3.7 Forestry

As discussed in Chapter I, the role of forestry and forestry industries in the national economy has been increasing very rapidly since late 1960's. During 1970 - 1978, total products of forestry in the country increased at an annual average rate of 17.0%, and attained 774,600 m^3 in 1978. Total forest area in Liberia is around 25,000 km^2 which includes 16,000 km^2 of the national forest area and 9,000 km^2 of unprotected forest area, and 33 foreign-owned concessions are operating under forest products utilization contracts.

In the influence area of the Gbarnga - Mendikoma road, two national forests, namely, North Lorma National Forest (between Zorzor and Voinjama section) and Lorma National Forest (between Gbarnga and Zorzor) exist along the road. Total forestry area of the influence area is around 2,400 km^2. Three logging companies, ALTCO, DLC and VLC acquired concessions, out of which only two, ALTCO and VLC, are operating at present.

Total forestry production in the influence area was around 15,000 m^3 in 1978, which included 10,000 m^3 of sawn timer processed at ALTCO sawmill in Luyema, Lofa Country, and 5,000 m^3 of logs. Most of the logs and timber produced in the influence area are being carried by road to Tropai, Nimba County through the project road, and are brought to Buchanan using LAMCO line. Only a part of the processed timber is transported to Monrovia by road, which are being used for local consumption. Production trend of the forestry products by the two concessions in the influence area is presented below.

Logs and Timber Production

(m[3])

Year	ALTCO/1	VLC/2	Total
1975	-	-	-
1976	4,813	N/A	4,813
1977	12,606	574	13,176
1978	14,413	344	14,757

/1: Associated Liberian Timber Corporation

/2: Varjam Logging Corporation

According to the information gained from interviews with the logging company (ALTCO) and the data of the national forestry inventory/1, the most important timber areas are located in the southeast region of the country and available forest in the northwest region, where the influence area is located, is poor in good species for export and quantities of logs with exploitable diameter. Furthermore, topographical condition is not so attractive with rough terrain and major portion of the forestry lies far away from the existing highways.

Production prospect in future would not be so bright, if the environmental aspects mentioned above will not be changed. However, the following factors shall be taken into account for the estimate of future forestry production.

a) Development of the Wologisi mine increases demand of local consumption.

b) Construction of Belle-Yella-Kolahun road, now under detailed design, will facilitate the forestry development by shortening the access in the influence area.

/1: National Forestry Inventory in Liberia, 1968

c) Project road will reduce transport cost considerably if improved, which will make it feasible to exploit relatively uneconomic forestry at present.

In due consideration of the above factors the production for local consumption is expected to grow at comparatively higher rate, while the products for export are not considered to increase much unless world market situation becomes quite favourable. This expectation is already traced by the current production trend in the influence area that the share of the local timber in the total production increased rapidly from 10% in 1976 to 70% in 1978 and the production for export stagnated.

After studying the potential development of the forestry resources in the influence area, future production of logs and timber is estimated at 31,000 tons in 1989 and 56,000 tons in 1999. The expected annual growth rate of the production are 10% during 1979-1989 and 7% during 1989-1999 for local consumption, while that for export is neglibigly small.

Future Production of logs and Timber

(m^3)

	1989	1999
for Export	4,600	4,600
for Local Cons.	26,200	51,500
Total	30,800	56,100

3.8 Mining

In the influence area, there exists a potential iron ore, the Wologisi Iron ore, the feasibility study for which is now underway. According to the plan/1 about 7 million tons of iron ore will be produced per year at the final phase. The development of the iron ore is expected to give substantial impacts both on regional economy and national economy in view of its dominant share in GDP. Impacts on employment cannot be neglected i.e., around 2,500 local people and 1,500 expatriates are to be involved during the peak construction period both for the Wologisi site and the port construction site.

Iron ore development is considered to affect the traffic on the Project road from the stage of the construction up to the operation. Preparation of the development is planned to start from 1981 and exploitation of the iron ore will start from 1984. During the preparation stage, about 100,000 tons of construction materials will be carried to the project site from Monrovia. Since there is no alternative transport mode for carrying these materials, only the Project road will be used for this transport.

As mentioned above, the iron ore exploitation will be made in different phases. The first phase covers 5 years starting from 1984 during which 4 million tons of concentrates will be produced annually, mainly from the weathered ore. In the second phase of 1989-1998, annual production will increase up to 7 million tons of finished products per year from a mixture of weathered and primary ore. The third phase envisages the production of 7 million tons of finished products a year from the primary ore reserves and will continue for more than 15 years. However, transport of the iron ore is now being planned to be made by pipe line which will be installed between the Wologisi

/1: Wologisi Iron Ore Project, Technical Study, 1979

Site and Monrovia port. Traffic on the project road will, therefore, not be affected by the transportation of the iron ore itself.

Along with the development of the mine, a community town will be constructed at the Wologisi Site where foreign engineers and management staff live together with local staff. The expected population in the town will be 2,100 in the first phase, 2,600 in the second phase and 2,700 in the third phase as shown in the Table 3.4. The increased population in the Wologisi Site is expected to affect the traffic on the project road.

Table 3.4 Planned Population at the Wologisi Site

	1st/1 Phase	2nd/2 Phase	3rd/3 Phase
Foreign Engineer and Administrator			
Married	4	4	4
Unmarried	17	15	15
Planned population	33	31	31
Foreign Technician			
Married	153	166	171
Unmarried	78	68	71
Planned population	843	898	926
Local Staff			
Married	195	279	285
Unmarried	61	65	67
Planned population	1,231	1,739	1,777
Total Planned Population	2,107	2,668	2,734

Source: Wologisi Iron Ore Project Technical Study, 1979

/1: 1984 - 1988

/2: 1989 - 1998

/3: 1999 - 2013

〔IV〕

TRAFFIC SURVEY

IV. TRAFFIC SURVEY

4.1 General

Before starting traffic survey on the project road, review on the available data and information concerning the traffic was made. Particularly, the records of recent traffic survey conducted by the Ministry of Public Works in June, 1978, were checked in detail together with the survey methods including zoning system and investigation period.

The traffic survey was made to quantify and classify present vehicle movements on the road under study. Classified vehicle counts and origin - destination survey at 8 stations were conducted under the schedule and procedures presented in Table 4.1 and Fig. 4.1.

The locations of the survey stations and the survey items on O-D survey were so selected as to trace most of the zone-to-zone movement both within the internal influence area and between the internal and the external. Period of the survey was determined to be seven days for grasping the weekly fluctuation of the traffic. Although the survey time was already in wet season, the rain was not so heavy with only short time shower and the survey was conducted under relatively fine weather condition.

Fig.4.1 Location of Traffic Survey Station

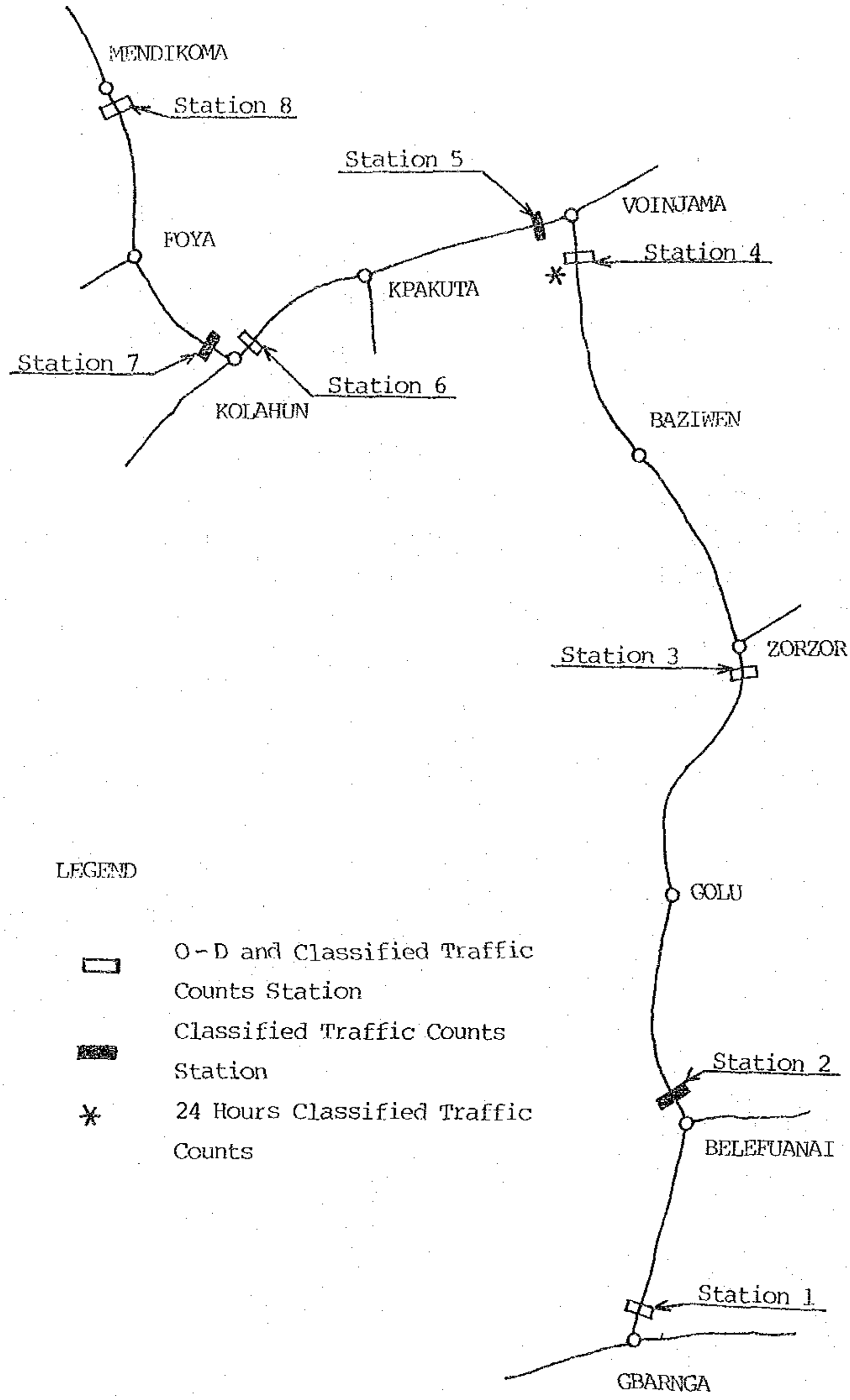


Table 4.1 Traffic Survey Schedule

Station No. and Location	July (7:00 a.m. to 7:00 p.m.)						
	9 MON	10 TUE	11 WED	12 THU	13 FRI	14 SAT	15 SUN
1. Gbarnga	TC	TC	TC	OD	TC	TC	TC
2. Belefuanai	TC	TC	TC	TC	TC	TC	TC
3. Zorzor	TC	TC	TC	OD	TC	TC	TC
4. Voinjama 1	TC	TC*	TC	OD	TC	TC	TC
5. Voinjama 2	TC	TC	TC	TC	TC	TC	TC
6. Kolahun 1	TC	TC	TC	OD	TC	TC	TC
7. Kolahun 2	TC	TC	TC	TC	TC	TC	TC
8. Mendikoma	TC	TC	TC	OD	TC	TC	TC

TC = Classified Traffic Counts

OD = Origin Destination Survey

* = 24 Hours Classified Traffic Counts

Station 1:	Gbarnga	(about 100 m from the intersection toward Voinjama)
Station 2:	Belefuanai	(about 300 m after Belefuanai toward Zorzor)
Station 3:	Zorzor	(1 km before Zorzor from Belefuanai)
Station 4:	Voinjama	(Immigration gate before Voinjama)
Station 5:	Voinjama	(300 m after Voinjama toward Kolahun)
Station 6:	Kolahun	(500 m before Kolahun from Voinjama)
Station 7:	Kolahun	(200 m after Kolahun toward Mendikoma)
Station 8:	Mendikoma	(100 m before Immigration gate).

4.2 Traffic Count

Classified traffic counts were carried out at 8 stations for one week starting from July 9 during 12 hours from 7:00 a.m. to 7:00 p.m. In the survey the present traffic was classified into 7 types of vehicle, i.e. passenger car, taxi, pick-up and bus for passenger traffic, and light truck, heavy truck and trailer for freight traffic. The results of the classified traffic counts are summarized in Table 4.2 and actual counts records from 7:00 a.m. to 7:00 p.m. by station, by day and by direction are presented in Annex IV-1.

Table 4.2 Result of Classified Traffic Counts

(vehicles / 12 hours)

Station	Car	Taxi	Pick-up	Truck	Total
1. Gbarnga	42	26	162	36	267
2. Belefuanai	32	14	82	19	146
3. Zorzor	27	23	97	30	177
4. Voinjama1	59	77	247	80	463
5. Voinjama 2	76	29	209	46	360
6. Kolahun 1	47	59	228	43	377
7. Kolahun 2	33	43	223	25	324
8. Mendikoma	14	38	114	17	183

Note : The traffic volumes exclude the number of vehicles travelling short distance (less than a mile).

Classified traffic counts for 24 hours were also carried out on station No. 4 to expand the 12 hours counts to 24 hours traffic by type of vehicle. Since the 24 hours count covers only one day, the results of the previous survey conducted by the Ministry of Public Works in the pre-feasibility study in 1978 were used to supplement our results.

The expansion factor was estimated by calculating the average of the present survey data and the previous ones, and are summarized in Table 4.3.

Table 4.3 Expansion Factor for ADT

Survey	P-Car	Taxi	Pick-up	Truck
1979 Survey	1.13	1.12	1.19	1.25
1978 Survey /1	1.39	1.28	1.26	1.44
Average	1.26	1.20	1.23	1.35

/1 : The expansion factors of pre-feasibility study were calculated by averaging data of each station excluding some extraordinary ones.

The estimated expansion factor showed that the day-time traffic from 7:00 a.m. to 7:00 p.m. was around 80 - 83% for passenger car, taxi and pick-up, and 74% for truck.

The average daily traffic volumes (ADT) by type of vehicle and by station were estimated by applying these expansion factors as shown in the Table 4.4.

Table 4.4 Estimated Average Daily Traffic Volumes
(Vehicles / day)

Station	Car	Taxi	Pick-up	Truck	Total
1. Gbarnga	53	31	199	49	332
2. Belefunai	40	17	101	26	184
3. Zorzor	34	28	119	41	222
4. Voinjama 1	74	92	304	108	578
5. Voinjama 2	96	35	257	62	450
6. Kolahun 1	59	71	280	58	468
7. Kolahun 2	42	52	274	34	402
8. Mendikoma	18	46	140	23	227

During the survey period, very few mini-buses were identified on the project road. Since they were similar to pick-up in the physical characteristics such as axle load and the use, the mini-bus was classified in the group of pick-up.

Although the seasonal variation of agricultural production and gas consumption were checked, their effect on traffic pattern could not be traced clearly. Adjustment of the seasonal fluctuation is, therefore, not made on the estimated ADT.

4.3 Origin and Destination Survey

An origin and destination survey was carried out to collect data mainly on :

1) Traffic pattern by O-D pairs and vehicle type;

2) Traffic pattern by O-D pairs and type of goods carried; and

3) Traffic characteristic such as type of fuel, purpose of trip and occupancy.

4.3.1 Survey Procedure and Data Compilation

Five stations were selected out of eight stations for the O-D survey as shown in Table 4.1 and Figure 4.1. Only motor vehicles were stopped and their drivers were interviewed by means of the questionnaire. The sample size of the O-D survey was 100% at all stations over the 12 hours (7:00 a.m. - 7:00 p.m.) survey.

In order to avoid duplication in the preparation of O-D matrix, the vehicles once stopped for interview were not stopped again at the other stations. The collected data were processed and compiled into the following matrices for trips between zones of origin and zones of destination.

1) Matrix for the number of trips with car
2) Matrix for the number of trips with taxi
3) Matrix for the number of trips with pick-up
4) Matrix for the number of trips with trucks

Since the O-D survey covers only one day records, available O-D matrices prepared by MPW on the basis of 1978 survey result were fully utilized for establishing the final O-D matrices. The O-D matrices thus compiled were further modified referring to the ADT estimated on the basis of the traffic count.

The estimated O-D matrices for different types of vehicle are presented in Annex IV-2.

4.4 Traffic Characteristics

Based on the O-D survey data, traffic characteristics were analysed. Results of the analysis are briefly explained below and the details are presented in Annex IV-3.

4.4.1 Type of Fuel

Most of cars, taxies and pick-ups use gasoline, super and regular. Particularly, super gasoline is most popular and consumed by 70% to 75% of vehicles of this group. Very few, 1% to 3% of this group, use diesel, Diesel is used mainly by trucks. About 86% of trucks use diesel and the remaining use gasoline, super or regular.

4.4.2 Ownership

As shown in Annex IV-3, more than 80% of the vehicles excluding passenger cars are privately owned. In case of passenger car, 66% belongs private owners, 34% is owned by the government.

4.4.3 Purpose of Trip

Most of the vehicles are used for the purposes of business, for work and shopping, and the use of the vehicles for the purposes of recreation and social/religious activity is limited.

Although the O-D survey was conducted during the OAU[/1] Conference held in Monrovia, no special influence of the conference to the traffic on the project road was identified. For cars, 70% is used for business, 14% for shopping, 8% for agricultural activity and 8% for social and religious purposes. For pick-up, 77% is used for business trip, 10% for agricultural activity, 9% for shopping and, 2% for social and religious purposes. For trucks, 75% is occupied by business trip, 17% for agricultural activity and 5% for shopping.

4.4.4 Average Number of Persons per Vehicle

The estimated occupancy rate ranges from 2.3 to 4.3 persons per car with an overall average of 3.8, while the occupancy rate for taxi are slightly higher ranging from 5.2 to 6.3 with an average of 5.8. The occupancy rate for pick-up is very high with an average of 10.9 persons, and that for truck is 2.8 including crew. Around 30% of the trucks are recorded to have second driver, while no second driver was recorded for car, taxi and pick-up.

4.4.5 Cargo Carried by Truck

As presented in Appendix IV-3, about 25% of the trucks carried agricultural crop products, 17% carried consumer goods, 5% carried log and timber, 9% carried fuel, 8% carried construction materials and mix. Around 38% of the trucks were recorded empty.

/1 : Organization for African Unity

4.4.6 Average Load Carried by Truck

According to the O-D survey results, only 38% of trucks were loaded fully, 14% were loaded three quarters and 10% were loaded half or less than half. Around 38% of the trucks were recorded as empty trucks.

4.4.7 Frequency of Trips

Frequency of trips by type of vehicle were also recorded during the O-D survey. Vehicles traveled more than one trip per day amount about 58% of passenger cars and around 50% of taxies. Pick-up recorded the highest frequency of trips, 68% of it have more than one trip per day, while truck recorded the lowest 32%.

〔V〕

PRESENT AND FUTURE TRAFFIC

V. PRESENT AND FUTURE TRAFFIC

5.1 Present Traffic Volume

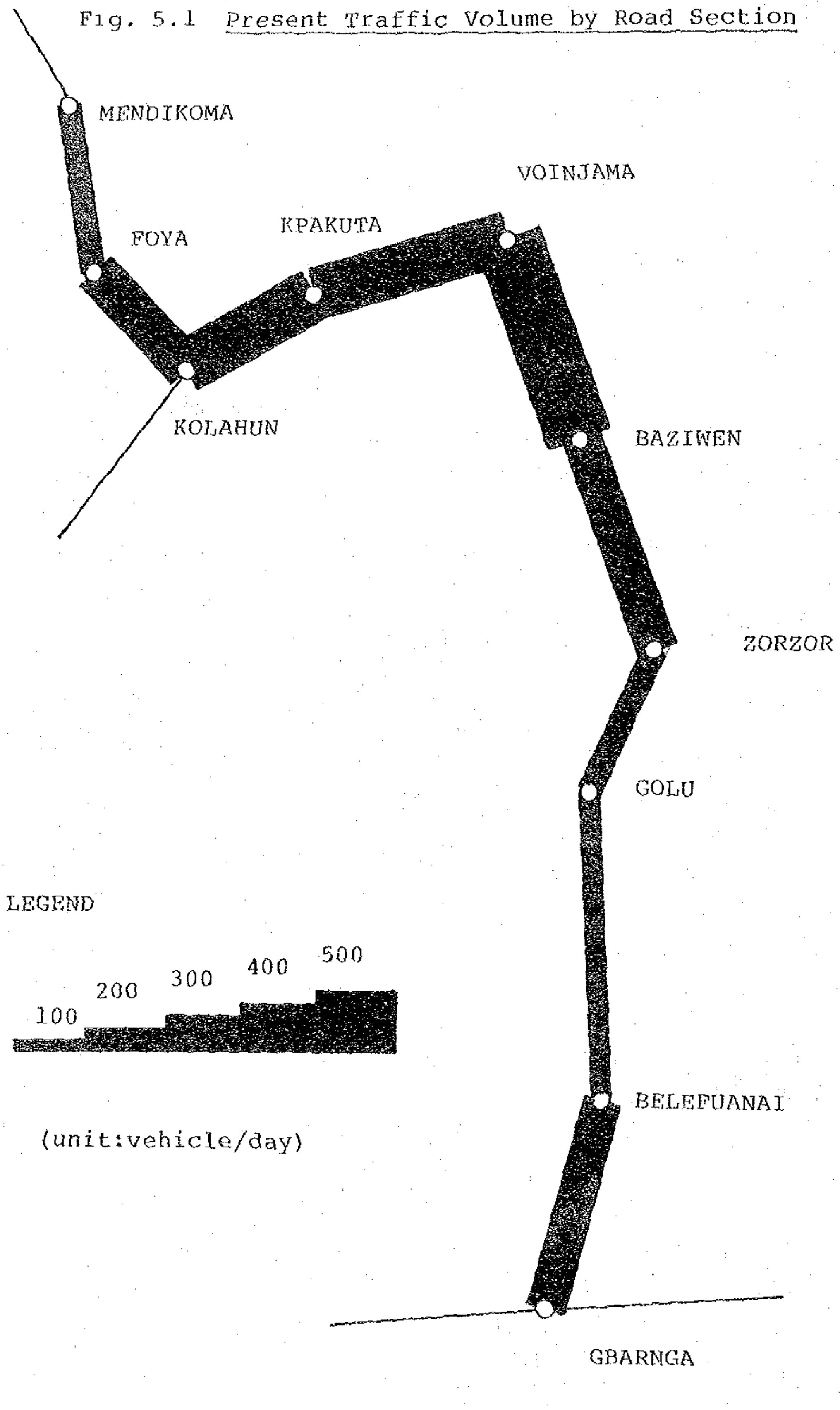
For the sake of traffic forecast, the Project road was divided into 9 links. Each of them has homogeneous characteristic in traffic pattern and road conditions.

The present traffic volume on each road link was calculated, on the basis of the O-D matrices presented in Annex IV-2. For the calculation, all the short distance traffic and the traffic within the same zone were excluded. The estimated traffic volume on each link is summarized in Table 5.1 and presented in Fig. 5.1.

Table 5.1 Present Traffic Volume (ADT in 1979)

	Link	P-car	Taxi	Pick-up	Truck	Total
1.	Gbarnga-Belefuanai	52	29	196	57	334
2.	Belefuanai-Golu	40	20	97	53	210
3.	Golu-Zorzor	35	26	116	54	231
4.	Zorzor-Baziwen	53	56	183	71	363
5.	Baziwen-Voinjama	74	91	302	109	576
6.	Voinjama-Kpakuta	96	34	255	61	446
7.	Kpakuta-Kolahun	59	71	280	56	466
8.	Kolahun-Foya	41	51	273	32	397
9.	Foya-Mendikoma	17	45	140	23	225

Fig. 5.1 Present Traffic Volume by Road Section



5.2 Future Traffic Volume

Future traffic volume on the project road was estimated for three different types, namely, normal traffic, generated traffic and diverted traffic, on the basis of the future population, land use and economic activities forecasted in Chapter III.

5.2.1 Normal Traffic

Normal traffic is the expected traffic under the assumption that the project road will not be improved but only be maintained in the present condition. The projection was made both for passenger traffic and cargo traffic separately. Expected traffic diversion from the project road to the Belle Yela-Kolahun road was also taken into account for the estimation of the normal traffic.

1) Passenger Traffic

The growth in passenger traffic inclucluding passenger car, taxi and pick-up was estimated on the basis of population growth, growth in per-capita income and income elasticity of transport demand, assuming that present pattern of the traffic will continue for the project life in future.

Basic conditions for the estimate of the normal passenger traffic growth are:

a) $T_{fi} = T_{pi} \times G_i$

T_{fi} = future traffic generation in zone i

T_{pi} = present traffic generation in zone i

G_i = growth rate of traffic generation in zone i

$G_i = (1+P_i)(1+\varepsilon Y_i)$

P_i = rate of population increase in zone i

Y_i = rate of per capita income increase in zone i

ε = income elasticity of transport demand

b) Population increase rate as projected in Chapter III.

c) Per capita income will increase around 3.0% per year during 1979 - 1989 and 2.0% per year during 1989 - 2004.

d) Income elasticity for transport demand is 1.5.

On the basis of the above conditions, future passenger traffic generation by zone was calculated as presented in Table 5.2. The estimated passenger traffic is, then, distributed to each different O-D pair by using the present pattern method (Frator method). The results are shown in Annex V-1. Based on the O-D matrices, normal traffic volumes in future on each link were estimated as listed in Table 5.3.

Table 5.2 Future Passenger Traffic Generation by Zone

(Vehicle/day)

Zone No.	1984			1994			2004		
	Car	Taxi	Pick-up	Car	Taxi	Pick-up	Car	Taxi	Pick-up
1	47	26	138	93	33	274	165	93	487
2	32	13	142	62	25	276	109	44	489
3	7	8	28	11	13	47	18	22	76
4	32	85	172	64	169	341	114	300	606
5	30	56	182	59	109	355	104	193	628
6	217	178	689	432	353	1,368	767	627	2,429
7	157	83	463	307	162	907	518	274	1,531
8	91	132	630	181	263	1,252	321	466	2,222
9	82	126	383	163	251	762	290	445	1,352
10	15	20	92	26	36	163	45	61	278
11	0	0	1	0	0	2	0	0	4
12	6	3	50	11	5	95	18	9	161
13	0	0	0	0	0	0	0	0	0
14	20	0	0	38	0	0	64	0	0
15	26	15	109	62	35	254	120	68	496
16	8	41	98	14	72	173	25	123	295
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
Total	770	786	3,177	1,523	1,546	6,269	2,678	2,725	11,054

Table 5.3 Future Normal Passenger Traffic by Road Link

(Vehicle/day)

Link	Type of Vehicle	1984	1994	2004
1. Gbarnga-Belefuanai	Car	75	160	295
	Taxi	40	87	166
	Pick-up	288	610	1,132
	Total	403	857	1,593
2. Belefuanai-Golu	Car	55	118	219
	Taxi	27	62	122
	Pick-up	143	329	637
	Total	225	509	978
3. Golu-Zorzor	Car	49	108	202
	Taxi	34	74	143
	Pick-up	169	374	711
	Total	252	556	1,056
4. Zorzor-Baziwen	Car	75	160	289
	Taxi	80	165	295
	Pick-up	273	591	1,104
	Total	428	916	1,688
5. Baziwen-Voinjama	Car	104	217	391
	Taxi	132	263	465
	Pick-up	446	924	1,687
	Total	682	1,404	2,543
6. Voinjama-Kpakuta	Car	140	277	497
	Taxi	47	100	182
	Pick-up	373	760	1,356
	Total	560	1,137	2,332
7. Kpakuta-Kolahun	Car	79	160	290
	Taxi	113	314	393
	Pick-up	428	885	1,572
	Total	620	1,359	2,255
8. Kolahun-Foya	Car	59	125	224
	Taxi	65	146	271
	Pick-up	380	761	1,360
	Total	504	1,032	1,855
9. Foya-Mendikoma	Car	23	40	70
	Taxi	59	106	183
	Pick-up	188	333	570
	Total	270	479	823

2) Cargo Traffic

The growth in cargo traffic is to be estimated on the basis of the expected future economic transaction including the commodity production and consumption for each zone. However, since detailed projection on the commodity production by zone was not practically made due to the limited available data and information, our cargo traffic projection is conducted on the wider regional basis assuming that the surplus production such as agricultural crops, rubber and forestry goods will be transported outside the influence area. The growth in cargo traffic was estimated with the following procedure.

a) Estimation of cargo composition /1 on the present traffic by commodity group by link;

b) Estimation of production growth for each commodity group;

c) Conversion of commodity production volume into traffic volume and estimation of cargo traffic growth rate; and

d) Estimation of future cargo traffic by applying the estimated future growth rate on cargo traffic to the present cargo traffic of each link

The rate of the present cargo composition was estimated for each link based on the O-D Survey as presented below.

/1: Estimated cargo composition on the basis of the O-D survey result was checked and revised referring to the regional production data.

Table 5.4 Rate of Cargo Composition Carried by Truck

(%)

Commodity Group	Link No.								
	1	2	3	4	5	6	7	8	9
Agricultural Crops	14	14	14	14	14	18	18	18	18
Rubber	2	2	2	0	0	0	0	0	0
Logs and Sawn Timber	18	18	18	19	19	0	0	0	0
Fuel	10	10	10	10	10	10	10	10	10
Consumer Goods	16	16	16	16	16	20	20	20	20
Construction Materials	6	6	6	6	6	7	7	7	7
Mix	2	2	2	2	2	2	2	2	2
Empty	32	32	32	33	33	40	40	40	40
Total	100	100	100	100	100	100	100	100	100

Using the above composition ratio, present cargo traffic by commodity group was estimated for each link as shown below.

Table 5.5 Present Cargo Traffic by Commodity Group

(Vehicle/day)

Link \ Commodity	1	2	3	4	5	6	7	8	Total
1. Gbarnga-Belefuanai	8	1	10	6	9	4	1	18	57
2. Belefuanai-Golu	7	1	10	5	9	3	1	17	53
3. Golu-Zorzor	8	1	10	5	9	3	1	17	54
4. Zorzor-Baziwen	10	0	14	7	11	4	1	24	71
5. Baziwen-Voinjama	15	0	21	11	17	7	2	36	109
6. Voinjama-Kpahuta	11	0	0	8	12	4	1	25	61
7. Kpahuta-Kolahun	10	0	0	7	11	4	1	23	56
8. Kolahun-Foya	6	0	0	4	6	2	1	13	32
9. Foya-Mendikoma	4	0	0	3	5	1	1	9	23

Note: Commodity Group:
1. Agricultural Crop
2. Rubber
3. Logs and Sawn Timber
4. Fuel
5. Consumer Goods
6. Construction Materials
7. Mix
8. Empty

The results of estimation of future production growth by commodity group presented in Chapter III were fully employed in the projection of the growth of cargo traffic. For the estimation of cargo traffic growth on the project road, the following conditions were applied:

a) Agricultural goods and rubber will be carried by 4.0 tons truck, and logs and timber be carried by 7.0 tons truck and 11.0 tons truck, respectively.

b) Consumption of fuel will increase in parallel to the expected traffic growth in the region .

c) Traffic of consumer goods, construction materials and mix will increase at approximately the same rate with that of the regional GDP.

The approximate growth rates of cargo traffic were thus estimated as follows:

Table 5.6 Growth Rates of Cargo Traffic

Commodity Groups	1979-1988	1989-2004
Agricultural Crops	11.5%	8.0%
Rubber	0 /1	11.0 /2
Logs and Sawn Timber	5.0	6.0
Fuel	8.0	6.5
Consumer Goods	7.5	5.5
Construction Materials	7.5	5.5
Mix	7.5	5.5
Empty	7.5	5.5

/1 : 1979 - 1984
/2 : 1984 - 1994, and 8% from 1994 to 2004

Future normal cargo traffic by commodity and by link is estimated by applying the calculated growth rate to the estimated present cargo traffic of each link. The results of the estimate are presented in Annex V-4, and summarized in the following table.

Table 5.7 Future Normal Cargo Traffic

(Vehicle/day)

	Link	1984	1994	2004
1.	Gbarnga-Belefuanai	83	159	285
2.	Belefuanai-Golu	75	148	262
3.	Golu-Zorzor	77	152	272
4.	Zorzor-Baziwen	102	200	353
5.	Baziwen-Voinjama	158	306	542
6.	Voinjama-Kpakuta	91	184	325
7.	Kpakuta-Kolahun	83	168	298
8.	Kolahun-Foya	48	93	173
9.	Foya-Mendikoma	33	70	119

3) Expected Traffic Diversion and Total Normal Traffic Projection

A new road connecting Belle Yella with Kolahun is planned to be constructed starting from 1981. The road, if completed, will reduce the distance and travel time between northern part of Lofa County and Monrovia, and then affect the traffic on the project road. The road, now in detailed design stage, is scheduled to be constructed by around 1984.

In addition, a new road is planned linking Kpakuta and Bopolu (up to Monrovia) for the construction of the pipe line of the Wologisi Iron Ore Development Project. This road will also reduce the distance from upper Lofa to Monrovia and is expected to affect the traffic on the project road. However, this road takes mostly same course in its major portion as the Belle Yella-Kolahun road. The impact of this road to the traffic on the project road can, therefore, be considered almost same as that of the Belle Yella-Kolahun road.

Since the Belle Yella - Kolahun road will reduce the time and cost, some portion of the traffic travelling on the project road from north-eastern part to Monrovia will divert to the new road. For the estimation of the diversion, travel time from upper Lofa to Monrovia is calculated for each different types of vehicles both on the project road and the Belle Yella - Kolahun road under the following traveling speeds assumed.

Estimated Travel Time from Upper Lofa to Monrovia

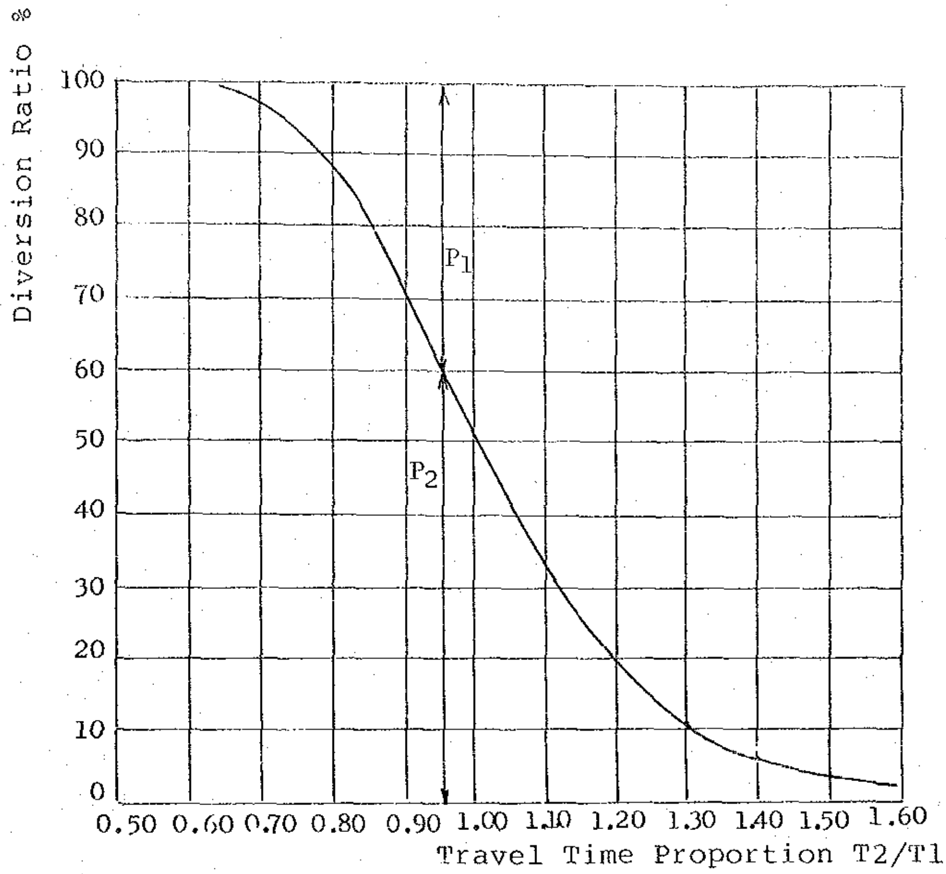
(hrs)

	Project Road	Belle Yella-Kolahun Road
P-Car	5.39	5.01
Taxi	5.39	5.01
Pic-up	6.04	5.76
Truck	6.79	6.82

By applying the time difference estimated above to the traffic diversion curve, diversion ratio from the project road to the Belle Yella - Kolahun road was estimated for different types of vehicles. From the estimated ratio and the normal through traffic, expected traffic diversion is calculated for each link as presented in Table 5.8. These diverted traffic will occur irrespective of the implementation of the Project, and, therefore, be taken into account in the estimation of future normal traffic on the project road.

Total normal traffic volume for passenger and cargo was finally estimated by deducting the diverted traffic from the estimated figures in the preceding section. The results of the calculation are presented in Table 5.9.

Fig. 5.2 Traffic Diversion Curve



T_1 : Travel Time on Route 1

T_2 : Travel Time on Route 2

P_1 : Percentage of Traffic Assignment to Route 1

P_2 : Percentage of Traffic Assignment to Route 2

Souce : The Economic Benefits of Road Construction and Improvements by Lionel Odier.

Table 5.8 Expected Traffic Diversion from the Project Road

(Vehicle/day)

Link	Type of Vehicle	1984	1994	2004
1. Gbarnga-Belefuanai	P-Car	9	19	35
	Taxi	1	3	5
	Pick-up	46	98	181
	Truck	25	48	85
	Total	81	168	306
2. Belefuanai-Golu	P-Car	8	18	33
	Taxi	1	3	6
	Pick-up	46	105	204
	Truck	24	47	84
	Total	79	173	327
3. Golu-Zorzor	P-Car	7	18	34
	Taxi	1	3	6
	Pick-up	46	101	192
	Truck	24	47	84
	Total	78	169	316
4. Zorzor-Baziwen	P-Car	8	18	32
	Taxi	2	3	6
	Pick-up	46	101	192
	Truck	24	47	84
	Total	80	169	314
5. Baziwen-Voinjama	P-Car	8	17	31
	Taxi	1	3	5
	Pick-up	45	92	169
	Truck	25	49	187
	Total	79	161	392
6. Voinjama-Kpakuta	P-Car	7	14	25
	Taxi	1	3	4
	Pick-up	22	46	81
	Truck	6	13	23
	Total	36	76	133
7. Kpakuta-Kolahun	P-Car	6	13	23
	Taxi	1	3	4
	Pick-up	26	53	94
	Truck	6	12	21
	Total	39	81	142

Note : Projection of the traffic diversion is based on the volume of the through traffic to Monrovia.

Table 5.9 Total Projected Normal Traffic

(Vehicle/day)

Link	Type of Vehicle	1984	1994	2004
1. Gbarnga-Belefuanai	Car	66	141	260
	Taxi	39	84	161
	Pick-up	242	512	951
	Truck	58	111	200
	Total	405	848	1,572
2. Belefuanai-Golu	Car	47	100	186
	Taxi	26	59	116
	Pick-up	97	224	433
	Truck	51	101	178
	Total	221	484	913
3. Golu-Zorzor	Car	41	90	168
	Taxi	33	71	137
	Pick-up	123	273	519
	Truck	53	105	188
	Total	250	539	1,012
4. Zorzor-Baziwen	Car	67	142	257
	Taxi	78	162	289
	Pick-up	227	491	916
	Truck	76	152	268
	Total	448	947	1,730
5. Baziwen-Voinjama	Car	96	200	360
	Taxi	131	260	460
	Pick-up	401	832	1,518
	Truck	133	257	455
	Total	761	1,549	2,793
6. Voinjama-Kpakuta	Car	147	291	522
	Taxi	48	103	187
	Pick-up	395	806	1,437
	Truck	97	197	348
	Total	687	1,397	2,494
7. Kpakuta-Kolahun	Car	85	173	313
	Taxi	114	317	397
	Pick-up	454	938	1,666
	Truck	89	180	319
	Total	742	1,608	2,695
8. Kolahun-Foya	Car	59	125	224
	Taxi	65	146	271
	Pick-up	380	761	1,360
	Truck	48	93	173
	Total	552	1,125	2,028
9. Foya-Mendikoma	Car	23	40	70
	Taxi	59	106	183
	Pick-up	188	333	570
	Truck	33	70	119
	Total	303	549	942

5.2.2 Future Generated Traffic

Improvement of the Project road will reduce the transport cost and time, and is expected to result in the inducement of additional traffic both for passenger and cargo. The generated cargo traffic comes out partly from increased price competitiveness of the goods in the influence area and partly from expanded production of goods. The generated passenger traffic is mainly caused by cost reduction effect and partly by increased population through the Project implementation, which is considered small in this case because the road already exists in the area and well maintained, and the agricultural development gives more significant influence on the regional population growth.

For the estimate of the generated traffic it is assumed that an additional traffic/1 will occur mainly by the reduction of the transport cost with a price elasticity of the traffic demand. Ratio between the reduced vehicle operating cost and the vehicle operating cost without the project is calculated for each road link.

On the basis of the ratio and the projected future normal traffic volume, the expected generated traffic is calculated as presented in Table 5.10. Composition of the generated traffic is also presented in Annex V-5. The generated traffic will come out after the completion of the improvement work in 1984, and grow at 7.5% during 1984 - 1989 and 5.5% during 1989 - 2004.

/1: $G.T. = ADT\ (Normal) \cdot \frac{C_1 - C_2}{C_1} \cdot \varepsilon$

Where C_1 = Vehicle operating cost without Project

C_2 = Vehicle operating cost with Project

ε = Price elasticity of transport demand is assumed at 1.0. (The figure is estimated by the recent experience of the Consultant)

5.2.3 Future Diverted Traffic

As mentioned in the preceding section 5.2.1, construction of new roads is planned to connect upper Lofa with Monrovia. The expected traffic diversion from the project road to the newly constructed road (possibly Belle Yella - Kolahun road) is already studied and incorporated into the final estimate of the normal traffic.

As no competitive road exists in the influence area, there will be no traffic to be diverted to the project road from the other road.

Possibility of the diversion from the air traffic was also examined and was judged to be negligible. As shown in the table below, the existing air passenger traffic between Monrovia and Voinjama is quite small. Furthermore, if considered the large time difference between air and land transport the possible diversion from the air to the project road will be negligiblly small.

Regular Flights - Lofa County (1978)

Direction	No. of passengers	No. of Flight	Persons/ day
Monrovia-Wologisi	83	48	0.23
Monrovia-Voinjama	1,410	48	3.86
Monrovia-Foya	949	48	2.60

Source: Air Liberia

5.2.4 Total Projected Traffic

Projected total traffic on the Project road is calculated by adding the generated traffic to the normal traffic, the result is presented in Table 5.11.

Table 5.10 Future Generated Traffic

(Vehicle/day)

Link	Type of Vehicle	1984	1994	2004
1. Gbarnga-Belefuanai	Car	14	29	47
	Taxi	8	16	26
	Pick-up	46	95	155
	Truck	17	35	57
	Total	85	175	285
2. Belefuanai-Golu	Car	10	21	34
	Taxi	5	10	16
	Pick-up	18	37	60
	Truck	15	31	50
	Total	48	99	160
3. Golu-Zorzor	Car	9	19	31
	Taxi	7	14	23
	Pick-up	23	47	77
	Truck	16	33	54
	Total	55	113	185
4. Zorzor-Baziwen	Car	14	29	47
	Taxi	16	33	54
	Pick-up	43	89	145
	Truck	23	47	77
	Total	96	198	323
5. B ziwen-Voinjama	Car	20	41	67
	Taxi	28	58	94
	Pick-up	76	157	256
	Truck	40	82	134
	Total	164	338	551
6. Voinjama-Kpakuta	Car	31	64	104
	Taxi	10	21	34
	Pick-up	75	155	252
	Truck	29	60	98
	Total	145	300	488
7. Kpakuta-Kolahun	Car	18	37	60
	Taxi	24	49	80
	Pick-up	86	177	288
	Truck	27	56	91
	Total	155	319	519
8. Kolahun-Foya	Car	12	25	41
	Taxi	14	29	47
	Pick-up	72	148	241
	Truck	14	29	47
	Total	112	231	376
9. Foya-Mendikoma	Car	5	10	16
	Taxi	12	25	41
	Pick-up	36	74	121
	Truck	10	21	34
	Total	63	130	212

Table 5.11 Total Projected Traffic

(Vehicle/day)

Link	Type of Vehicle	1984	1994	2004
1. Gbarnga-Belefuanai	Car	80	170	307
	Taxi	47	100	187
	Pick-up	288	607	1,106
	Truck	75	146	257
	Total	490	1,023	1,857
2. Belefuanai-Golu	Car	57	121	220
	Taxi	31	69	132
	Pick-up	115	261	493
	Truck	66	132	228
	Total	216	583	1,073
3. Golu-Zorzor	Car	50	109	199
	Taxi	40	90	168
	Pick-up	146	320	596
	Truck	68	138	242
	Total	305	657	1,205
4. Zorzor-Baziwen	Car	81	171	304
	Taxi	94	195	343
	Pick-up	270	580	1,061
	Truck	99	199	345
	Total	544	1,145	2,053
5. Baziwen-Voinjama	Car	116	241	427
	Taxi	159	318	554
	Pick-up	477	989	1,774
	Truck	173	339	589
	Total	925	1,887	3,344
6. Voinjama-Kpakuta	Car	178	355	626
	Taxi	58	124	221
	Pick-up	470	961	1,689
	Truck	126	257	446
	Total	832	1,697	2,982
7. Kpakuta-Kolahun	Car	103	210	373
	Taxi	138	366	477
	Pick-up	540	1,115	1,954
	Truck	116	236	410
	Total	897	1,927	3,214
8. Kolahun-Foya	Car	71	150	265
	Taxi	78	1175	318
	Pick-up	452	909	1,601
	Truck	62	122	220
	Total	664	1,356	2,404
9. Foya-Mendikoma	Car	28	50	86
	Taxi	71	131	224
	Pick-up	224	407	691
	Truck	43	91	153
	Total	366	679	1,154

〔VI〕

VEHICLE OPERATING COST

VI. VEHICLE OPERATING COST

6.1 General

For the calculation of the vehicle operating cost (VOC) on the Project road, a method developed by the Transport and Road Research Laboratory, UK (TRRL) and the conventional method/1 were studied comparatively. Though the comparison, the TRRL method/2 was chosen from the view points that the estimated VOC can reflect actual road conditions using various factors in case of the TRRL more than that in case of the conventional method.

The TRRL method was formulated on the basis of the assumptions that vehicle speed and operating cost are related to the horizontal and vertical alignment and the road surface condition in addition to vehicle type, price, age and load. As the physical parameters of the road, the following eight variables are considered.

(1) Rise and fall
(2) Horizontal curvature
(3) Road width
(4) Roughness
(5) Altitude
(6) Moisture content
(7) Rut depth
(8) Looseness

/1 : Used in "Quantification of Road User savings" Jan de Weille

/2 : For the practical application, only standing cost and depreciation cost were estimated by modified method.

6.2 Typical Vehicles and Unit Cost

Based on the results of the traffic survey, typical vehicles on the Project road were selected as presented below.

Passenger Car : Toyota Corona
Taxi : Toyota Carolla or Datsun 120Y
Pick-up : Mazda 1,600 or Toyota Stout
Medium Truck : Isuzu TX-40 or Toyota 600D6
Heavy Truck : Mercedes LK2624

Characteristics of the vehicles are summarized in the following table:

Item	Toyota Corona	Toyota Carolla	Mazda Pick-up 1600	Isuzu TX-40	Mercedes LK2624
Pay Load Capacity	-	-	-	12 tons	22 tons
No. of Axles	2	2	2	2	3
Type of Fuel	Gasoline	Gasoline	Gasoline	Diesel	Diesel
Horse Power	113	73	-	125	240
No. of Tyres	4	4	4	6	10
Tyre Size	5.60x13	6.15x13	6.00x14.6	8.25x20	10.00x20
Gross Weight (Vehicle Weight)	-	-	-	5.0 t	16.0 t

Unit cost/1 for the typical vehicles and other relevant basic figures for calculating VOC are summarized in the following table.

/1 : As of December, 1979

Table 6.1 Unit Cost

		P-Car	Taxi	Pick-up	M-Truck	H-Truck
Purchase Price (US$)	DF	7,340	5,470	6,000	22,900	70,000
	DP	9,250	6,890	7,500	28,100	86,000
Tyre & Tube Price (US$)	DF	55	45	67	300	335
	DP	65	55	90	350	390
Age of Vehicle(Year)	P	2	1.33	2	2	2
	UNP	2	1.33	2	2	2
Useful Life of Vehicle(Year)	P	4.5	3.5	3.5	5.0	6.0
	UNP	3.0	2.0	2.0	3.0	4.0
Average Annual Milage (km/year)		30,000	65,000	40,000	55,000	60,000
Wages (US$/year)		-	1,500	1,800	2,200	4,500
Taxes (US$/year)		76	309	426	1,182	1,547
Insurance (US$/year)	P	685	800	840	2,800	9,050
	UNP	856	1,000	1,050	3,500	11,315
Fuel(US$/Gallon)	DF	1.59	1.59	1.59	1.26	1.26
	DP	1.80	1.80	1.80	1.50	1.50

DF : Duty Free　　P : Paved Road
DP : Duty Paid　　UNP : Unpaved Road

6.3 Vehicle Operating Cost under Various Conditions

The VOC varies depend on the various road conditions. Based on the results of the inventory survey, and soil survey on the Project road and the future improvement plan, the following conditions were considered.

(1) Rise and fall : 10, 50, 70 m/km

(2) Horizontal curvature : 50 degrees/km

(3) Road width : 10 m

(4) Roughness : Paved road = 2,500, 3,750, 5,500 mm/km
Unpaved road = 4,500, 6,500, 9,000 mm/km

(5) Altitude : 500 m

(6) Moisture content : 15%

(7) Rut depth : 15 mm

(8) Looseness : 25 mm

Calculation of the VOC was made using the TRRL formula and the results are shown in Table 6.2. (Details of VOC calculation by the modified TRRL method are presented in Annex VI-1 and the results are shown in Annex VI-2 in detail) Since the horizontal alignment of the Project road will be improved on the relatively limited portions, the estimated effect of the curvature improvement on the VOC is small. Therefore, the calculation of the VOC both for with- and without-Project conditions was made in due consideration of the two variable components, Rise and Roughness.

The degrees of Rise and Fall for each road section were estimated on the basis of the results of the road inventory survey and planned profile of the Project road. The Roughness was also calculated using the TRRL formula/1 for each section and for each year of the economic life of the road up to the year of 2003.

/1: Roughness is given by the following formula.

For paved roads

$R = Ro + mN$

where N = number of accumulated millions of standard axles

Ro = initial roughness of the road

$m = 1.250/\text{antilog}_{10}(a^{1/3} - b^{1/3} - 1.3841)$

$a = \sqrt{0.20209 + 23.1318 C^2} - 4.8096C$

$b = \sqrt{0.20209 + 23.1318C^2} + 4.8096C$

c = 2.1989 - SN (modified structural number)

For unpaved roads

$R = 3.250 + 84T - 1.62T^2 + 0.016T^3$

where T = number of accumulated thousands of standard axles

Table 6.2 Vehicle Operating Cost

(USCent/km)

Type of Vehicle	Road Condition	Paved Road Rise and Fall(m/km) 10	50	70	Unpaved Road Rise and Fall(m/km) 10	50	70
Passenger Car	G	13.80	14.33	14.65	20.14	20.78	21.15
	F	15.91	16.44	16.76	23.57	24.27	24.62
	P	18.90	19.43	19.75	29.10	29.79	30.18
Taxi	G	11.30	11.83	12.15	15.10	16.44	16.11
	F	12.38	12.91	13.23	17.03	17.70	18.08
	P	13.98	14.51	14.83	23.63	24.32	24.71
Pick-up	G	19.92	21.11	21.98	26.99	28.52	29.59
	F	22.05	23.44	24.31	30.88	32.55	33.54
	P	25.36	26.75	27.62	38.24	39.97	40.99
M-Truck	G	35.92	40.05	42.70	47.15	49.80	51.56
	F	39.10	43.23	45.88	52.94	55.64	57.49
	P	44.51	48.64	51.29	63.42	66.21	68.17
H-Truck	G	72.04	74.86	76.65	95.30	98.12	99.79
	F	79.35	82.17	83.96	107.79	110.67	112.35
	P	90.20	93.02	94.81	126.98	129.87	131.67

Paved Road : G = Good (Roughness = 2,500 mm/km)
F = Fair (R = 3,750 mm/km)
P = Poor (R = 5,500 mm/km)

Unpaved Road : G = Good (R = 4,500 mm/km)
F = Fair (R = 6,500 mm/km)
P = Poor (R = 9,000 mm/km)

〔VII〕

ENGINEERING STUDIES

VII. ENGINEERING STUDIES

7.1 Road Sections

In view of practical implementation and for the purpose of the alternative study, the whole section of the road was divided into five sections taking into account the projected future traffic volumes as shown in Fig. 7.1. The traffic volumes on the five sections were obtained as shown in Table 7.1 on the basis of the result of traffic forecast presented in Chapter V.

7.2 Road Inventory

7.2.1 General

The first portion of the existing road between Gbarnga and St. Paul River was constructed in 1954, the second portion between St. Paul River and Foya was completed in 1958, and the last portion between Foya and Mendikoma is considered to have been completed thereafter. Since then, the laterite pavement has been well maintained by Bong and Lofa maintenance offices.

According to the available drawings prepared by the MPW engineers, the design standard of the road is as follows: pavement width is 6.0 m (20 ft.); maximum gradient is 10%; and design speed is about 50 km/h. The total running time from Gbarnga to Mendikoma totalling about 275 km is about six to eight hours.

Special characteristic of the existing road comes from the laterite soil, a typical soil found in tropical areas. For considering the improvement plan, the following general characteristics of the laterite soil are to be fully taken into account:

1) It is very hard in dry season and fairly stable even in wet season.

Fig.7.1 Road Section

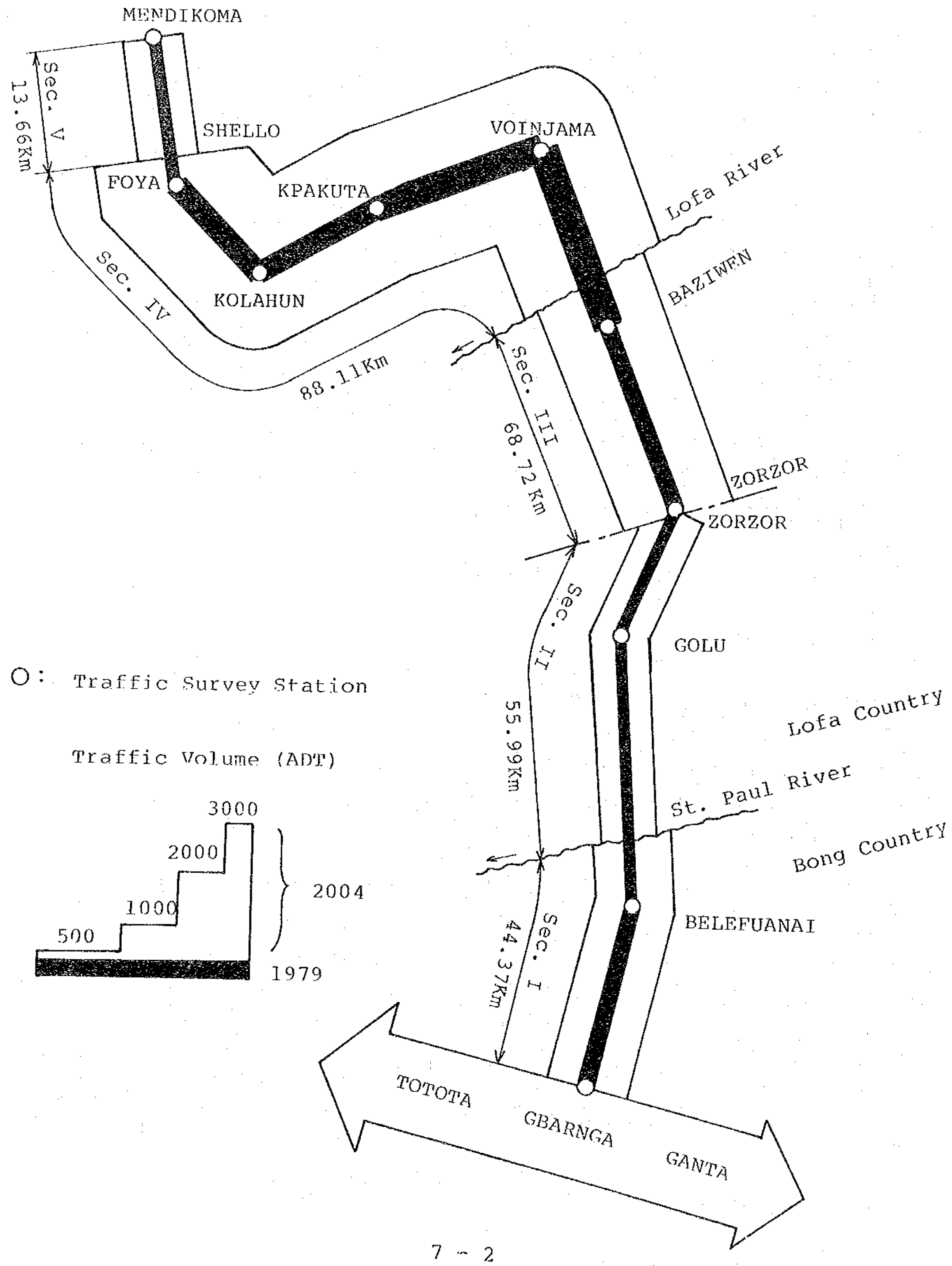


Table 7.1 Traffic Volume by Road Section

(vehicle/day)

Road Section		Normal Future Traffic Volume				Generated Traffic Volume			Total Traffic Volume			
		1979	1984	1994	2004	1984	1994	2004	1979	1984	1994	2004
I. Gbarnga - St. Paul River	Car	48	60	128	237	13	26	43	48	73	154	280
	Taxi	26	35	76	147	7	14	23	26	42	90	170
	Pick-up	165	196	421	787	37	77	125	165	233	498	912
	Truck	56	56	108	193	16	34	55	56	72	142	248
	Total	295	347	733	1364	73	151	246	295	420	884	1610
II. St. Paul River - Zorzor	Car	37	43	94	175	9	20	32	37	52	114	207
	Taxi	24	30	66	129	6	12	20	24	36	78	149
	Pick-up	109	113	254	486	21	43	70	109	134	297	556
	Truck	54	52	103	184	16	32	52	54	68	135	236
	Total	224	238	517	974	52	107	174	224	290	624	1148
III. Zorzor - Lofa River	Car	57	73	153	277	15	31	51	57	88	184	328
	Taxi	63	88	181	322	11	22	36	63	99	203	358
	Pick-up	206	261	557	1033	49	102	167	206	310	659	1200
	Truck	78	87	173	305	26	54	88	78	113	227	393
	Total	404	509	1064	1937	101	209	342	404	610	1283	2279
IV. Lofa River - Shello	Car	67	96	195	352	20	41	68	67	116	236	420
	Taxi	63	91	209	332	19	40	65	63	110	249	397
	Pick-up	275	403	824	1476	76	157	256	275	479	981	1732
	Truck	66	93	184	328	28	58	94	66	121	242	422
	Total	471	683	1412	2488	143	296	483	471	826	1708	2971
V. Shello -Mendikoma	Car	17	23	40	70	5	10	16	17	28	50	86
	Taxi	45	59	106	183	12	25	41	45	71	131	224
	Pick-up	140	188	333	570	36	74	121	140	224	407	691
	Truck	23	33	70	119	10	21	34	23	43	91	153
	Total	225	303	549	942	63	130	212	225	366	679	1154

Note : Traffic by road section was estimated by calculating weighed average of the distance.

2) Trafficability of the laterite road is influenced mainly by the characteristics of other soils such as clay, silt, sand and gravel.

Road inventory survey was conducted during the field investigation starting from late June, 1979, the results of which are summarized in Annex VII-1 and explained briefly hereunder. (Detailes of the road inventory are presented in Appendix).

7.2.2 Road Surface

General conditions on the road surface are explained hereunder.

Section I. Gbarnga - St. Paul River

The road surface was fairly good in the dry season all through the stretches. Many pot holes were, however, shaped and the surface on the shoulder became very slippery during the heavy rain season.

Section II. St. Paul River - Zorzor

In the whole sections throughout Gbarnga to Mendikoma, this stretch is relatively stable and reliable from the view point of the road surface condition because the gravel laterite is well spread on the road.

Section III. Zorzor - Lofa River

In this stretch, in addition to the poor alignment, many portions are covered by the clay laterite, which affects trafficability and sometimes stop the traffic after continous rainy days. On the other hand, drivers and users suffer from uncomfortable shock by bumpy surface and dust cloud during dry season and even in the wet season when fair weather continues for several days.

Section IV. Lofa River - Shello

The road surface of Lofa river - Voinjama stretch is comparatively well maintained in spite of many traffic. The road surface starting from Voinjama to Kolahun is comparatively good, but in the next stretch from Kolahun to Shello, the laterite contains much clay soil, and many pot holes were found on the road surface caused by rain water, but still its trafficability was fairly maintained.

Section V. Shello - Mendikoma

The last portion of the road from Shello to Mendikoma is narrow in road width, but the road surface is fairly maintained.

7.2.2 Horizontal and Vertical Alignments

According to the result of the surveys, it was found that improvement in the vertical alignment is considered to be more urgently required than in the horizontal alignment. The road stretches with the gradient of more than 5% are 251 points on the Project road. About 21 stretches of the road are of the steep gradients with more than 9%. The road stretches with steep gradients by section are summarized as follows:

Table 7.2 Road Gradient (Points)

Section	5% < G ≦ 7%	7% < G ≦ 9%	9% < G
Section I	22	2	0
Section II	49	21	4
Section III	43	27	8
Section IV	35	27	9
Section V	3	1	0
T o t a l	152	78	21

Compared with the vertical alignment, the condition of horizontal alignment is relatively fair. But there still exist about 122 places with steep curvature of less than 250 m on all the road stretch. About 28 road stretches are with steep curvature of less than 150 m. The number of the points with relatively steep curvature on the Project road is summarized in the following table.

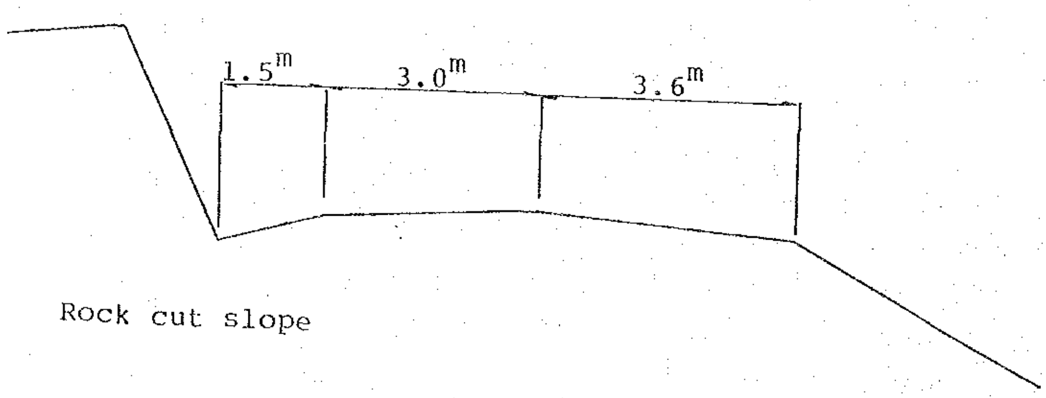
Table 7.3 Road Curvature (Points)

Section	R≤150	150<R≤250	250<R<400
Section I	0	9	38
Section II	6	21	66
Section III	18	38	80
Section IV	4	26	74
Section V	0	0	7
Total	28	94	265

7.2.3 Cross Section

On the basis of the cross section survey, typical cross sections of the road are shown below. The effective carriage way of the road from Gbarnga to Kolahun is 7-12 m wide. The carriage way width is, in general, relatively wider on the embankment portion but becomes narrower on the cutting section. From Kolahun the carriage way becomes narrower, particularly on the section between Foya and Mendikoma with the effective width of 5.5-6.5 m.

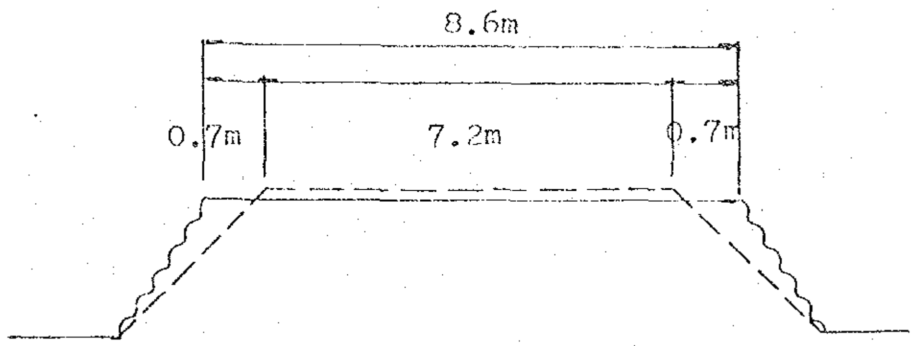
Typical Cross Section of Existing Road



A predominant feature of the Project road is that the width of the carriage way on the embankment portion was enlarged as shown below.

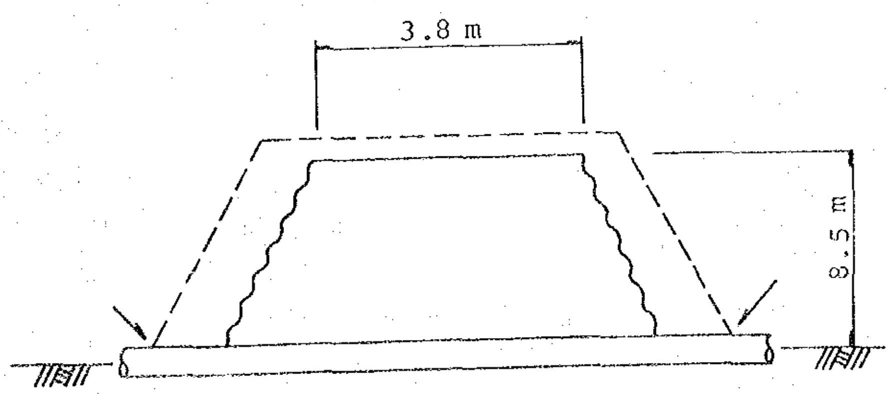
Originally, the slope of the embankment was designed and constructed with sufficient safety. The road has become wider by about 1.4 m and the slope of the embankment has become steeper due to regular maintenance works of the road surface.

Widened Embankment Section



Erosion of the embankment was found only on limited portions of the road. Particularly, the high embankment portions near St. Paul River Bridge was extremely eroded mainly due to heavy rain and the width of the carriage way was shrunk to about 3.8 m, which was insufficient for two lane traffic as illustrated below.

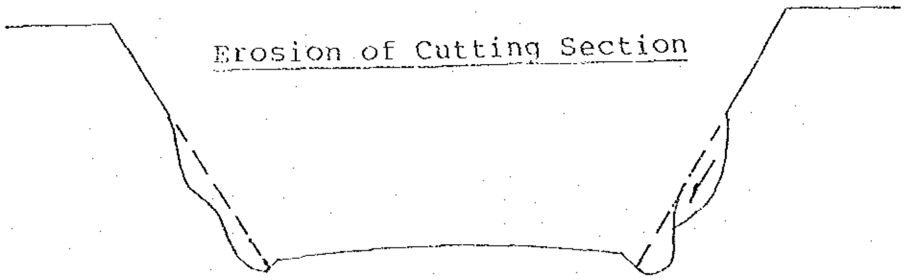
Eroded Embankment Section



At the original embankment edge of the culvert, trace of serious erosion was identified. For the improvement of the road, such characteristics of erosion has to be fully taken into account.

On many portion of the cutting section, erosion of the cutting slope was found as illustrated below.

Erosion of Cutting Section



This was caused by the erosion of the side ditch. Such erosions were identified at 73 places on the cutting slopes of the Project road as given below:

Gbarnga - Zorzor	6	points
Zorzor - Voinjama	31	"
Voinjama- Mendikoma	36	"

For the improvement, the cutting section is to be widened by bench cut shape with about 0.7 m wide step on the foot of slope.

7.3 Bridges and Drainage Structures

In Liberia, bridges are basically of concrete structure. The reason for this is that 1) all the steel materials are imported and steel bridges are very costly, 2) concrete materials are easily available, and 3) long span is not required, because there is no deep valley and no earthquake.

In Liberia, super structure of concrete bridges are being standardized on the basis of the length of the span as given below, and substructures are free from horizontal force from earthquake.

Length of Span	Type of Bridge
Less than 30 ft	Slab bridge
40 ~ 70 ft	T-beam bridge
80 ~ 100 ft	Box-girder bridge

The strength of concrete structure of the existing bridges was measured on the basis of Schmidt Hammer and the results are summarized below:

Concrete Structure	Compression Strength (kg/cm^2)
Slab	380 - 460
Beam	400 - 560
Deck	320 - 360
Pier	260 - 280
Abutment	380 - 600
Wing	300 - 360

From the field inspection, no brittleness phenomenon was found on the surface of concrete structure, and it is judged that the strength of the concrete has been increased as time has proceeded. The bridge inventories are presented in Annex VII-2 and the conditions of bridge and drainage structures are briefly described as follows:

Gbarnga-Zorzor

There are eleven existing bridges from Gbarnga to Zorzor. two bridges (Mem Creek and St. Paul River) are of steel structure, and other nine bridges are of concrete structure. There are no problems for the bridges from the structural and hydrological viewpoints. /1

/1: Hydrological analysis is presented in Appendix.

Box and pipe culverts were checked and the function was analyzed. They were fairly well maintained except that the maintenance of the slab surface concrete was requred for the first bridge located at 28.7 km from Gbarnga.

Zorzor-Voinjama

There are fourteen bridges of concrete structure from Zorzor to Voinjama. Five of them are longer than 45 m; the longest one is the Lofa River Bridge of 93.2 m length; the second is the Loma River Bridge of 68.4 m length; and other river bridges are of 49.95 m, 49.10 m, and 47.6 m length. From the field survey and hydrological analysis it was judged that all the bridges have enough clearance.

Most of the pipe culverts found on this section are located under the existing ground level but drainage function was not poor.

Voinjama-Mendikoma

In Voinjama-Mendikoma, there exist four bridges. The largest bridge is located near Mendikoma of 43.85 m length. The structural condition of these bridges were good.

Besides, boxes and pipe culverts are found, which were well maintained and their function was good.

As a result of the field survey and the hydrological analysis, it was confirmed that the existing bridges are in good condition as described in above, and judged that replacement is not necessary for coming 20 years.

7.4 Soils and Aggregate

7.4.1 Soil Sampling and Test

Soil samples /1 were taken from thirty points along the existing road in such a manner that at least one soil sample is to be picked up from the road stretch of about 9 km.

/1: Regarding the sampling method, more detailed discription was made in Appendix.

Main object of the soil sampling and test is to confirm the reliability of the laterite soil as the embankment body.

Soil samples were brought to the Soil Laboratory of the Ministry of Public Works, Liberia, where soil tests were made for eight test items. All the tests were carried out in accordance with the AASHTO standard, except the CBR test for subgrade which was tested according to the JIS A1211,/1 a modified or simplified method of the AASHTO CBR test.

From the results of the laboratory tests it is judged that the CBR value of the sub-grade or top of the embankment is at least 4 to 11. This indicates that the construction of the sub-grade will be made satisfactorily by using the laterite soil.

The list of the soil samples and laboratory tests, and the summary results of the test are shown in Annex VII-3. (Details of the soil sampling and the test results are presented in Appendix).

7.4.2 Road Surface Test

In order to understand the existing road surface, the road surface test was conducted in the field. The test items and the survey points are as presented below.

1)	Field CBR test	16 Points
2)	Road surface deflection test	16 "
3)	Sounding test	16 "

For the test of items 1) and 2), a heavy truck fully loaded with laterite soil of 5.2 tons with tyre air pressure of 60 kg/cm^2 was used as the test load. The field CBR test was conducted in accordance with AASHTO standard, while the deflection test was carried out by using the Benkelman Beam. Sounding test was also conducted by using a special equipment designed by the Road Research Laboratory of the Ministry of Construction, Japan.

/1: Japan Industrial Standard
These results are converted to soil support value and applied for pavement design.

The results of the field road surface test are also listed in Annex VII-3.

The recorded field CBR value shows a high value ranging from 15.4 to 108.0 with an approximate average of 47.0, which seems to be of very high value if considered that the test was carried out in the rainy season. The maximum deflections of the road surface recorded were less than 2.5 mm in Gbarnga-Voinjama stretch, and less than 4.5 mm in Voinjama-Mendikoma stretch. Besides, the thickness of laterite pavement as support layer was checked and confirmed to be about 20 cm by the sounding test. Through this test and analysis for subgrade material it is judged that the laterite soil is good material for road body-embankment. (Details of the road surface test are also presented in Appendix.)

7.4.3 Aggregate Materials

The investigation of coarse aggregate for asphalt mixture was conducted and 10 quarry sites were identified. Location of the quarry sites as well as the estimated volumes are presented in Appendix.

Through the reconnaissance, it was found that most of them belong to igneous group characterized by the presence of quartz and feldspar, and classified as granite or syenite. These igneous group rocks are considered as fair to good for the bituminous mixture. All the proposed sites have no problem for the right of way, reserve volumes, and the access road to the sites can be constructed rather economically.

Rock tests /1 on the quarry material taken from the proposed sites were carried out for the items of specific gravity and its moisture content by the Ministry of Public Works Laboratory. The value of specific gravity was 2.64 and 2.66, and the moisture content was 0.41% and 0.92%.

/1: Abrasion test was excluded, since it was judged that the quality of the rock is fairly suitable for the material of asphaltic mixture through the test exploration.

For the analysis of the gravelly laterite, CBR test was conducted for the blended sample materials (G-3' and V-9), which were taken from the investigated borrow pits. The result was presented in Fig. 7.2. As shown in the figure, the CBR value is 50 to 60 under the optimum condition or the dry condition although it is less than 10 under wet condition. Since gravelly soil with CBR value exceeding 30 is considered as a good material for sub-base, the field performance is expected to be made satisfactorily if compacted in dry season.

On the other hand, characteristics and practical applicability of the gravelly laterite were preliminarily analized in accordance with AASHTO criteria. The following conditions are required to be met for using the soil aggregate as sub-base and base material by AASHTO./1

Consistency:

- *Liquid limit* 25
- Plasticity index 6

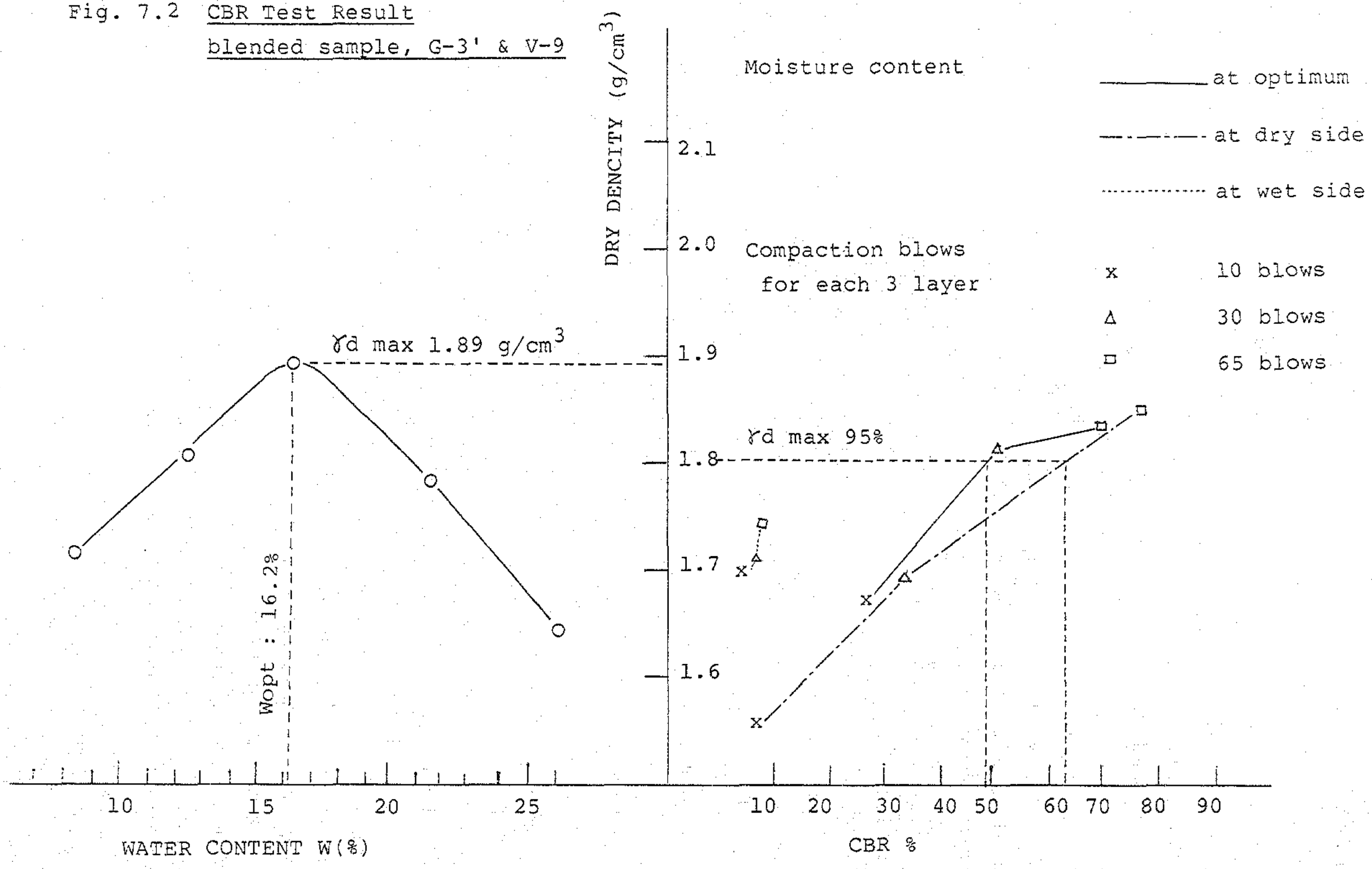
Grading:

- within the group of A, B, C, D, E and F
  (For using as the surface course, Grading A and B are excluded.)

By comparing the test results with these criteria it is found that most of the samples are classified as bad or poor for the materials of sub-base and base except the sample G-4 although around one third of the samples meet only the grading requirement. The result suggests that the laterite in the Project area is better to be mechanically treated using crushed stone or chemically treated for using as sub-base and base materials. Application of the chemically treatment is discussed in more detail in Annex VII-4.

/1: AASHTO M 147-65.

Fig. 7.2 CBR Test Result
blended sample, G-3' & V-9



From the results of the studies mentioned above, the following conclusive remarks are made for the course aggrigate.

1) It can be possible that the gravelly laterite in the natural condition be applied only for the sub-base course if carefully selected excluding fine and clayly soils.

2) Selected laterite soils are, in general, not suitable for pavement course, but if stabilized mechanically or chemically they can be used as sub-base and base materials.

3) Crushed aggregate are to be applied not only for the wearing or surface course but also for base and sub-base course as a stable material.

Alternative plans for the pavement structure are formulated in due consideration of the above each idea and the availability of the aggregate.

7.5 Design Ständards

7.5.1 Basis of Design Standards

In Liberia, there is no specific standard for road design. All roads have been designed basically referring to the design standard of AASHTO.

In case of asphalt paved road, MPW has been using the following design standard.

Design speed	72 km/h (45 mph)
Minimum curvature	360 m
Maximum gradient	7.0%
Minimum sight distance	90 m
Bridge design load	HT-20
Pavement structure	Bituminous 3.75-7.5 cm, pavement on 40-50 cm laterite base

In deciddingdesign standard of the Project road, various factors were carefully studied mainly on the basis of the above standard and referring to the ASSHTO's standard.

7.5.2 Design Speed

The Project road is the main road linking interior hilly regions to the Great Monrovia. The Project road, one of international roads connecting neighboring countries, is considered to be a primary road. The design speed of the primary road in Liberia is standardized to be 80-110 km/h in flat region, 55-80 km/h in hilly region, and 40-60 km/h in mountainous region.

According to the field survey, it was found that the most part of the road belong to hilly region except the mountaineous region extending 40 km of the stretch between Konia-Lofa.

In due consideration of the topographic characteristics and the applied design standard in Liberia, design speed is basically proposed to be 80 km/h. For determining the design speed on the stretch of Konia-Lofa, comparative study was made between the different design speeds of 80 km/h and 60 km/h. The result of the comparison justifies the application of 60 km/h for the design speed on the limited section. (Details of the comparison are presented in Annex VII-5.)

7.5.3 Sight Distance

Sight distance is expressed by stopping sight distance and is calculated by the following formula:

$$D = \frac{V}{3.6}t + \frac{V^2}{2gf \times (3.6)^2}$$

where,
- D: Stopping sight distance (m)
- V: Running speed (km/h)
- f: Coefficient of longitudinal friction between tyre and road way
- t: Reaction time of driver to push brake
- g: Acceleration due to gravity

The reaction time (t) changes case by case, but t=2.5 sec is applied following to the AASHTO. Substituting these values in the above formula the following is obtained:

$$D = 0.694V + 0.00394 \times \frac{V^2}{f}$$

Coefficient of longitudinal sliding friction (f) varies according to the condition of tyre, road surface, brake humid condition, etc. However, the following figures are applied in the case.

Sight Distance

Design Speed (km/h)	Running Speed (km/h)	f	0.694 V	$0.0039 \frac{V^2}{f}$	D (m)
80	68	0.31	47.1	58.7	105.8
60	54	0.33	27.4	34.8	72.2

On the basis of the above result, the proposed stopping sight distance is calculated at 110 m at design speed 80 km/h and 75 m at design speed 60 km/h.

7.5.4 Minimum Curvature

The minimum curvature is decided by the design speed and is determined by the following formula:

$$R = \frac{V^2}{127\ (f' + i)}$$

where,
- R: Minimum curvature
- V: Design speed
- f': Coefficient of horizontal sliding friction between tyre and road surface
- i: Slope of road surface

In case of asphalt paved road, the value of (f') is 0.4-0.8 for dry surface road and 0.2-0.3 for wet surface road. The relation between design speed and (f') established in international standards such as AASHTO, RAL and JRC is shown in Fig. 7.3. In this case, the value of (f') is assumed at 0.12 when design speed 80 km/h and 0.13 at design speed 60 km/h.

The value of (i) is assumed to be 8% in case of asphalt paved curve portion and maximum joint slope is assumed to be 10%.

Substituting the values of (f') and (i) in the above formula, the value of R is calculated as given below:

When design speed is 80 km/h

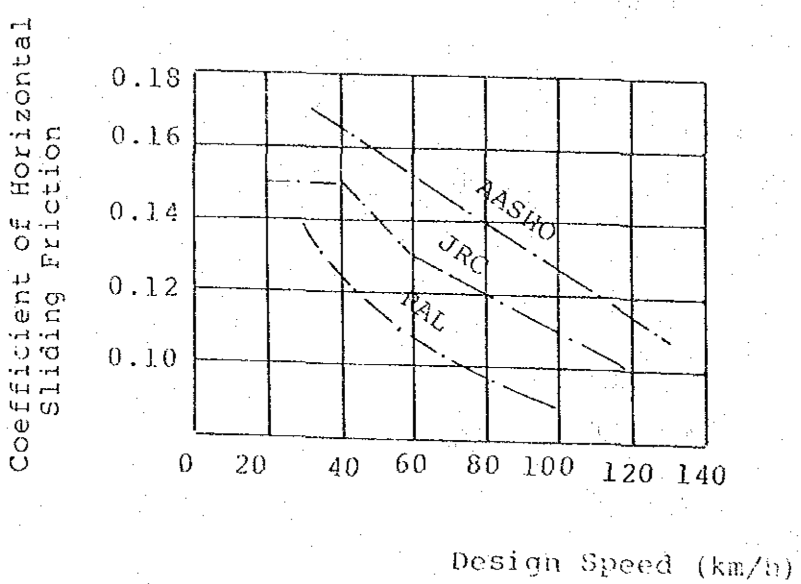
$$R = \frac{80^2}{127\ (0.12 + 0.08)} = 252\ m$$

When design speed is 60 km/h

$$R = \frac{60^2}{127\ (0.13 + 0.10)} = 135\ m$$

From the above result, the value of minimum curvature (R) is proposed at 250 m when design speed is 80 km/h and 140 m when design speed is 60 km/h.

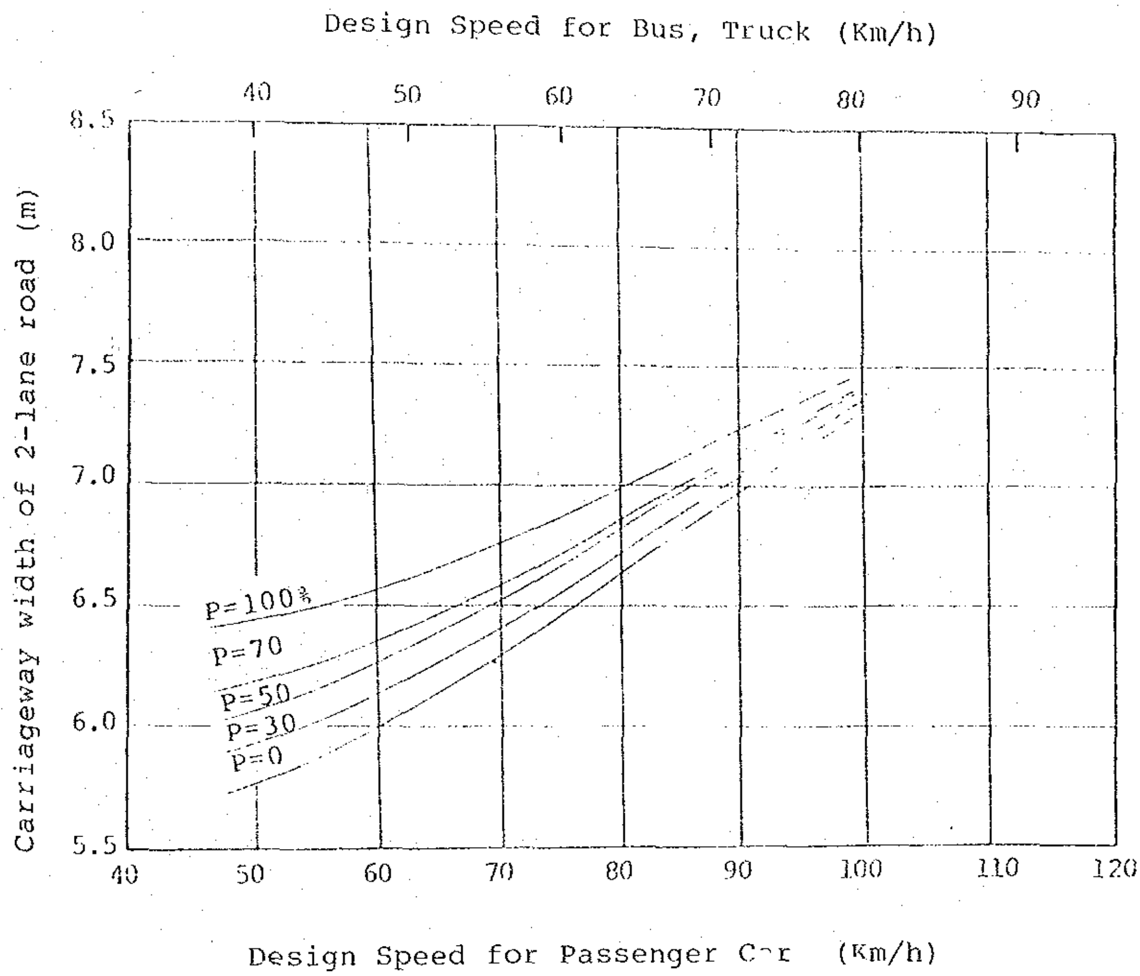
Fig. 7.3 Speed & Road Friction



7.5.5 Road Width

According to the design standard applied in Liberia, width of asphalt paved road is 7.8 m, which is considered to include shoulder width of 1.5 - 2.0 m. In the AASHTO

Fig. 7.4 Minimum Carriageway Width of 2-Lane Road Determined by Operating Experiments



Source: Japan Road Design Standard

P : Sharing rate of the total of buses and truck in ADT (%)

This table was obtained by the running test in two direction-two lane road in Japan under the following conditions:

a) The running speed of each coming car should be kept to be constant.

b) The sharing rate (P%) of total buses and truck in ADT changes as the key parameter to estimate the necessary road width for drivers under the above restriction.

standard, road width is set at 6.0-6.5 m and 6.5-7.0 m for speeds 60 km/h and 80 km/h, respectively. On the basis of the above conditions and referring to the experience in Japan presented in Fig. 7.4, road width for the Project road is proposed as follows:

a) 7.0 m for speed 80 km/h

b) 6.5 m for speed 60 km/h

Present and forecasted traffic volume of the Project road is given in Table 7.1. The future traffic volume per hour of each section is estimated at 140-500 DHV (future design hourly volume in year 2004).

Considering basic traffic capacity for 2 lane and 2 direction road is 2,500 DHV, the above standard for road width is considered to be enough.

7.5.6 Superelevation of Cross Section

Generally, road cross slope is set at 1.5-2.0% for paved road. In case of the proposed road, superelevation for drainage is proposed to be 3% in order to let drain water pass smoothly to the side earth ditch, the slope of which will be kept at less than 5% to stop the erosions of ditch beds.

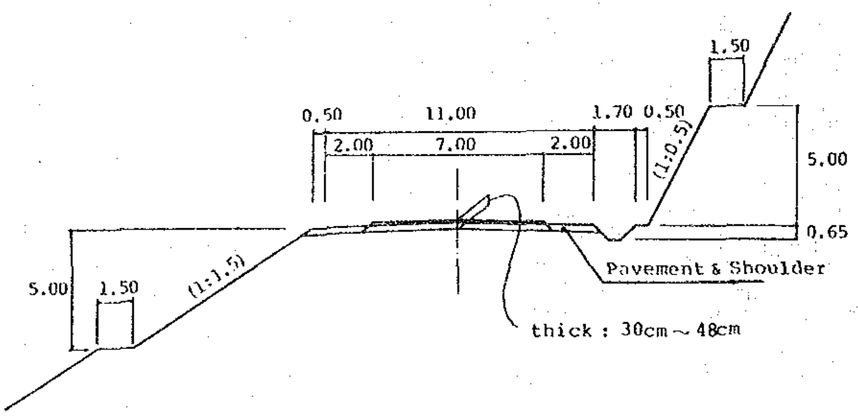
On the basis of the studies mentioned in the preceding sections, the proposed design standard for the Gbanga-Mendikoma Highway Project is determined and summarized in Table 7.4. Proposed typical cross sectoins are presented in Fig. 7.5.

Table 7.4 Proposed Design Standard

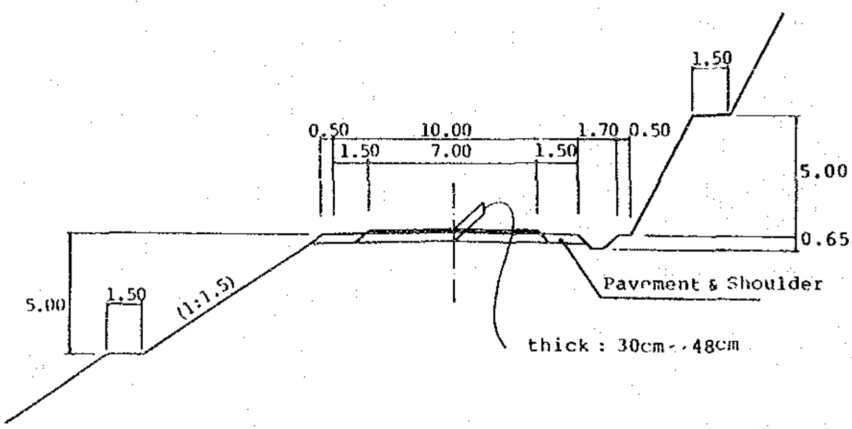
	Design Feature	Hilly Region	Mountainous Region
1.	Design speed (km/h)	80	60
2.	Pavement width (m)	7.00	6.50
3.	Shoulder width (m)	2.00-1.50	1.75
4.	Right-of-way (m)	50.00	50.00
5.	Stopping sight distance (m)	110.00	75.00
6.	Minimum radius of horizontal curves (m)	250.00	140.00
7.	Minimum radius of vertical curves (m)	75.00	50.00
8.	Maximum vertical grade	7%	8%
9.	Minimum coefficient of vertical curves:		
	K (crest)	2,900 m	1,400 m
	K (sag)	2,400 m	1,000 m
10.	Minimum coefficient of horizontal curves:		
	K (crest)	2,900 m	1,400 m
	K (sag)	2,400 m	1,000 m
11.	Combined grade	10.5%	10.5%
12.	Road drainage grade	3.0%	3.0%
13.	Shoulder horizontal grade	4.0%	4.0%

Fig. 7.5 Proposed Typical Cross Sections

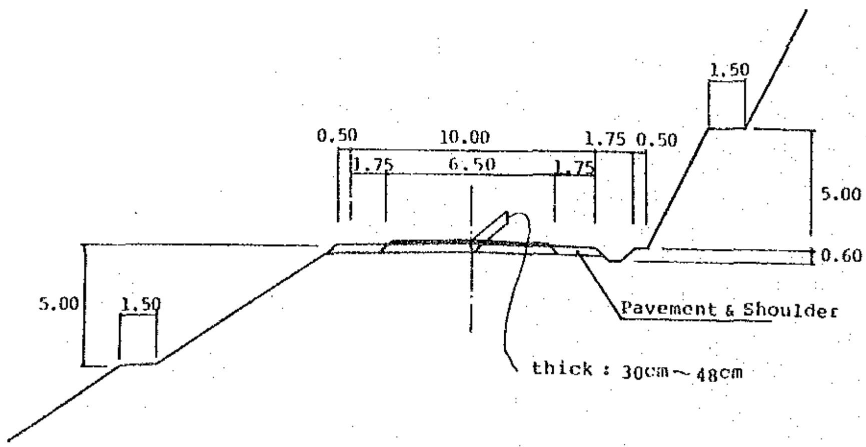
Design Speed 80 km/n (Lofa River - Voinjama - Shello)



Design Speed 80 km/n (Gbarnga-Konia, Shello - Mendikoma)



Design Speed 60 km/n (Konia-Lofa River)



7.6 Preliminary Design

Preliminary design of the proposed road was made based on the design standard explained in the preceding section.

7.6.1 Plan and Profile

Improved plan and profile were prepared in accordance with the proposed design standard, which are presented in Appendix. Horizontal alignment is to be improved with the following number of curved portions.

Section	No. of Portions to be Improved
Section I	7
Section II	26
Section III	51
Section IV	24
Section V	(No change.)
Total	108 portions

The portions with the gradient of more than 7% for the design section of 80Km/h and more than 8% for the design section of 60Km/h are to be improved. Accordingly, most of the vertical alignment on the residual stretches will be improved to make it smooth line.

As the result of improvement, the length of the road will become about 271Km as presented below.

(Km)

Section	Road Length	
	Improved	Present
I	44.4	44.5
II	56.0	56.5
III	68.7	69.0
IV	88.1	91.1
V	13.7	13.7
Total	270.9	274.8

7 6.2 Earthwork

The embankment height was determined taking into consideration such factors as topographic conditions, flood conditions and drainage structures. It is designed that the maximum embankment height is around 10m in due consideration of continuous heavy rain in the Project area. In the portion where the height of the embankment is more than 5m, a step or terrace with 1.5m of the width is to be provided on the embankment to keep it stable. Proposed slope of the embankment is designed at 1.5:1.0. Since it is found that the laterite soils are suitable for the road body, the laterite soils along road are planned to be used as the embankment materials.

Cutting was planned to improve mainly at the steep or undulated portion of the existing vertical alignment. Steep cut slope is proposed in view of the characteristics of the laterite soil and to protect it from erosion caused by the heavy rain. The slope of the cutting section is designed at 0.5:1.0. For protecting the cutting section from the erosion, a terrace is designed at the place where height of the slope exceeds 5m.

7.6.3 Pavement Design

For selecting the optimum pavement design of the Project road, such local conditions as climatic condition and available pavement materials are fully taken into consideration, and the following three design methods were comparatively studied.

1) AASHTO, Interim Guide for Design of Pavement structure.

2) US Asphalt Institute Method in "Thickness Design Asphalt Pavement Structures for Highway and Street".

3) UNESCO, Pavement Design Method

In addition, Pavement Design Guide of Japan Highway Institute was reviewed only for referrence. Through the comparative study, AASHTO method was selected to be applied since regional or local factors can be incorporated and suitable design thickness can be given in the method.

In order to determine the most optimum pavement design alternative plans were formulated for surface course, base course and sub-base course as presented in Table 7.5.

Alternative A emphasizes the structural safety and Alternative B, C and D consider the use of local materials (laterite) as much as possible. Initial construction cost is planned to be kept minimum in the alternative D.

Comparison and selection of the optimum pavement design for the Project road were conducted under the following procedure.

1) Estimate of Total Axle Load/1

For the estimate of the axle load on the Project road, average equivalent factor for one truck against the standard one with the axle load of 8.2 tons was calculated by using the cargo loading ratio/2 and average truck weight data/3. The estimated average equivalent factor for one truck is 0.80.

Then, average one-lane annual traffic volume of the truck was calculated over the design years. By multiplying the average equivalent factor of 0.8 to the average annual traffic volume, average equivalent traffic volume was calculated.

/1: Details of the calculation are presented in Annex VII-6.
/2: Estimated from O-D Survey
/3: Obtained from Automobile Guide Book.

Table 7.5 Alternative Plans for Pavement Structure

Surface & Wearing Courses	Base Courses	Sub-Base Courses
A. Hotmix asphalt concrete for 20 years design period	Bituminous treated crushed aggregate or Crushed aggregate	Crushed aggregate
B. Hotmix asphalt concrete for 10 years design period, overlayed every 10 year	Cement treated gravelly laterite with gradation adjustment	Gravelly laterite
C. Roadmix asphalt treatment for 10 years design period overlayed every 10 year	Cement treated gravelly laterite with gradation adjustment or Mechanically treated gravelly laterite	Mechanically treated gravelly laterite
D. Roadmix asphalt treatment for 5 years design period, overlayed every 5 year	Mechanically treated gravelly laterite or Cement treated gravelly laterite with gradation adjustment	Mechanically treated common laterite or Gravelly laterite

Total axle load was finally estimated by multiplying the expected design years and number of days per year to the calculated average equivalent traffic volume.

a) Soil Support Value (S)

Soil support value was estimated on the basis of the calculated design CBR value/1 of the sub-grade and correlation between the soil support value and CBR value. The estimated soil support value was presented in Annex VII-6.

b) Calculation of Structural Number (SN)

For deciding the thickness of the pavement, the structural Number (SN) of asphalt pavement was calculated for each section and for four different design years of the road on the basis of the total axle load and soil support value estimated above in due consideration of the regional factor. The estimated Structure Number (SN) was presented in Table VII.3 in Annex VII-6.

c) Pavement thickness

The pavement thickness for each alternative was calculated by using SN value as explained in Annex VII-6, which is summarized in Annex VII-7.

2) Selection of the Most Optimum Pavement Structures

For selecting the most optimum pavement structures for each section of the Project road, costs comparison/2 was conducted in terms of net present value discounted at 12%.

/1: The CBR value was estimated under the condition that soil samples were soaked for four days.

/2: Under the condition that the expected economic benefits are equal, the least cost alternative can be selected as the optimum plan.

The costs to be compared includes costs for the pavement structures, annual maintenance cost and vehicle operating cost./1 Through the net cost comparison/2, Alternative B was selected for all the road sections as summarized in the following table.

Cost Comparison of Alternative
Pavement Structure (Present Value/3)

	Section I	Section II	Section III	Section IV	Section V
Alternative A	19,639	20,846	40,133	66,832	4,970
Alternative B	16,854	17,514	35,814	57,567	4,199
Alternative C	17,570	17,517	37,419	60,434	4,369
Alternative D	17,641	17,987	38,319	61,825	4,361

7.6.4 Drainage Design

Drainage is one of the most important factors to keep the road all weather condition. For the evaluation of the existing drainage structures, hydrological analysis/4 was preliminarily made on the basis of the available data. Results of the Schmidt Hammer test were checked to evaluate the structural strength. Information on the past floods gained from neighbouring people was also used as the supplimental data for the evaluation.

Through this, all the existing bridges were found to be safe for flood with 100 year recurrence period and to have enough

/1 : Vehicle operating cost differs between the different pavement structures.

/2 : Details are presented in Annex VII-8.

/3 : Discounted at 12%.

/4 : Results of the analysis are presented in Appendix.

structural strength compared with the design loading of AASHTO H-20. In some portions the capacity of the drainage structures such as corrugated pipe and culvert box is not enough for discharging the flood water with 25 years and 50 years recurrence period, respectively. Number of the portions to be improved are summarized for each section as follows.

	Section	No. of Portions
Sec. I	Gbarnga — St. Paul River	6
Sec. II	St. Paul River — Zorzor	4
Sec. III	Zorzor — Lofa River	12
Sec. IV	Lofa River — Shello	6
Sec. V	Shello — Mendikoma	4
	Total	32

Besides the improvement of the existing structures, box culberts and corrugated pipe are additionally required for the stretch of realignment. Proposed structures for the Project are summarized below.

Type of Drainage structure	Cross Section (m)	Max. Discharge (m^3/sec)
Corrugate pipe	ø 1.00	1.40
do	ø 1.50	3.80
do	ø 1.50 x 2	7.60
Box culvert	3.00 x 3.00	21.47
do	(3.00x3.00)x2	42.94
do	4.00 x 4.00	46.22

7.7 Construction Work Quantities

Construction work quantities were calculated based on the information obtained during the field investigation including inventory survey and the preliminary design made in the preceding section. They are calculated by section with the following items, and are summarized in Table 7.6.

Site clearance

Earth works

1) Common road excavation
2) Rock road excavation
3) Borrow excavation
4) Waste excavation

Pavement works

1) Surface course
2) Base cource
3) Sub-Base course
4) Shoulder work

Drainage

1) Corrugated pipe
2) Culvert box
3) Side ditch

Miscellaneous works

Table 7.6 Construction Work Quantities

	Unit	Section I (44.4 km)	Section II (56.0 km)	Section III (68.7 km) A	B	Sub-total	Section IV (88.1 km) A	B	C	Sub-total	Section V (13.7 km)	Total
1. Site Clearance												
Clearing & Grubbing	ha.	38	54	30	42	72	22	42	19	83	12	259
2. Earth Works												
Common Rd. Excavation	m^3	490,000	600,000	220,000	320,000	540,000	150,000	730,000	400,000	1,280,000	100,000	3,010,000
Rock Rd. Excavation	m^3	0	9,000	0	20,000	20,000	0	0	0	0	0	29,000
Borrow Excavation	m^3	120,000	50,000	50,000	0	50,000	0	0	130,000	130,000	0	350,000
Waste Excavation	m^3	200,000	550,000	360,000	320,000	680,000	200,000	100,000	0	300,000	110,000	1,840,000
3. Pavement Structure												
Surface	m^2	311,000	392,000	197,000	264,000	461,000	165,000	312,000	140,000	617,000	96,000	1,877,000
Base	m^2	311,000	392,000	197,000	264,000	461,000	165,000	312,000	140,000	617,000	96,000	1,877,000
Sub-Base	m^2	233,000	294,000	148,000	198,000	346,000	124,000	234,000	105,000	463,000	72,000	1,408,000
Shoulder	m^3	47,000	59,000	36,000	61,000	97,000	43,000	82,000	37,000	162,000	13,000	378,000
4. Drainage Structure												
Corrugated Pipe ø1.0	m	295	170	130	150	280	45	125	45	215	35	1,195
Corrugated Pipe ø1.5	m	165	200	140	355	475	95	50	60	205	65	1,205
Corrugated Pipe ø2.0	m	30	25	35	30	65	15	80	10	105	-	300
Culvert Box 0.8 x 0.8	m	30	40	15	45	60	15	20	15	50	-	180
Culvert Box 3.0 x 3.0	m	50	40	20	35	55	25	110	5	40	-	200
Side Ditch	m	21,300	54,300	24,000	36,000	60,000	12,600	24,500	11,600	48,700	8,200	192,500
5. Miscellaneous												
Traffic Sign	No.	180	230	190	270	460	100	180	80	360	50	1,280
Road Marking	m	44,400	56,000	28,100	40,600	68,700	23,500	44,600	20,000	88,100	13,700	270,900
KM Post	No.	44	56	28	40	68	23	45	20	88	14	270
Guard Rail	m	4,400	5,100	2,000	2,800	4,800	2,200	4,100	1,800	8,100	1,100	23,500

Note: 1) Section III is divided into sub-section A(28.1 km) and B(40.6 km)
2) Section IV is divided into sub-section A(23.5 km), B(44.6 km) and C(20.0 km)

7.8 Construction Plan and Schedule

7.8.1 Construction Plan

To formulate the construction plan for the Project road the following assumptions or conditions are considered.

1) Construction work is to be conducted only during the dry period of 8 months (November to June) a year.

2) Whole the construction work is divided into 3 packages in due consideration of the work volumes together with the financial requirement.

3) During the construction, the existing traffic is to be kept on the Project road.

Under the consideration of the above factors, construction plan is made as follows.

1) Earthwork

For the embankment, the moisture of the laterite soil to be used shall be kept at around the optimum point from the results of the soil tests. For confirming this, the earth work is planned to be carried out only in the driest 6 months.

During the construction, the existing traffic is to be kept. The construction is, therefore, planned to be carried out half by half of the road. During the embankment of the first half, the traffic will use the other half, and upon completion of the embankment of the first half, the traffic will be led to the completed half and the embankment will proceed to the remaining half. In addition, the method of night time construction is also considered in some part for keeping the existing traffic.

As considerable amount of laterite soil will be used for the road embankment structure, study on the materials including soil support values is further to be made in more detail in accordance with the actual implementation plan.

2) Pavement Works

The pavement works are also to be conducted in dry season, since heavy rain will increase the water contents of sub-base and base course materials which cause difficulty in compaction. For executing the pavement works for each package, two sets of the asphalt plant with the capacity of about 60 tons per hour each and two road stabilizer with the capacity of 3,000m^2 per day each are planned to be installed or mobilized.

The most important work is construction of the cement stabilized base course which will be operated on the road for mixing the selected gravelly laterite and cement using the road stabilizer.

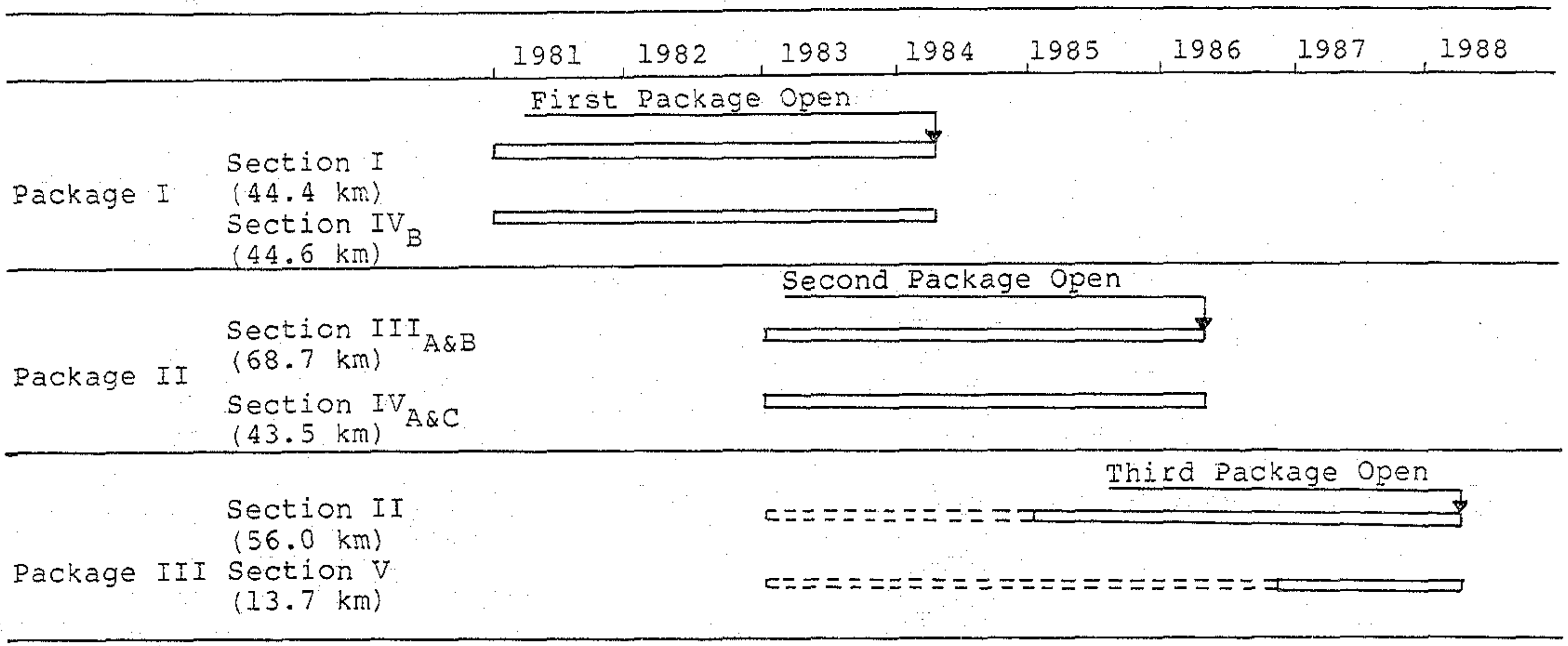
For the road section II and V, projected traffic for which is relatively small, improvement by seal coat is planned temporarily during the period between 1983 and the commencement of the proposed pavement works in order to materialize the expected benefit of the whole project at the earlier stage.

7.8.2 Construction Schedule

Whole the construction work is divided into 3 packages, each of which contains 2 construction sections. The size of these construction sections were determined in due consideration of the construction quantities. For the preparation of the schedule, the construction section with larger traffic volumes is planned to be implemented in the earlier stage and construction of each section can be completed in around three years except Section V.

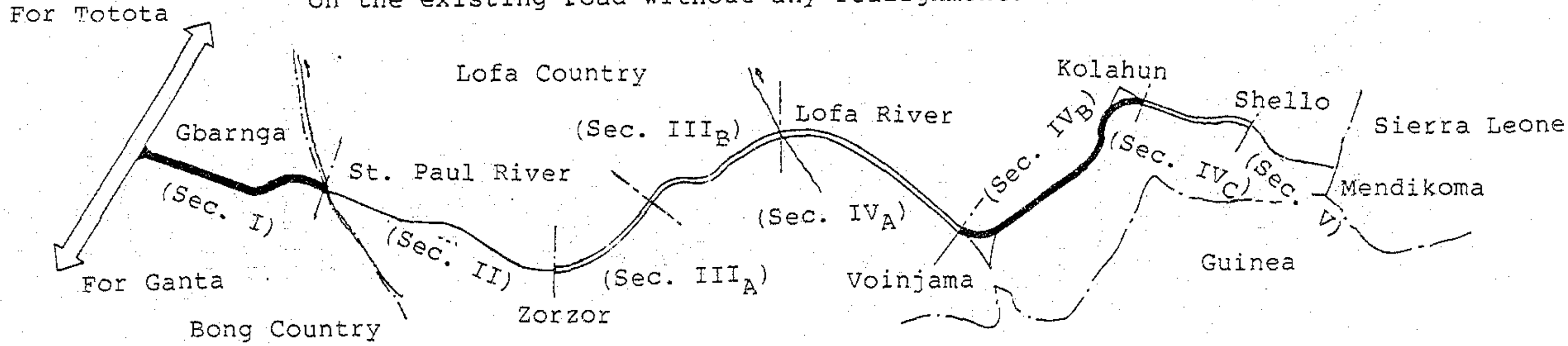
Tentative construction schedule for each package are presented in Fig. 7.6.

Fig. 7.6 Tentative Implementation Schedule



Note: During the period with dotted line, only seal coat will be provided on the existing road without any realignment.

Fig. 7.7



7.9 Cost Estimate

7.9.1 General

On the basis of the estimated work quantities and unit prices, construction cost was estimated under the following conditions and assumptions:

1) The construction works will be undertaken by contractor(s) selected by international competition.

2) The basic costs of materials and labours to be incorporated into unit prices of construction costs are as follows:

Material Cost	Rate(US$/ℓ)	Labour Cost	Rate(US$/h)
Bitumen	0.33	Engineer	6.25
Fuel	0.33	Foreman	1.10
Lubricant	1.36	Operator	0.78
Cement	70.00/t	Driver	0.66
		Labourer	0.47

3) Foreign currency component of the construction cost consists of the following:

a) Construction material: around 90% of the construction materials such as bitumen, fuel lubricant, cement, steel, corrugate drainage pipe and others are included in foreign portion.

b) Equipment and machinery: all the costs of construction equipment and machineries are included in foreign component, but for the maintenance costs five percent of them belong to local component.

c) Labour: some of the special machinery and plants are operated by foreign operators, and their costs are included in foreign currency component.

d) Engineering cost: detailed design and construction supervision are conducted by foreign engineers.

4) All the costs other than estimated in 3) are included in local components

5) Transportation cost of machinery and equipment is estimated as the mobilization cost.

6) The installation, dismantling and overhead costs of plants are included in related unit prices.

7) Physical contingency id estimated at 10 percent of the total cost excluding engineering services.

8) The cost for engineering services and the administrative cost are assumed at about 10 percent of the total cost.

9) All the cost estimation is based on late-1079 price level.

7.9.2 Construction Cost

On the basis of the above assumptions, the construction cost by section for the proposed plan was estimated by applying these unit prices to the estimated work quantities, the summary of the cost estimate is presented in Table 7.7 and 7.8. The estimated total construction cost is US$75.2 million which consists of US$59.6 million of the foreign currency portion and US$15.6 million of the local currency portion. Disbursement schedule of the construction cost is presented in Table 7.9. (Detailed cost estimate for each section is shown in Annex VII-9.)

7.9.3 Road Maintenance Cost

Road maintenance costs were calculated by using the following formula after compared with the actual disbursed cost in Lofa area./1

$$K = K_b\left(1 + \frac{T - T_b}{2\,T_b}\right) \quad /2$$

where,
- K: Maintenance cost (US$/km/year)
- K_b: Basic maintenance cost corresponding to T (US$/km/year)
- T: Present traffic (ADT)
- T_b: Basic traffic (ADT)

For the application of this formula, the basic maintenance cost is to be revised in accordance with the recent cost data. This adjustment was made by analyzing the cost components.

/1: Details of the comparison are presented in Annex VII-10.

/2: This formula was quoted from the final report on highway organization and maintenance study, Liberia 1976

The basic maintenance cost, thus calculated, for each pavement structure is as follows.

K_b for laterite roads : 950 US$/km/year
K_b for surface-treated road: 2,800 US$/km/year
K_b for asphalt concrete road: 3,600 US$/km/year

For the estimate of the maintenance cost, the basic traffics to be applied are assumed at 100 ADT for laterite surface road, 600 ADT for surface treated road and 1,000 ADT for asphalt concrete road.

Annual road maintenance costs of the Project road are calculated under the above conditions, the results of which are presented for the representative year below.

Annual Maintenance Cost of Hotmix Pavement Road

(T_b=1,000, K_b=3,600) (US$)

Year	Sec. I	Sec. II	Sec. III	Sec. IV	Sec. V
1984	160,200	203,400	248,400	327,960	49,320
1994	160,200	203,400	284,294	444,058	49,320
2003	201,532	211,638	394,335	625,092	51,613

Annual Maintenance Cost of Roadmix Pavement Road

(T_b=600, K_b=2,800) (US$)

Year	Sec. I	Sec. II	Sec. III	Sec. IV	Sec. V
1984	124,600	158,200	194,810	303,120	38,360
1994	154,089	160,364	304,129	490,604	40,885
2003	219,711	221,612	446,775	725,277	54,120

Table 7.7 Construction Cost of the Proposed Plan

(Unit: 10^3 US$)

WORK ITEMS	I			II			III			IV			V			GRAND TOTAL		
	F.	L.	TOTAL	F.	L.	TOTAL	F.	L.	TOTAL	F.	L.	TOTAL	F.	L.	TOTAL	F.	L.	TOTAL
1. Site Clearance	122	30	152	199	49	248	328	82	410	246	61	307	33	8	41	928	230	1,158
2. Earth Works																		
1) Common road excavation	2,058	637	2,695	2,640	780	3,420	2,214	648	2,862	5,632	1,664	7,296	450	130	580	12,994	3,859	16,853
2) Rock road excavation	0	0	0	59	17	76	126	38	164	0	0	0	0	0	0	185	55	240
3) Borrow excavation	708	204	912	270	80	350	275	85	360	819	247	1,066	0	0	0	2,072	616	2,688
4) Waste excavation	500	140	640	1,375	385	1,760	1,700	476	2,176	750	210	960	275	88	363	4,600	1,299	5,899
3. Pavement Structure																		
1) Surface course	1,524	342	1,866	1,882	392	2,274	2,213	461	2,674	2,900	617	3,517	490	105	595	9,009	1,917	10,926
2) Base course	1,057	249	1,306	1,529	313	1,842	1,798	369	2,167	2,838	617	3,455	355	77	432	7,577	1,625	9,202
3) Sub-Base course	536	116	652	764	177	941	1,280	277	1,557	1,528	324	1,852	137	29	166	4,245	923	5,168
4) Shoulder work	334	70	404	472	106	578	1,096	243	1,339	1,474	324	1,798	95	21	116	3,471	764	4,235
4. Drainage																		
1) Corrugated pipe	142	26	168	126	22	148	284	54	338	207	38	245	33	6	39	792	146	938
2) Culvert box	61	49	110	52	42	94	74	60	134	56	45	101	0	0	0	243	196	439
3) Side ditch	72	30	102	185	76	261	204	90	294	175	78	253	33	14	47	669	288	957
5. Miscellaneous Works	182	36	218	227	44	271	354	61	415	385	72	457	59	12	71	1,207	225	1,432
6. Mobilization	142	8	150	180	10	190	209	11	220	295	15	310	47	3	50	873	47	920
7. Right of Way	0	111	111	0	142	142	0	121	121	0	227	227	0	34	34	0	635	635
8. Contingency																		
1) Physical contingency	744	205	949	995	264	1,259	1,216	307	1,523	1,730	454	2,184	201	52	253	4,886	1,282	6,168
9. Engineering Service & Administrative Cost	893	245	1,138	1,195	316	1,511	1,459	369	1,828	2,077	544	2,621	243	63	306	5,867	1,537	7,404
10. Total	9,075	2,498	11,573	12,150	3,215	15,365	14,830	3,752	18,582	21,112	5,537	26,649	2,451	642	3,093	59,618	15,644	75,262

Note: F = Foreign currency portion
L = Local currency portion

Table 7.8 Construction Cost of the Proposed Plan

(Unit: 10^3 US$)

WORK ITEMS	Package I (I, IV-B)			Package II (III, IV-A, C)			Package III (II, V)		
	F.	L.	TOTAL	F.	L.	TOTAL	F.	L.	TOTAL
1. Site Clearance	246	61	307	451	111	562	231	58	289
2. Earth Works									
1) Common road excavation	5,270	1,586	6,856	4,634	1,363	5,997	3,090	910	4,000
2) Rock road excavation	0	0	0	126	38	164	59	17	76
3) Borrow excavation	708	204	912	1,094	332	1,426	270	80	350
4) Waste excavation	750	210	960	2,200	616	2,816	1,650	473	2,123
3. Pavement Structure									
1) Surface course	2,990	654	3,644	3,648	765	4,413	2,371	498	2,869
2) Base course	2,493	560	3,053	3,200	675	3,875	1,884	390	2,274
3) Sub-Base course	1,308	280	1,588	2,036	438	2,474	901	205	1,106
4) Shoulder work	1,080	234	1,314	1,824	403	2,227	567	127	694
4. Drainage									
1) Corrugated pipe	251	45	296	381	73	454	160	28	188
2) Culvert box	76	62	138	115	92	207	52	42	94
3) Side ditch	161	69	230	291	129	420	217	90	307
5. Miscellaneous Works	376	72	448	545	97	642	286	56	342
6. Mobilization	292	15	307	353	20	373	228	12	240
7. Right of Way	0	226	226	0	233	233	0	176	176
8. Contingency	1,600	428	2,028	2,089	538	2,627	1,197	316	1,513
9. Engineering Service & Administrative Cost	1,920	514	2,434	2,509	643	3,152	1,438	380	1,818
10. Total	19,521	5,220	24,741	25,496	6,566	32,062	14,601	3,858	18,459

Note: F = Foreign currency portion
L = Local currency portion

Table 7.9 Disbursement Schedule for the Project Cost (Financial Cost)

(US$1,000)

Year	Package I			Package II			Package III			Ground Total
	Section		Sub-Total	Section		Sub-Total	Section		Sub-Total	
	I	IVB		III	IVA&C		II	V		
1981	2,315	2,634	4,949 (3,904)							4,949 (3,904)
1982	3,472	3,951	7,423 (5,856)							7,423 (5,856)
1983	4,630	5,268	9,898 (7,808)	3,716	2,696	6,412 (5,099)				16,310 (12,907)
1984	1,157	1,317	2,474 (1,952)	5,574	4,044	9,618 (7,649)				12,042 (9,601)
1985				7,432	5,393	12,825 (10,198)	3,073		3,073 (2,430)	15,898 (12,628)
1986				1,858	1,348	3,206 (2,550)	4,610	309	4,919 (3,890)	8,125 (6,440)
1987							6,146	2,475	8,621 (6,821)	8,621 (6,821)
1988							1,537	309	1,846 (1,460)	1,846 (1,460)

Parentheses show foreign currency portion.

〔VIII〕

PROJECT EVALUATION

VIII. PROJECT EVALUATION

8.1 General

For the economic evaluation, economic Project costs and quantifiable benefits were estimated, based on which economic internal rate of return was calculated. Sensitivity analysis was also conducted to assess the economic viability of the Project under various assumptions.

In addition to the economic analysis, socio-economic impacts of the Project implementation such as impacts on regional economic development, improvement of health and education, etc. were studied and incorporated in the Project evaluation.

8.2 Economic Evaluation

8.2.1 Economic Costs

Economic construction cost is estimated by applying shadow wage rate for unskilled labourers to the estimated construction cost, which is assumed to be 50 percent of actual wage. The calculated economic construction cost is US$72.9 million.

The road maintenance costs estimated in Chapter VII were applied for the economic analysis as the economic cost.

8.2.2 Economic Benefits

For the calculation of the economic internal rate of return, the following quantifiable benefits were considered:

(1) Savings of road users' cost;

(2) Savings of road maintenance cost; and

(3) Dust stopping.

In addition to the above benefits, development benefit is expected from the increased agricultural production in the influence area under with-Project condition. However, this benefit was not directly estimated in view of the present situation of the Project area that the existing road has been functioning relatively well under good maintenance work, the alignment of which will not be changed basically in the Project, and the big scale agricultural development projects are already underway together with the feeder roads development. Instead, this expected agricultural development benefit was indirectly estimated and included in the future generated cargo traffic.

Reduction of the accident would also be an expected economic benefit of the Project, but which was excluded in this report since the available accident data were quite limited and the resulting estimation would have considerable uncertainty.

1) Saving of Road Users' Cost

Savings of road users' cost consist of the savings of vehicle operating cost and time cost, which are the major benefit attributable to the Project. The expected savings are estimated by calculating the difference of road users' cost between with Project and without Project conditions. For the calculation whole the savings are counted for the benefits for normal traffic, while one half of the savings for generated traffic.

a) Savings of Vehicle Operating Cost

Based on the estimated basic vehicle operating cost in Chapter VI, vehicle operating cost for each section and for each year of the economic life up to 2003 was calculated by type of vehicles both under with and without Project conditions.

The savings of vehicle operating cost is the difference between with and without Project conditions, and calculated in each section as summarized in Table 8.2.

b) Savings of Time Cost

Expected savings of travel time is evaluated as road users' benefit. For the evaluation, time value was measured at US$0.24 per hour on the basis of the per-capita GDP of US$480/1 in 1979 and assumed annual average working hours of 2,000 hours.

Using the estimated time value with the calculated occupancy ratio time value for each type of vehicle was calculated as presented below. In the calculation, time value for driver(s) is not included except for passenger car since it was already incorporated in the vehicle operating cost.

/1: Estimated on the following assumptions:
(1) GDP in 1979 is US$860 million at 1979 price.
(2) Population in Liberia is 1,790 thousand in 1979.

Type of Vehicle	Time Cost (US$/h)
P-Car	0.96
Taxi	1.20
Pick-up	2.40
M-Truck	0.48
H-Truck	0.48

On the basis of the estimated time value, average running speed and the road length, difference of travel time cost between with and without Project conditions was calculated for each road section as presented below.

Savings of Time Cost

(US$)

Road Section	Year 1984	1994	2003
I	43,174	91,681	159,000
II	36,665	80,290	141,263
III	93,004	195,962	335,501
IV	183,886	378,471	630,241
V	12,121	22,024	35,611
Total	368,850	758,428	1,301,616

2) Savings of Road Maintenance Cost

When the existing laterite surfaced road is improved, new maintenance system for paved road is employed. The maintenance cost on the present laterite road will be avoided after the Project be implemented. The avoided maintenance cost on the existing road is a benefit of the Project, which are summarized for each section as presented below.

Savings of Road Maintenance Cost

(US$)

Road Section	Year 1984	1994	2003
I	94,484	176,075	292,120
II	90,711	165,587	272,132
III	199,600	381,501	630,591
IV	338,824	654,280	1,060,609
V	26,225	42,234	64,554
Total	749,844	1,419,677	2,320,006

3) Dust Stopping

One of the most important effect of the road improvement will be the dust stopping on the Project road, which will benefit not only road users but also non-road users including the residents along the road.

The benefits from dust stopping were measured by the least cost alternative. The selected alternative is the prime coat spreading which will be required for the existing laterite without the Project. Such dust stopping costs were calculated on the basis of following assumptions:

a) Minimum road width for spreading of prime coat is 6.0 m.

b) For the whole section, spreading of prime coat will be made once a year after the rainy season.

The dust stopping costs to be saved by the Project were calculated and presented in the table below. However, this benefit was excluded in the basic analysis on the project economy and included in the sensitivity analysis.

Section	Cost (US$/year)
I	152,000
II	191,000
III	235,000
IV	301,000
V	47,000
Total	926,000

Note: Prime coat cost is 0.57 US$/$m^2$.

8.2.3 Economic Evaluation

Based on the economic costs and benefits, economic evaluation was made by calculating economic internal rate of return (EIRR) and benefit cost ratio (B/C Ratio) over the assumed economic project life of 20 years. Results of the calculation are presented in the following table. (Calculation sheets are presented in Annex VIII-1.)

Section	EIRR	B/C/1	First Year Rate of Return
I	15.4	1.3	11.9%
II	13.5	1.1	10.0
III	18.9	1.7	12.6
IV	21.8	2.1	14.6
V	12.1	1.0	10.7
Whole Project	18.9	1.6	10.0

/1: at the discount rate of 12%

The EIRRs for Package I, II and III are 18.8 %, 20.6 % and 13.3 %, respectively.

As indicated hereinabove, the Project is economically justifiable as a whole although the EIRRs of Section II and V are relatively low because of the low traffic volume.

Sensitivity of the EIRR was tested with respect to 15% increase in the construction cost, 15% reduction of the benefits, and under the condition that the dust stopping benefit is included in the Project benefit.

Results of the sensitivity analysis are presented in the following table.

Sensitivity Analysis (EIRR)

(%)

Section	Case I	Case II	Case III	Case IV
I	13.7	13.2	11.6	16.3
II	11.3	10.6	8.7	14.5
III	17.1	16.6	14.9	19.7
IV	19.8	19.4	17.6	22.4
V	9.7	8.9	6.9	13.7
Whole	17.0	16.5	14.7	19.7

Case I : Construction cost increase by 15%.

Case II : Project benefit reduces by 15%.

Case III: Construction cost increases by 15% and Project benefit reduces by 15%.

Case IV : Dust stopping benefit is included in the Project benefit.

The results show that increase in the construction cost affects the economic viability more than the benefit reduction, and the Project is economically viable even though under the condition of the cost increase by 15%. If the dust stopping benefit is included, the EIRR becomes a high rate of 19.7%.

Table 8.1 Economic Cost

(US$1,000)

Cost Item	Section						Total
	I	II	III	IV-B	IVA,C	V	
1. Site Clearance	144.4	236.0	390.2	147.6	144.1	38.8	1,101.1
2. Earth Works	4,093.0	5,412.9	5,367.0	4,325.0	4,672.0	922.0	24,791.9
3. Pavement	4,129.2	5,503.6	7,551.1	5,253.2	5,134.6	1,177.4	28,749.1
4. Drainage	351.0	571.1	707.6	262.8	290.3	79.5	2,262.3
5. Miscellaneous	215.4	267.1	409.0	226.9	223.6	70.2	1,412.2
6. Mobilization	142.5	180.5	209.0	149.0	145.5	47.5	827.0
7. Right of Way	111.0	142.0	121.0	114.9	112.1	34.0	635.0
8. Contingency	918.6	1,231.3	1,475.2	1,048.0	1,072.2	236.9	5,982.2
9. Engineering Service	1,102.4	1,477.6	1,770.3	1,257.6	1,286.7	286.7	7,181.3
Total	11,207.5	15,022.1	17,997.4	12,785.0	13,079.1	2,893.0	72,984.1

Table 8.2 Savings of Vehicle Operating Cost

(US$ 1,000)

Section	Year	VOC				Savings of VOC
		With Project		Without Project		
		N.T.	G.T.	N.T.	G.T.	
I	1984	1,205	268	2,413	532	1,340
	1994	2,516	573	5,009	1,125	2,769
	2003	4,438	891	8,711	1,722	4,688
II	1984	1,119	266	2,213	521	1,221
	1994	2,394	554	4,706	1,074	2,572
	2003	4,245	872	8,237	1,662	4,387
III	1984	2,737	611	4,634	1,026	2,105
	1994	5,730	1,285	9,615	2,133	4,309
	2003	9,948	2,041	16,425	3,333	7,123
IV	1984	4,553	1,037	8,055	1,821	3,894
	1994	9,465	2,154	16,466	3,715	7,782
	2003	16,315	3,446	27,580	5,785	12,435
V	1984	300	66	512	113	236
	1994	564	140	951	233	433
	2003	919	220	1,534	364	687
Total	1984	9,914	2,248	17,827	4,013	8,796
	1994	20,669	4,706	36,747	8,280	17,865
	2003	35,865	7,470	62,487	12,866	29,320

Note: N.T. is normal traffic
G.T. is generated traffic

For the calculation of the savings for truck, the following composition ratio estimated on the basis of O-D Survey was applied.

Medium truck: 72%
Heavy truck : 28%

8.3 Socio-Economic Impacts

In addition to the quantified benefits described in the preceding section, considerable favourable impacts, tangible or intangible, are expected through the Project implementation.

One of the most important impacts will be the effect on regional economic development mainly through facilitating agricultural production such as food crops, and logs and timber. Particularly, the progress of the existing agricultural development projects (LCADP and BCADP) will be further promoted, which will increase the income of the farmers and at the same time, enhance the regional economic activity.

To keep the trafficability all through the year on the Project road, which is now hampered by continuous rainfall during the rainy season, is an another important impact not only to the regional economic activity but also to the socio-political activities. The improvement of the road will also contribute to the betterment of educational and health situation in the region by shortening the access to the schools and hospitals.

During the implementation of the Project considerable number of workers will be employed recruited from the region, which is expected not only to solve the unemployment or under-employment situation in the region, but also will contribute to the development of the regional economic activity. Through all these impacts, living standard of the people in the region is expected to be raised up.

Another aspect of the impact is the contribution to national and international integration. The Project road connects the Trans-West Africa Coastal Highway at Gbarnga and will be an important branch in the international road network. The improvement of the Project road is expected to encourage socio-economic activities on a wider regional basis. The Project road will also improve the national integration by encouraging smooth socio-economic exchange between the central government and provincial governments.

Beside the above favourable impacts, negative impacts on the regional socio-economy are expected. Considerable large investment for the road project will raise the prices of the construction materials, wages and other related materials in the region. Labor shortage problem is also expected, particularly for skilled labors. For the efficient implementation of the project, these negative impacts are to be fully taken into account and be made them as minimum as possible.

〔IX〕

CONCLUSION AND PECOMMENDATION

IX. CONCLUSION AND RECOMMENDATION

The Project evaluation indicates that the Project is technically sound, economically viable and socially desirable. It is, therefore, recommended that the following actions be taken for the earlier implementation of Project.

1) As the Project is justifiable it is strongly recommended that necessary works including the detailed design be started at the earliest moment.

2) As the Project requires the considerable amount of fund for the full development and traffic volume differs for each road section, stage wise construction is recommended.

3) Considering the amount of the required fund, it will be one of the possible measures to arrange with the external sources for financing the Project. Preparation of such arrangement is recommended to implement the Project as scheduled.

4) As the base course of the Project road, cement treated base is proposed in this report. For confirming this and determining definite cement component, it is recommended that the following test be conducted in the Soil Laboratory of the Ministry before starting detailed design.

   - Wetting and Drying Test of Compacted Soil-Cement Mixture (AASHTO T135-70)
   - Cement Content of Soil-Cement Mixtures (AASHTO T144-74)

ANNEX

Annex III-1

Crop Production in the Influence Area (1978/1979)

Crops	Area (ha)	Yield (t/ha)	Products (t)
Upland Rice			
Lofa county /1	24,600	0.9	22,140
Bong county	5,300	1.0	5,300
(Sub-total)	(29,900)		(27,440)
Swamp Rice			
Lofa county /1	3,300	1.3	4,290
Bong county	400	1.3	520
(Sub-total)	(3,700)		(4,810)
Total Rice Production	33,600		32,250
Coffee			
Lofa county /1	6,300	0.28	1,760
Bong county	200	0.2	40
(Sub-total)	(6,500)		(1,800)
Cocoa			
Lofa county /1	5,000	0.28	1,400
Bong county	400	0.25	100
(Sub-total)	(5,400)		(1,500)
Oil Palm			
Lofa county /1	600	5.0	3,600
Bong county	100	5.0	500
(Sub-total)	(700)		(3,500)

Source: (1) Upper Lofa County Rural Development Project
(2) Upper Bong County Rural Development Project
(3) Agricultural Census, 1971
(4) LPMC Production Records

/1 : includes both LCADP area and outside LCADP area

Annex III-2

Crop Production in the Influence Area (1988/1989)

Crops	Area(ha)	Yield(t/ha)	Products(t)
Upland Rice			
Lofa county			
- improved	5,600	1.7	9,520
- not improved	19,000	1.0	19,000
(Sub-total)	(24,600)		(28,520)
Bong county			
- improved	1,600	1.4	2,240
- not improved	3,700	1.0	3,700
(Sub-total)	(5,300)		(5,940)
Total of upland rice	29,900		
Swamp Rice			
Lofa county			
- improved	2,300	3.5	8,050
- not improved	2,800	1.3	3,640
(Sub-total)	(5,100)		(11,690)
Bong county			
- improved	600	3.0	1,800
- not improved	300	1.3	3,900
(Sub-total)	(900)		(5,700)
Total of swamp rice	6,000		17,390
Total Rice Production	35,900		51,850
Coffee			
Lofa county			
- improved/new	2,800	0.9	2,520
- not improved	4,500	0.28	1,260
(Sub-total)	(7,300)		(3,780)
Bong county			
- improved	400	1.0	400
- not improved	200	0.2	40
(Sub-total	(600)		(440)
Total Coffee Production	7,900		4,220
Cocoa			
Lofa county			
- improved	2,300	0.8	1,840
- not improved	4,200	0.27	1,180
(Sub-total)	(6,500)		(3,020)
Bong county			
- improved	800	1.0	800
- not improved	400	0.25	100
(Sub-total)	(1,200)		(900)
Total Cocoa Production	7,700		3,920
Oil Palm			
Lofa county	1,600	10.0	16,000
Bong county	200	6.0	1,200
Total Oil Palm Production	1,800		17,200

Source: (1) Upper Lofa County (2) Upper Bong County
(3) LCADP Annual Report, 1978