.40	0.17	0.28
	Subtotal		3.000		0.39	0.63		0.40	0.66		0.52	0.85

Note : Construction Cost ; Pavement Thickness3cm, 0.19 MEC$/km Pavement Thickness 5cm, 0.32 MEC$/km

11.5 PROJECT COST

A summary of the cost for each of the Study Roads is presented in Table 11.5.1 with a breakdown for each of the cost components.

Table 11.5.1 Project Cost

Road No.	Road Name	Length (km)	Construction Cost (M EC$)	R.O.W Acquisition Cost (M EC$)	Engineering Cost (M EC$)	Resettlement Cost (M EC$)	Total (M EC$)
R-1	Grand Etang Road	21.7	27.11	1.79	3.25	1.79	33.94
R-2	Morne Jaloux Road	4.1	1.95	0.01	0.23	0	2.19
R-3	Vineyard Bridge	0	0.60	0	0.07	0	0.67
R-4	Mt. Gay / Springs Road	6.0	4.36	0.01	0.52	0	4.89
R-5	Eastern Main Road	16.5	9.72	0.02	1.17	0	10.91
Total		48.3	43.74	1.83	5.24	1.79	52.60

CHAPTER 12

ECONOMIC EVALUATION

CHAPTER 12

ECONOMIC EVALUATION

The objective of this economic evaluation is to investigate the economic viability of implementing the improvement and rehabilitation works on the selected Project Roads. The period of the economic analysis is set-up as 25 years of operation after completion of the construction which is tentatively scheduled to be the mid of year 2001. Depreciation periods of construction works are considered as 50 years and a residual value is posted after 25 years of completion of the construction.

12.1 PROJECT ECONOMIC COST

The economic costs of each project road consist of the following:

- Construction Cost
- Land Acquisition Cost
- Engineering Cost
- Maintenance and Repair Cost

The disbursement schedule for the first three items in the economic capital cost of each of the study roads is shown in Table 12.1.1 for the four selected Project Roads and Vineyard Bridge on R-3 for which the design is added to the Project. These three items are counted as initial capital investment while the forth item is counted as annual operational investment.

The financial project costs presented in Chapter 11 are shadow-priced utilizing adjustment factors to correct key imbalances, especially for foreign exchange and unskilled labour costs of the local component portion and to eliminate the transfer cost which is composed of compound taxes such as import duties and value added taxes. Adjustment factors are estimated roughly in this stage as 0.9 for the construction and maintenance costs and 1.0 for right-of-way acquisition and engineering costs.

The financial cost of the maintenance works, which is estimated based on an annual rate overlay criteria, is converted to the economic cost to be used in the economic analysis. This cost is determined according to the road width without considering price escalation. The annual economic maintenance and repair cost for each of the project roads is as presented previously in Chapter 8, Table 8.1.2.

Table 12.1.1 Disbursement Schedule of Economic Capital Cost (EC$)

Road	Year	Construction	Engineering	R-O-W	Total
R-1	1st	0	1,626,685	1,000,000	2,626,685
	2nd	2,440,028	162,669	790,000	3,392,697
	3rd	14,152,163	943,478	0	15,095,640
	4th	7,808,090	520,539	0	8,328,629
R-2	1st	0	117,018	10,000	127,018
	2nd	1,491,977	99,465	0	1,591,442
	3rd	263,290	17,553	0	280,843
	4th	0	0	0	0
R-3	1st	0	35,867	0	35,867
	2nd	0	0	0	0
	3rd	193,681	12,912	0	206,593
	4th	344,321	22,955	0	367,276
R-4	1st	0	261,469	10,000	271,469
	2nd	1,019,728	67,982	0	1,087,710
	3rd	2,902,303	193,487	0	3,095,790
	4th	0	0	0	0
R-5	1st	0	583,222	0	583,222
	2nd	0	0	20,000	20,000
	3rd	4,549,128	303,275	0	4,852,403
	4th	4,199,195	279,946	0	4,479,141

12.2 PROJECT BENEFITS

The road improvement project is expected to generate direct benefits, which can be evaluated on a monetary basis, and indirect benefits which are assessed in regard to the socioeconomic impact of the project. Benefits of the project are measured through the comparison of the two cases of "with Project" and "without Project".

12.2.1 Direct Benefits

Several types of benefits, basically as savings in cost, are expected from the implementation of the Project under the direct benefits, such as:

- Savings in vehicle operating cost (VOC) due to road improvement
- Savings in travel time cost
- Savings in detour cost
- Savings in vehicle operating cost due to no one-lane sections
- Savings in routine restoration and maintenance cost
- Savings in temporary bridge cost
- Savings in damaged agricultural production cost

Out of these benefits, the first two items provide the major component of the direct benefits in this analysis. In regard to the other benefits, annual urgent restoration and maintenance works, without implementing the project, have to be done for spots damaged under any circumstances.

Savings in these costs together with the routine maintenance costs of temporary Bailey bridges (R-3 and R-5), and the high possibility of severe damage or failure of old bridges resulting in full road section closure and traffic interruption, provide additional benefits as savings in detour costs, which can also be added and analyzed in a monetary basis.

The methodology of estimation and results of vehicle operating cost and travel time value based on the local conditions and data collected in Grenada are presented in the following sections.

(1) Vehicle Operating Cost (VOC)

This is the main economic benefit of implementing a transport scheme or road improvement project which is basically estimated for each type of vehicle under optimum road and traffic conditions and then adjusted to the actual conditions taking into consideration such factors as the road surface and geometric characteristics as well as the vehicular speed. The VOC is composed of the cost of the following items:

Distance-Related Cost: This cost varies directly with the distance operated and includes the following:

- Fuel Consumption
- Lubricants
- Tires
- Vehicle Maintenance (Spare Parts and Labour)

Time Related Cost: This cost is directly related with the operating time and involves the following:

- Depreciation
- Capital Consumption
- Interest on Capital Employed
- Wages and Overheads

The following sections present a description for the procedure applied which utilizes the TRRL Report 1031 method prepared to estimate the main items of the savings in VOC in the Caribbean.

1) Vehicle Type and Capital Cost

The most dominant types of vehicles used in the country, as applied in the traffic survey of the Study, are classified into four main categories which are passenger car, bus, light truck and heavy truck. Types of vehicles included in each of the four categories are as follows:

- Passenger car: This category includes all cars, taxis and jeeps with a capacity of five passengers including the driver.
- Bus: This category includes medium-size buses and vans which are the most dominant public transport mode with a capacity of 15 passengers.
- Light Truck: This category includes commodity vehicles with two axles and four wheels, which are mostly pick-up vehicles.
- Heavy Truck: This category includes all commodity vehicles with more than four wheels and two or more axles.

Based on information collected during the field survey and supplemented by data collected from other related studies, the main characteristics of the typical vehicles used in Grenada are as presented in Table 12.2.1. Table 12.2.2 gives average values for the financial and economic capital costs for the vehicles.

The financial cost represents the market price while the economic cost is estimated as the CIF-base price by deducting the applied import and consumer tax (IVA). Taxes applied on new vehicles are 65% in total divided to 15% as import tax and 50% as consumer tax.

As the future traffic volumes are estimated based on the PCU values, conversion is performed for each evaluation case depending on the preliminary results of the traffic composition on each road. Conversion factors for the passenger-car units applied in the traffic demand forecast procedure are set as 1.0 for passenger car and light truck, 1.5 for bus and 1.8 for heavy truck.

Table 12.2.1 Typical Vehicle Characteristics

Code	Category	Typical Type		Capacity	Av. Occupancy	Tires
		Maker	Type			
PC	Passenger Car	Daihatsu	Charade 1200cc	4+1 p	2.5	4
		Toyota	Corolla 1600cc	4+1 p		4
		Suzuki	Jeep	4+1 p		4
BS	Bus	Nissan	Bus	14+1 p	9.2	4
		Toyota	Hi-ace	14+1 p		4
LT	Light Truck	Mitsubishi	Canter	2–4 ton	2.3	4
HT	Heavy Truck	Daihatsu	Truck	4–7 ton	2.5	6
		Leyland	Truck	7–10 ton		10

Table 12.2.2 Vehicle Capital Cost (EC$)

Code	Type	Financial Cost	Economic Cost	Av. Ec. Cost
PC	Daihatsu Charade	45,700 – 50,000	27,000 – 30,300	42,000
	Toyota Corolla	72,000	43,600	
	Suzuki Jeep	52,500 – 89,500	31,800 – 54,200	
BS	Nissan Bus	87,500 – 100,000	53,000 – 60,600	55,000
	Toyota Hi-ace	85,500	51,200	
LT	Mitsubishi Canter	84,150	51,000	51,000
HT	Daihatsu Truck	101,244	61,360	80,000
	Leyland Truck	165,000	100,000	

2) Road Condition

The vehicle operating cost depends to a large extent on vehicular speed and road surface condition. Road classes which are used in the estimation of speed and cost are classified based on the roughness index in Table 12.2.3.

Table 12.2.3 Road Condition and Roughness

Type	Class	Condition	Roughness (mm/km)
Paved Roads	C-1	Good	2,000
	C-2	Good/Fair	3,000
	C-3	Fair	4,000
	C-4	Fair/Poor	5,000
	C-5	Poor	6,500
Unpaved Roads	C-6	Good	5,000
	C-7	Fair	8,000
	C-8	Poor	14,000

3) Fuel Cost

The fuel price in the economic cost is calculated by type of fuel deducting taxes from the financial cost (market price), as presented in Table 12.2.4. Ratios of vehicles using each fuel type and average fuel cost are presented in Table 12.2.5. The fuel consumption rates were calculated based on formulas from the TRRL methods of VOC estimation for each vehicle category and on the PCU base for different running speeds. The results as well as the estimated fuel economic cost on the PCU base are presented in Table 12.2.6.

4) Lubricant Cost

The same procedure of estimating the fuel cost is applied here to estimate the lubricant economic cost based on market price and TRRL consumption rates for different vehicles on different speeds, and estimated in PCU, as presented in Tables 12.2.7 and 12.2.8.

Table 12.2.4 Unit Fuel Cost (EC$)

Item	Leaded (MOGAS 95OCT)	Unleaded (MOGAS%ULG)	Diesel
Financial Cost / gallon*	6.25	6.27	4.94
Taxes	65 %		
Economic Cost / litre	0.850	0.853	0.672

* 1 gallon = 4.4546 litres

Table 12.2.5 Average Fuel Cost

Vehicle Code	Leaded (MOGAS 95OCT)	Unleaded (MOGAS%ULG)	Diesel	Average Fuel Cost (EC$/litre)
PC	55%	45%	-	0.896
BS	40%	50%	10%	0.884
LT	5%	5%	90%	0.695
HT	-	-	100%	0.672

Table 12.2.6 Average Fuel Consumption Rate and Economic Cost

Speed Km/hr	Fuel consumption Rate (liter/1000km)					Economic Cost EC$/km (PCU)
	PC	BS	LT	HT	PCU	
10	131.4	167.4	226.6	285.8	157.6	0.129
20	75.5	121.4	144.4	167.3	94.5	0.077
30	68.2	116.6	126.8	137.0	84.4	0.069
40	65.2	111.7	122.0	132.2	80.9	0.066
50	67.4	111.3	125.8	140.3	83.6	0.068
60	72.9	113.5	135.4	157.2	90.2	0.074
70	81.1	117.8	149.4	181.0	99.9	0.082
80	91.5	123.8	167.4	211.0	112.4	0.092
90	104.0	131.2	188.9	246.5	127.3	0.104

Table 12.2.7 Lubricant Economic Cost

Item	Texaco (40-Motor Oil)
Financial Cost / gallon	EC$ 38.4
Taxes	65 %
Economic Cost / litre	EC$ 5.234

Table 12.2.8 Average Lubricant Consumption Rate and Economic Cost

Speed Km/hr	Lubricant consumption Rate (litre/1000km)					Economic Cost EC$/km (PCU)
	PC	BS	LT	HT	PCU	
10	3.67	5.72	8.84	11.96	5.09	0.027
20	2.88	4.48	6.93	9.37	3.99	0.021
30	2.08	3.24	5.01	6.78	2.89	0.015
40	1.94	2.97	4.68	6.39	2.69	0.014
50	1.80	2.70	4.35	6.00	2.50	0.013
60	1.73	2.44	3.97	5.49	2.34	0.012
70	1.65	2.18	3.58	4.98	2.18	0.011
80	1.56	1.99	3.22	4.45	2.02	0.011
90	1.47	1.79	2.86	3.92	1.85	0.010

5) Maintenance Cost

Based on the TRRL procedure in estimating the maintenance cost, spare parts consumption is obtained through non-dimensional factors, which are considered as a function of road roughness and vehicle age in running distance and adjusted based on road geometric characteristics, to be multiplied by the price of a new equivalent vehicle.

Based on collected data and those of studies in similar countries, the labour cost is estimated as 45% of the parts cost. Table 12.2.9 gives the estimated average values of the economic maintenance cost for each vehicle category and on the PCU base.

Table 12.2.9 Economic Maintenance Cost (EC$/km)

Economic Cost	PC	BS	LT	HT	PCU
Spare Parts	0.088	0.115	0.107	0.167	0.098
Labour	0.040	0.052	0.048	0.075	0.044
Maintenance Cost	0.127	0.167	0.155	0.242	0.142

6) Tire Cost

Tire cost is estimated as one separate item of the consumable parts of vehicles. Tire consumption depends mainly on the running speed, road surface condition and average tire life. Table 12.2.10 presents the basic financial and economic tire price while Table 12.2.11 shows the consumption rates and economic cost per kilometer for different road conditions and by vehicle category.

Table 12.2.10 Financial and Economic Tire Price

Item	PC	BS	LT	HT	PCU
No. of Tires	4	4	4	6/10	-
Market Price (EC$/set)	640	960	960	1,280	-
Tax	65 %				
Economic Price (EC$/set)	388	582	582	776	456

Table 12.2.11 Tire Consumption and Cost

Item	Road	PC	BS	LT	HT	PCU
Tire Life (km)	Good	45,000	50,000	45,000	55,000	46,084
	Fair	28,000	31,000	28,000	34,000	28,650
	Bad	13,000	14,000	13,000	16,000	13,287
Economic Cost (EC$/km)	Good	0.009	0.012	0.013	0.014	0.010
	Fair	0.014	0.019	0.021	0.023	0.016
	Bad	0.030	0.042	0.045	0.049	0.034

7) Vehicle Depreciation Cost

The depreciable amount of a vehicle is defined as the vehicle economic cost less a salvage cost after each year of the vehicle life-span, mostly up to a period of 10 years. The salvage value is estimated based on the local conditions and the depreciation is basically divided into depreciation subject to use and subject to time. Depreciation is assumed to be subject to a linear model so that the average decrease in value per year is proportionally estimated. Table 12.2.12 gives the annual depreciation rates for each vehicle category based on the vehicle age with the average depreciation cost per vehicle-hour by applying the TRRL factors and procedures.

Table 12.2.12 Depreciation Rate and Cost

Age	Annual Depreciation Rate (%)					Depreciation Cost
(year)	PC	BS	LT	HT	PCU	(EC$/veh-hr)
1	22.00	10.80	22.00	10.80	20.36	0.0716
2	14.70	17.20	14.70	17.20	15.07	0.0529
3	7.80	12.10	7.80	12.10	8.43	0.0296
4	7.80	9.60	7.80	9.60	8.06	0.0283
5	7.80	8.10	7.80	8.10	7.84	0.0276
6	7.80	7.10	7.80	7.10	7.70	0.0271
7	7.80	6.30	7.80	6.30	7.58	0.0266
8	7.80	5.80	7.80	5.80	7.51	0.0264
9	7.10	5.30	7.10	5.30	6.84	0.0240
10	0.00	4.90	0.00	4.90	0.72	0.0025
11	0.00	2.80	0.00	2.80	0.41	0.0014
Average						0.0289

8) Capital Opportunity Cost

This cost is not affected by use but only as time passes and it is determined based on the vehicle price, life period, salvage value rate and annual interest rate. Table 12.2.13 presents the estimated average values for the capital cost.

Table 12.2.13 Capital Cost

Item	PC	BS	LT	HT	PCU
Capital Cost (P) – EC$	42,000	55,000	51,000	80,000	46850
Salvage Value (L) - %	25	15	20	15	22.9
Vehicle Life in years (n)	9	11	9	11	9.29
Capital Recovery Factor-CRF*	0.1877	0.1684	0.1877	0.1684	0.18
Annual Opportunity Cost –EC$**	7,173	8,863	8,882	12,891	7,929
Opportunity Cost (EC$/hr)	0.8188	1.0117	1.0139	1.4716	0.9051

* CRF = $[I * (1+I)^n] / [(1 + I)^n - 1]$ I: Annual Interest Rate of 12%

** AOC = P(1-L)*CRF + P*L*I

9) Wages and Overhead Cost

The cost of drivers and crew of commercial vehicles, including their wages, allowances and overheads, is estimated as presented in Table 12.2.14 based on data collected by interviewing owners of busses and commercial vehicles.

Table 12.2.14 Wages and Overhead Cost (EC$)

Item	BS	LT	HT	PCU
Driver Salary / month	1625	1500	1875	1629.1
Crew Salary / month	1000	1125	2x1125	1375.7
Overhead Cost / month	200	200	300	225.32
Shadow Wage Rate				86%
Total Economic Cost / hour				0.8074

11) Summary of Vehicle Operating Cost

The previous sections give the cost of the different items of the VOC in its two components of distance-related and time-related operating costs. Table 12.2.15 gives a summary for the two components of VOC.

Table 12.2.15 Summary of Vehicle Operating Cost

a. Distance-Related VOC (EC$/pcu-km)	
Fuel	0.0844
Lubricant	0.0148
Tire	0.0217
Maintenance	0.1420
Total	0.2629
b. Time-Related VOC (EC$/pcu-hr)	
Depreciation	0.0289
Capital	0.9051
Crew	0.8074
Total	1.7414

(2) Savings in Travel Time Cost

Table 12.2.16 presents the time value estimated for car-owning households and passengers of two passenger vehicle types, which are the passenger car and bus, based on the average GNP/capita and the household income presented in the Abstract of Statistics, Ministry of Finance and Planning, 1996. Values were converted to the PCU base by applying the traffic composition ratios and occupancy of each vehicle type.

Table 12.2.16 Travel Time Cost

Vehicle Type	PC	BS
Average Monthly Income/household (EC$)	2698.4	
Monthly Income/household (EC$)	4692.9	2346.4
Monthly Income/person (EC$)	1,174	587
Working Hours/month	176	176
Time Value (EC$/ person-hr)	6.67	3.34
Occupancy Rate	2.5	9.2
Time Value – Business Trip (EC$/pcu-hr)	16.68	30.68
Time Value – Other Trip (EC$/pcu-hr)	4.17	7.67
Business Trip/Other Trip Ratio	47/53 %	
Time Value Total Average	10.05	18.49
Ratio to Car Trips	0.58	0.42
Contribution to Travel Time Saving (EC$/pcu-hr)	5.85	7.73
Total Weighted Travel Time Saving(EC$/pcu-hr)	13.58	
Employment Rate	25%	
Shadow Wage rate	86%	
Travel Time Economic Cost (EC$/pcu-hr)	2.9197	

Results of the OD survey showed that business trips compose 47% of all trips and the time value of other trips was assumed to be 25% of that of the value estimated for business trips. The income data and employment rate of 25% is based on the statistical data in the Annual Abstract of Statistics 1996 which is published by the Central Statistical Office of the Ministry of Finance. Savings in this travel time cost are added to the time-related savings.

(3) Savings in Bridge Detour Cost

With the full closure of a road section due to serious bridge damage, vehicles are expected to use alternative roads, where available, as detours. The shortest detours to be used were determined for each bridge section of the road for all the bridges subject to reconstruction or improvement works, depending on the traffic volumes on the road and the road network in the area.

The road class, length, condition and terrain for each section of the road used in the original trip and the detoured trip were identified to conclude the operating speed and travel time for the vehicles in PCU base. Values of the VOC, either as distance-related or time-related, and time cost savings were then applied for both original and detoured trips and the extra costs in the detour case were concluded for the total traffic volumes.

At narrow sections of R-2 or in the case of partial closure of the road, in which one single lane is secured for traffic, the operating speed of vehicles is expected to reduce and the road class to be downgraded. This situation is taken also into consideration for the narrow R-2 as it causes considerable increase in both the travel time and VOC to determine benefits of providing an additional lane.

To estimate these benefits, a traffic interruption pattern was established based on the probability model of bridge unserviceability and the need to use detours. The model mainly depends on the age of each bridge and considering the condition and proposed improvement measures. The logistic formula of the applied probability model is as follows:

$$P(t) = 1 / (1+ e^{-0.2(t-y)})$$

P(t)	:	Probability of bridge unserviceability by the year t
Y	:	Bridge age
t	:	Year

12.2.2 Indirect Benefits

With the full dependence on the road sector in handling both passenger and freight transport in Grenada, the road improvement project will generate several indirect benefits which can be stated as follows:

- Regional Socioeconomic Development
- Promotion of Commercial, Manufacturing and Agricultural Activities
- Promotion of Tourism
- Improvement in Living Conditions
- Road Safety

An improved road network will help in promoting the development of regional and rural economic activities. With shorter travel time and good condition roads, more opportunities will be created in the development of agro-based industries as well as other commercial, manufacturing and agricultural activities. In addition, and to promote the tourism sector and to increase its share in the GDP of the country, the tourism movement and destinations will be distributed all over the island which allow visitors to see more sites instead of the current concentration to small and limited areas.

The economic development due to better efficiency and accessibility by the improved road network will generate employment opportunities, increase the income, reduce social disparities, improve living standards and produce more balanced distribution in population.

Improvement works of the road network will include safety facilities such as traffic signs and markings as well as sidewalks and guardrails at populated areas to separate motorized and non-motorized traffic. These improvements in the safety level on roads will decrease any potential for road accidents as a result of higher travel speed on roads.

In this Study, which deals with the improvement of existing roads, the indirect benefits were investigated and assessed, but not quantified, in regard to the socioeconomic development impact of the Project.

12.3 ECONOMIC ANALYSIS RESULTS

12.3.1 Implementation Schedule

The implementation schedule applied in this analysis has a four-year framework as presented in Table 8.2.1. A period of 9 months is required for the detailed engineering design and 24 months for the construction activities of the whole project roads. The construction of each of the roads is assumed to start after the tendering stage with different construction periods depending on the length and volume of work for each road as presented in Chapter 15.

12.3.2 Economic Analysis Procedure

The three economic parameters of benefit/cost ratio (B/C), economic internal rate of return (EIRR) and net present value (NPV) are used in this economic analysis to investigate the economic viability of the Project Roads. Costs and benefits are divided, as shown below, into direct costs and benefits which are evaluated on a monetary basis and indirect costs and benefits which are assessed under the project's socioeconomic impact.

The main benefits are normally gained from savings in vehicle operating costs as well as savings in travel time cost of passengers. For existing traffic on existing roads, the improved roads result in lower fuel and tire consumption as well as vehicle maintenance requirements in addition to savings in traveled distance and time.

The distance-related benefits are based on savings in the traveled distance (dL, EC$/pcu-km) and time-related benefits on savings in travel time (dT, EC$/pcu-hr), for all vehicles on the road network for each of the project roads and for the case of improving all the project roads together.

12.3.3 Evaluation Results

The results of the economic analysis are presented in Table 12.3.1 for the cases of implementing each of the four Project Roads R-1, R-2, R-4 and R-5. R-2 gives the lowest indicators, however, it has a high potential for tourism development in the future. In addition to the individual evaluation of the Project Roads, the economic analysis procedure was applied to check the economic viability of implementing the four roads together and the results show high viability as presented in the table.

Table 12.3.1 Economic Parameters

Road	Total Cost (MEC$)	B/C	EIRR %	NPV (MEC$)
R-1	33.94	2.39	26.74	48.44
R-2	2.19	0.90	10.70	-0.18
R-4	4.89	1.32	15.12	1.91
R-5	10.91	1.42	15.78	4.97
Whole Project	51.93	2.28	25.25	70.65

In this economic analysis, a residual value of 50% was considered in the estimation based on the assumption that the life span of roads and bridges from the engineering point of view is 50 years.

Appendix 16 includes the estimation procedure of estimating the economic parameters for all of the applied cases.

12.3.4 Sensitivity Analysis

A sensitivity analysis was conducted to take into account the uncertainty of assumptions and to determine the potential of each project road for unexpected increase in construction costs or decrease in benefits. The cases considered in this analysis are:

- Case 1: Cost + 10% and Benefit – 10%
- Case 2: Cost + 20% and Benefit – 20%

The results of this sensitivity analysis, which are presented in Table 12.3.2, show that even in the extreme Case 2 with increasing the project cost by 20% and decreasing the project benefits by the same ratio, the Project as a whole is still economically viable with an EIRR of 17.92%.

Table 12.3.2 Sensitivity Analysis Results

Road	B/C	EIRR %	NPV (MEC$)
Case 1			
R-1	1.97	22.50	36.89
R-2	0.75	8.69	-0.48
R-4	1.10	12.98	0.62
R-5	1.17	13.64	2.25
Whole Project	1.88	21.34	53.06
Case 2			
R-1	1.61	18.82	25.33
R-2	0.63	6.81	-0.78
R-4	0.90	10.98	-0.67
R-5	0.97	11.66	-0.48
Whole Project	1.54	17.92	35.47