



REPUBLIC
OF
ZAMBIA

The Feasibility Study
on
the Kafue Road Bridge
Reconstruction Project
in
the Republic of Zambia

Final Report

October, 1990

Japan International Cooperation Agency

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Reconstruction Project, the Republic of Zambia

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P R E F A C E

In response to a request from the Government of the Republic of Zambia, the Japanese Government decided to conduct a feasibility study on the Kafue Road Bridge Reconstruction Project in the Republic of Zambia and entrusted the study to the Japan International Cooperation Agency.

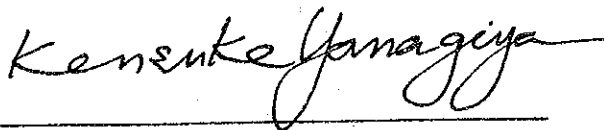
JICA sent to the Republic of Zambia a survey team headed by Mr. Katsuyuki Hioki, Chodai Co., Ltd., and composed of members from Chodai Co., Ltd., and the Pacific Consultants International Co., Ltd., from November 1989 to September 1990.

The team held discussions with the officials concerned of the Government of Zambia, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the Project and to enhancement of friendly relations between our two countries.

I wish to express our sincere appreciation to the officials concerned of the Government of Zambia for their close cooperation extended to the team.

October 1990



Kensuke Yanagiya

President

Japan International Cooperation Agency

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LIST OF ABBREVIATION

JICA	Japan International Cooperation Agency
MPTC	Ministry of Power, Transport and Communications
the Study	the Feasibility Study on the Kafue Road Bridge Reconstruction Project
MOWS	Ministry of Works and Supply
USAID	the United State of America Agency for International Development
ADT	the Average Daily Traffic
O-D	Origin and Destination
DANIDA	
FNDP	Fourth National Development Plan
NCDP	National Committee of Development and Plan
GDP	Grand Domestic Products
ZESCO	Zambia Electricity Supply Corporation
B.S.	British Standards
EIRR	Economic Internal Rate of Return
JIS	Japanese Industrial Standard

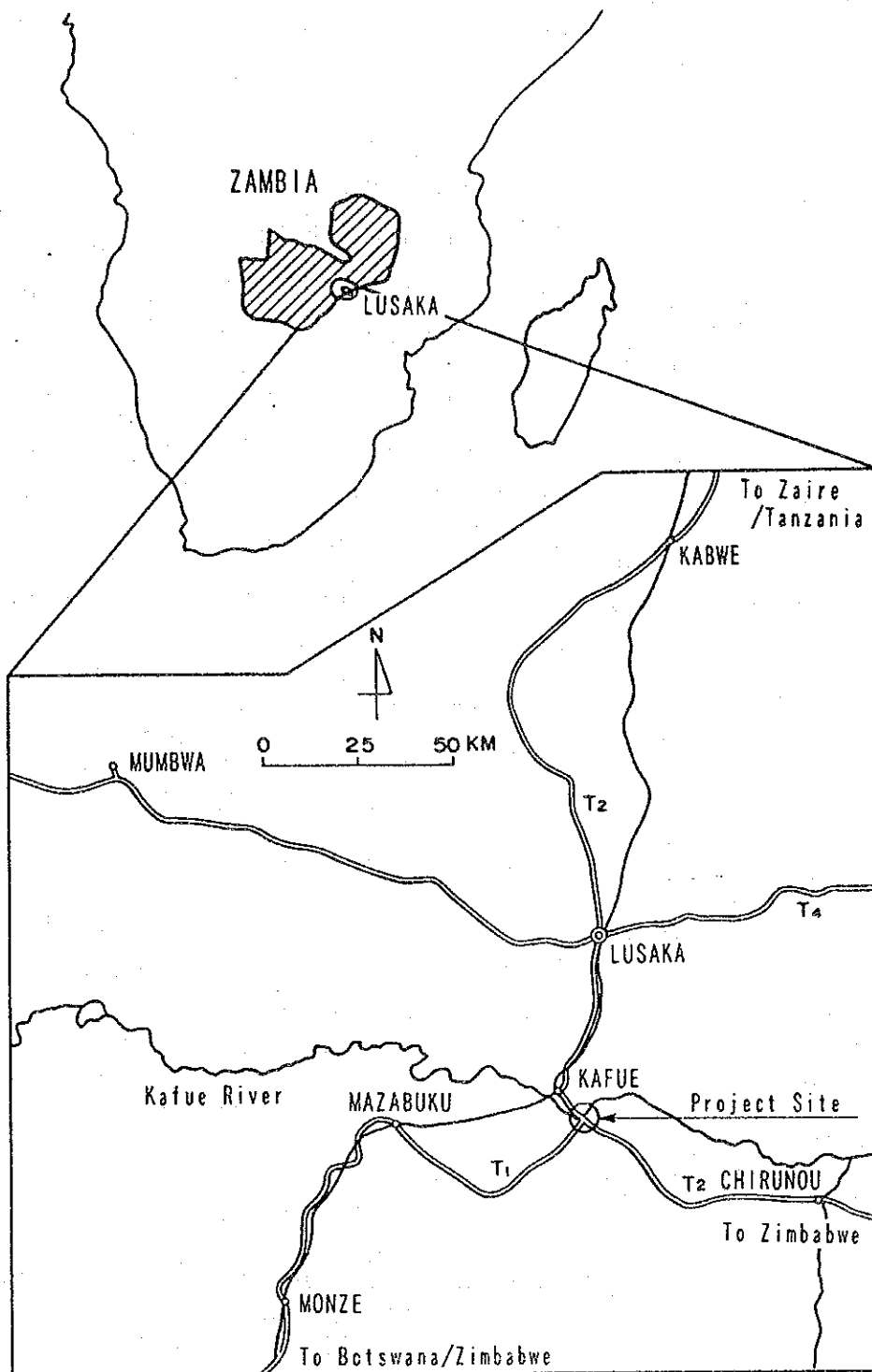


Fig. 1-1 Location of the Kafue Road Bridge

SUMMARY

The Kafue Road Bridge is located 56 km to the south of the capital city, Lusaka, on the main trunk road running from the north of the country to the south through to southern African countries. The region through which the road passes is the most fertile agricultural and consumptive area. Consequently, the road is one of the most important aspects for the development of the Republic of Zambia.

The Superstructure of the existing Kafue Road Bridge was constructed across the Thames River in beginning of 1940's. The bridge was relocated to Kafue River in 1949 and has subsequently been raised and improved in 1968.

The bridge has been in use for some 50 years since its original construction and suffered from heavy traffic conditions requiring constant maintenance and surveillance. Besides, heavy vehicles have been obliged to give way for face-to-face traffic due to the insufficient width of traffic lane on the Bridge.

In Zambia's successive plans, the development of transport and communications has been one of the highest priorities in view of the fact that Zambia is a land-locked country.

In order to promote the social and economic development of the vital sectors of economy such as agriculture, mining, manufacturing and trade, it is necessary to improve existing infrastructure and facilities, and to ensure the road transport for foreign trade.

Due to these circumstances, the government of Zambia made a request to the government of Japan to pursue a feasibility study of the bridge's reconstruction.

The Japan International Cooperation Agency, the official agency responsible for the implementation of technical cooperation programme of the Government of Japan, and the Ministry of Power, Transport and Communications, the Government of Zambia, agreed on the Scope of Work for the Feasibility Study on the Kafue Road Bridge Reconstruction Project on 10th March, 1989.

The Study commenced in November 1989 and completed in October 1990.

The Study comprises two phases. The major activities of each phase include the followings;

Phase I :

- 1) Preparatory Works
- 2) Collection and analyses of data and information
- 3) Inspection of the existing bridge
- 4) Preliminary surveys
- 5) Traffic survey and forecast of future traffic demand
- 6) Bridge alternative study and selection of bridge type
- 7) Detailed surveys

Phase II:

- 1) Preliminary engineering design
- 2) Socio-economic evaluation

The Study concluded the Kafue Road Bridge was on delicate balancing condition and might suffer possible destruction by becoming unstable due to unidentified factors. Although to predict collapse is beyond the binds of structural analysis and most likely impossible, it is required in above context to urgently replace the Bridge, considering importance of the Bridge and social consequence by its possible destruction.

The reconstruction programme of the new Kafue Road Bridge is as outlined below:

1. Features of the Bridge

- (1) Bridge Length 162.0 m
- (2) Span Length 38.0 m + 43.0 + 43.0 m + 38.0 m
- (3) Cross Section Carriageway; 3.65 m × 2 = 7.30 m
Footpath ; 1.00 m × 2
- (4) Type of Superstructure
 4-continuous span plate girder
- (5) Type of Substructure Pier ; Pile Bent
 Abutment; Reversed T type (A1)
 Caisson Type (A2)
- (6) Type of Foundation Pier ; Pile Foundation
 Abutment ; Spread Foundation
- (7) Length of Approach Roads
 750 m

2. Implementation Programme

(1) Construction Cost Approx. 2,000 million yen

(2) Construction Period Aprox. 24 months

The reconstruction of the Kafue Road Bridge is expected to contribute to industrial development of the Republic of Zambia, as the new bridge ensures improvement of safety and copes with the increasing traffic volume.

CHAPTER 1



INTRODUCTION

- 1-A PREFACE
- 1-B BACKGROUND
- 1-C OBJECTIVES
- 1-D STUDY FLOW AND SCHEDULE
- 1-E ORGANIZATION

CHAPTER 1 INTRODUCTION

1-A. PREFACE

- 1 The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programme of the Government of Japan, and the Ministry of Power, Transport and Communications, the Government of Zambia (hereinafter referred to as "MPTC", agreed on the Scope of Work for the Feasibility Study on the Kafue Road Bridge Reconstruction Project (hereinafter called "the Study") on 10th March, 1989.
- 2 JICA set up a study team (hereinafter referred to as "Study Team") to conduct the Study. The Study Team shall carry out the Study in close cooperation with the Road Department of MPTC in accordance with the agreed Scope of Work and content of the Inception Report, agreed on 24th November, 1989.
- 3 In this Final Report, the results of the Study implemented during November, 1989 and October, 1990 by the Study Team will be presented. This Report has been prepared to select the most suitable bridge type as well as length and number of spans, preliminary engineering design and socio-economic evaluation.

1-B. BACKGROUND

- 4 In Zambia's successive plans, the development of transport and communications has been one of the highest priorities in view of the fact that Zambia is a land-locked country.
- 5 In order to promote the social and economic development of the vital sectors of economy such as agriculture, mining, manufacturing and trade, it is necessary to improve existing infrastructure and facilities, and to ensure the road transport for foreign trade.

- 6 The Kafue Road Bridge is located 56 km to the south of the capital city, Lusaka, on the main trunk road running from the north of the country to the south through to southern African countries. The region through which the road passes is the most fertile agricultural and consumptive area. Consequently, the road is one of the most important aspects for the development of the Republic of Zambia.
- 7 The Superstructure of the existing Kafue Road Bridge was constructed across the Thames River in beginning of 1940's. The bridge was relocated to Kafue River in 1949 and has subsequently been raised and improved in 1968.
- 8 As for the bridge conditions, the bridge has been in use for some 50 years since its original construction and suffered from heavy traffic conditions requiring constant maintenance and surveillance. Besides, heavy vehicles have been obliged to give way for face-to-face traffic due to the insufficient width of traffic lane on the Bridge.

1-C. OBJECTIVES

- 9 The objective of the Study is to carry out the feasibility study for reconstruction of Kafue Road Bridge including its approaches and connection Roads.

The Study conclusively proposed most suitable bridge plan to be replaced with the existing bridge, its span lengths, most suitable alignment and implementation programme.

1-D. STUDY FLOW AND SCHEDULE

- 10 The Study comprises two phases. The major activities of each phase include the followings;

Phase I :

- 1) Preparatory Works
- 2) Collection and analyses of data and information
- 3) Inspection of the existing bridge
- 4) Preliminary surveys
- 5) Traffic survey and forecast of future traffic demand
- 6) Bridge alternative study and selection of bridge type
- 7) Detailed surveys

Phase II:

- 1) Preliminary engineering design
- 2) Socio-economic evaluation

The flow chart of the study is shown in Appendix 1-1.

- 11 The study commenced in November 1989 and was completed in October 1990. The detailed work schedule is shown in Appendix 1-2 and respective reports are submitted at times as indicated in the work schedule.

1-E. ORGANIZATION

- 12 The agencies directly concerned with the Study are Ministry of Works and Supply (MOWS) and JICA. The Study has been, however, carried out by the Study Team in a close contact with Roads Department of MOWS. The schematic organization chart during implementation of the Study is shown in Fig. 1-2.

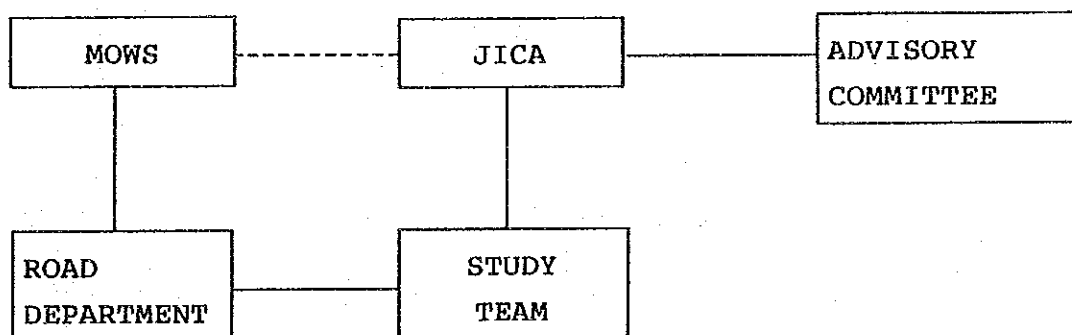


Fig. 1-2 Organization for the Study

JICA has set up Advisory Committee for execution of the Study.

CHAPTER 2



FUTURES OF STUDY

- 2-A GENERAL
- 2-B ENVIRONMENT
- 2-C RELEVANT PROJECT

CHAPTER 2 FEATURES OF STUDY

2-A. GENERAL

- 13 A study area of this project is confined in the Road Bridge crossing Kafue River and its approaches. The alignments include a new alignment for reconstruction in a range of 300 m downstream of the existing bridge as well as the present alignment.
- 14 The Kafue Road Bridge is to form a link in the chain of southern trunk roads in Zambia and is the sole long span bridge among roads to connect Lusaka-Livingstone and Lusaka-Chirundu. Bypasses of this bridge are remote and there exist no nearby bridges other than this except the Rail Bridge located upstream. The Kafue Road Bridge, therefore, is a most essential infrastructure facility and its destiny would affect on economy of not only the southern Zambia but also the south African countries as well.
- 15 The reconstruction of the Bridge has attracted Zambian people's attention and everybody is interested in this project. Thus, the bridge planning is expected to attain functional aspects as well as became a highly visual development facility.
- 16 The road between the south side of the Bridge and Chirundu has been already rehabilitated, while the road starting from the north side of the Bridge up to Lusaka is expected to be rehabilitated soon under funding by USAID. Accordingly, the reconstruction of the Bridge must coincide with these related projects.
- 17 The existing bridge is composed of three (3) single truss spans, while five (5) single truss spans were originally built on the Thames River. It is noted that the Bridge was not designed to comply with geographical features of the site.

2-B. ENVIRONMENT

- 18 The Bridge site is far from the downtown of Kafue, and crosses a part of Kafue River which meanders through an

open flatland. The site is located at the very end of the flatland influenced by back water of Kafue Gorge Dam at the downstream side. Its water level still is affected by impound/discharge of the Dam.

- 19 Due to the construction of Kafue Gorge Dam, the water level has been rising and river was broadened to approx. 300 m. As a result, the existing bridge length became too short and the approach embankment projects into the river at right angle.
- 20 As swamp extends to the whole neighborhood at the site and since there are no tall trees around, there are no obstacles to disturb traffic sight.
- 21 In Kafue River, there are alligators and hippopotamuses as well as fish and there are no signs of water pollution. There is a filtration plant at approx. 3.3 km downstream the Bridge. Harmfull chemical materials should not be allowed to be used and construction methods which might affect water cleanness should be avoided.

2-C. RELEVANT PROJECT

- 22 Data and information of relevant projects have been reviewed thoroughly with respect to the Study.

(1) Kafue-Chirundu Road Project

- 23 Kafue-Chirundu Road was rehabilitated using fund provided by the United States of America Agency for International Development (USAID).

(2) Kafue-Lusaka Road Project

- 24 As part of its Southern Africa Regional Programme the USAID is planning to provide funds in the financial year 1990, to rehabilitate the Kafue-Lusaka Road from Kafue River Bridge to the Makeni Road Turn off. The section of the road totalling 49.4 kilometres connected with the Kafue-Chirundu Road.

(3) Kafue Rail Bridge

25

Report on Rehabilitation or Replacement May 1981.
The study was carried out to help the Zambia Government to decide whether it would be technically and economically feasible to prolong the life of the existing Kafue Rail Bridge by a programme of remedial work, or whether a new rail crossing should be constructed.

The study was financed by the Overseas Development Administration of United Kingdom in 1981.

(4) Rehabilitation or Replacement of Kafue Rail Bridge
Feasibility Study update - Sep. 1989

26

USAID is planning to provide funds in fiscal year 1991 commencing on October 1990, as part of its Southern African Regional Programme.

CHAPTER 3



TRAFFIC VOLUMES AND FORECASTS

- 3-A PRESENT TRAFFIC CONDITION
- 3-B TRAFFIC SURVEY
- 3-C RESULTS OF
ROADSIDE SURVEY
- 3-D ESTIMATION OF
FUTURE TRAFFIC VOLUME

CHAPTER 3 TRAFFIC VOLUME AND FORECAST

3-A. PRESENT TRAFFIC CONDITION

(1) Traffic Volume

- 27 Traffic counting survey was conducted at three (3) stations near Kafue Road Bridge by Roads Department as indicated in Fig. 3-1. There is no other station between Lusaka and Kafue. The station No. 66A is located at the weighbridge about 0.5 km south from Kafue Road Bridge. Hence, the volume counted at this station could be understood to directly represent that at Kafue Road Bridge.
- 28 ADT (the average daily traffic) is made from the average of the survey results in the spring (usually April) and the Autumn (usually December).
- 29 The traffic volume of Kafue Road Bridge from 1984 to 1989 did not increase significantly. This is shown in Table 3-1. The traffic count tends to be affected by the reduction of economic activities in Zambia.

Table 3-1 Traffic Volume around the Kafue Road Bridge

RD No.	Location of Station	Year	ADT	% of Truck
66	3.8km s.w. of T1/T2 Junction	1983	1095	43%
		1984	845	37%
		1985	743	35%
		1986	768	39%
		1987	559	37%
		1988	573	30%
66A	Weighbridge at Kafue Bridge	1984	1122	27%
		1985	960	31%
		1986	1015	37%
		1987	795	36%
		1988	1203	35%
		1988	(1116)	(34%)
66B	Turnpike near T1/T2 Junction	1984	742	27%
		1985	763	31%
		1986	504	35%
		1987	436	28%
		1988	381	30%

Source : Roads Department, Ministry of Works and Supply

Remark : Number inside () is the result of survey by Study Team

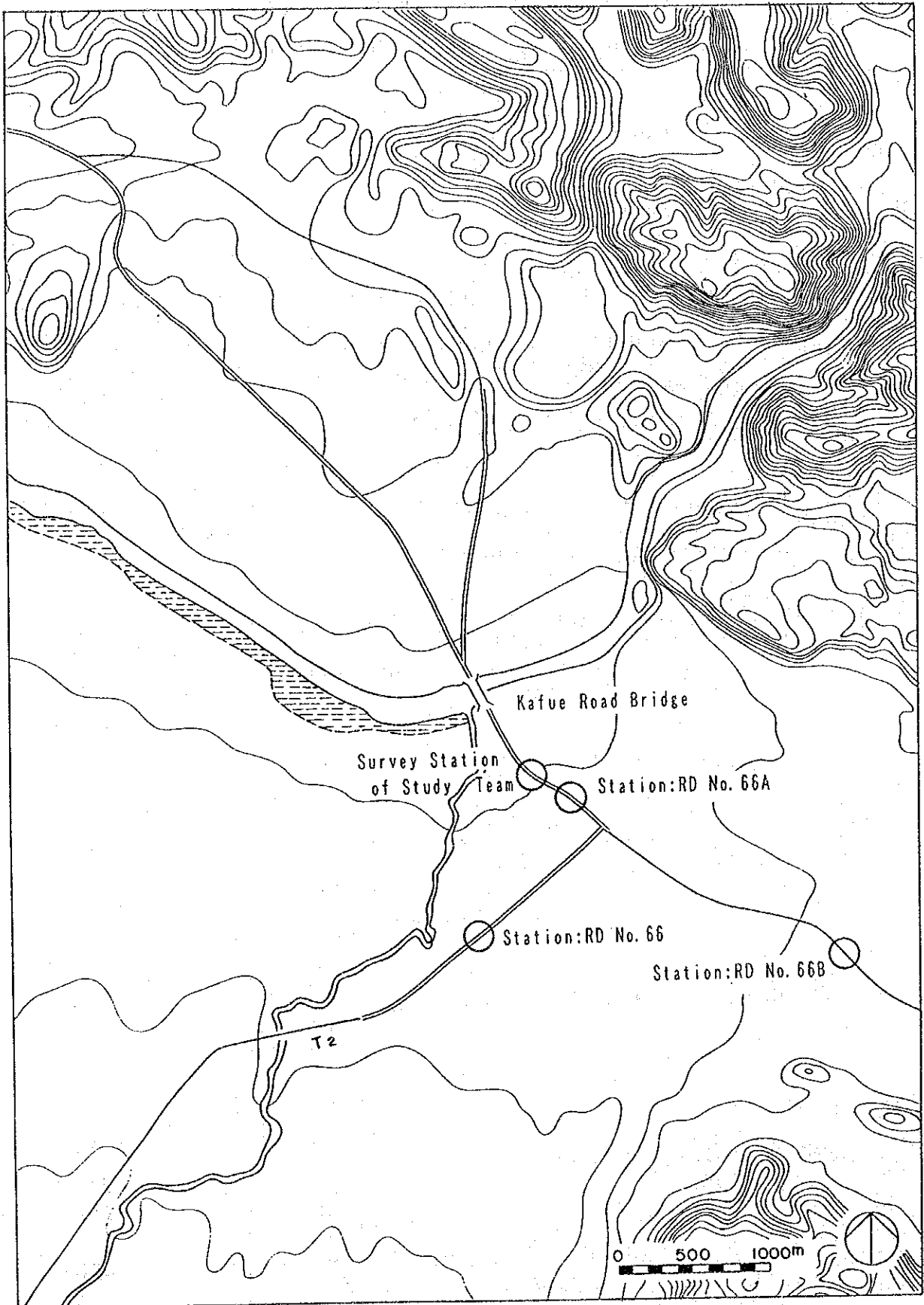


Fig. 3-1 Traffic Survey Station

Table 3-2 Classification of Traffic (ADT of 1988)

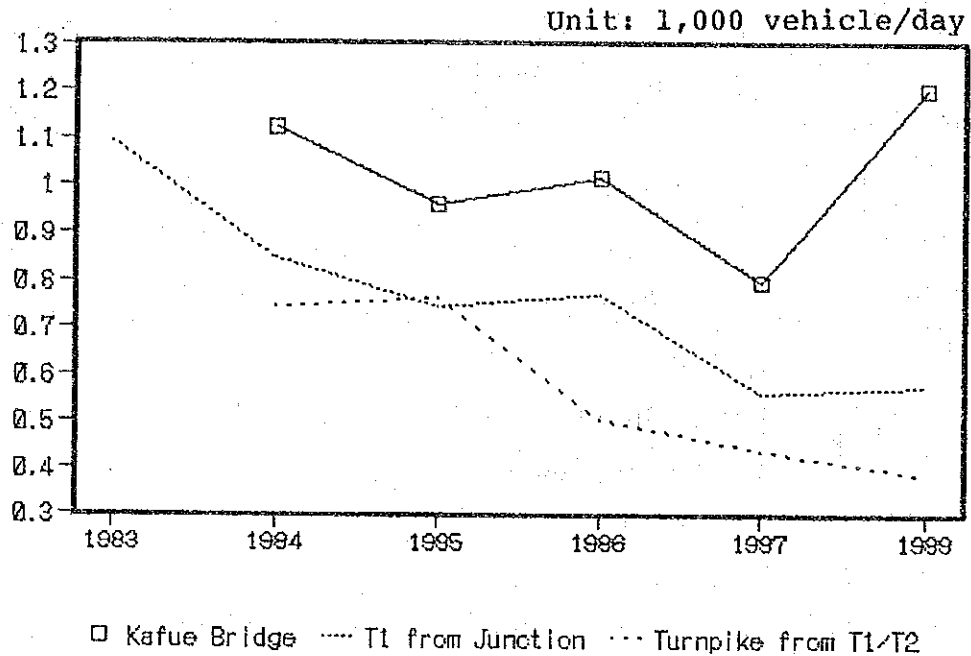
	Weighbridge at Kafue Road Bridge	RD No.66 South-West of T1/T2 Junction	RD No.66B Turnpike of T1/T2 Junction	Survey by Study Team 11/Dec/89	Survey by Study Team 14/Dec/89
1.Light Traffic	786	407	267	694	662
2.Buses	13	11	3	17	27
3.Light Trucks	243	97	53	180	183
4.Heavy Trucks	161	58	58	225	256
5.Total	1203	573	381	1116	1128
Heavy Vehicle (%)	34.7	29.0	29.9	37.8	41.3
Very Heavy (%)	13.4	10.1	15.2	20.2	22.7

Source: Roads Department, MOWS

Remark: 1. Heavy Vehicle = (2+3+4)/(5)

2. Very Heavy = (4)/(5)

Fig. 3-2 Traffic Volume at Kafue Road Bridge



- 30 Review of historical figures of Kafue-Lusaka road indicates that the traffic volume in 1985 has been declining at a rate of 6% since 1975. It is assumed the opening of the Tanzania - Zambia Railway and an independence struggle in Zimbabwe which lasted until 1981 together with current depreciation of Zambian economy adversely affected on the volume.
- 31 According to the 1983-89 records at the station 66A, the share of truck traffic remains static and is 33%. However, the single type truck traffic has reduced while the articulated type truck traffic has increased. This changing trend could be due to the modernization of the truck fleet in Zambia and other surrounding countries through international donor assistance in recent year.

Table 3-3 Traffic Growth at Traffic - Station 66 A 1983-89

Year	Light Vehicles	Buses	Single	Articulated*	Total
1983	554	27	295	57	933
1984	756	28	279	59	1122
1985	595	23	276	66	960
1986	635	38	282	60	1015
1987	507	29	159	100	795
1988	786	13	243	161	1203
1989**	632	19	173	129	911

Source : Roads Department

* Assumed to include all commercial vehicles other than single unit trucks and buses.

** Not assessed as part of the annual traffic census.

Table 3-4 Truck Traffic as percentage of total traffic at Kafue weighbridge (1983-1989)

Year	Single Unit Truck Traffic as % of Total Traffic	Articulated Truck Traffic as % of total Traffic	Total Truck Traffic as % of Total Traffic
1983	31.6	6.1	37.7
1984	24.9	5.3	30.2
1985	28.8	6.9	35.7
1986	27.8	5.9	33.7
1987	20.0	12.7	32.7
1988	20.2	13.4	33.6
1989	19.0	14.2	33.2

Source : Roads Department

(2) Weekly Variation

32 Among the whole-day trips, passenger cars occupies 64% while shares of lorry/truck and trailer are 20% and 14%, respectively. Average daily traffic volume in 1989 is estimated 911 vehicles by Roads Department.

33 The share of trucks is almost static, but the share of passenger car fluctuates significantly. The share of passenger car tends to increase toward the weekend. On Saturday and Sunday, the passenger car occupies more number than that on weekdays.

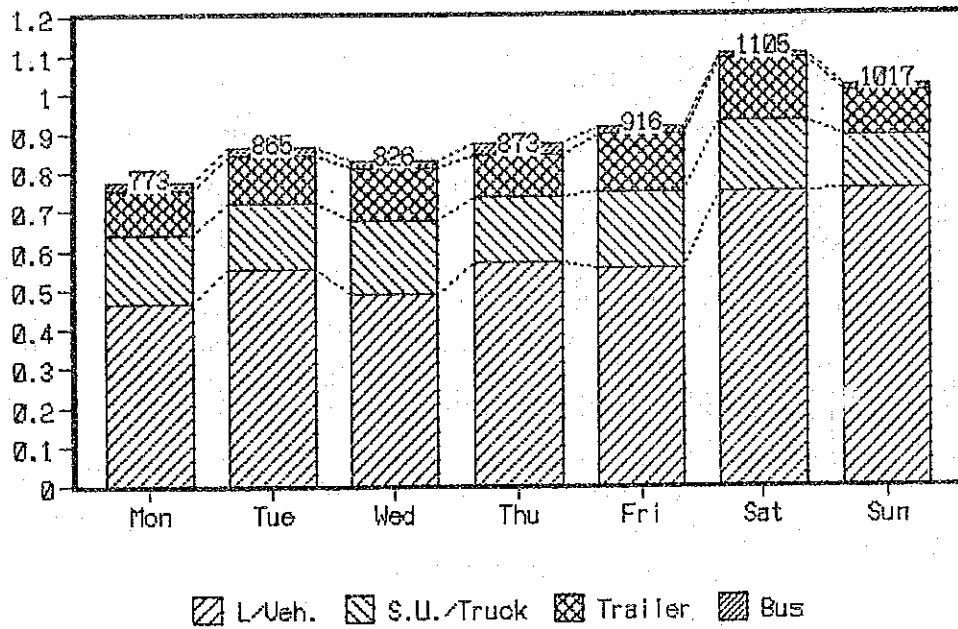


Fig. 3-3 Weekly Variation of Volume

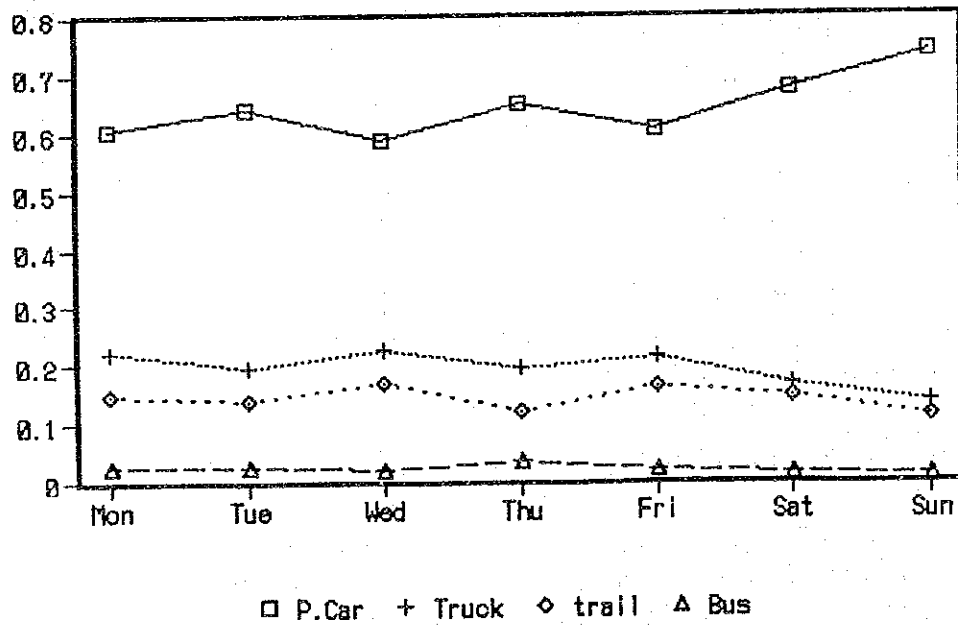


Fig. 3-4 Percentage of Weekly Variation

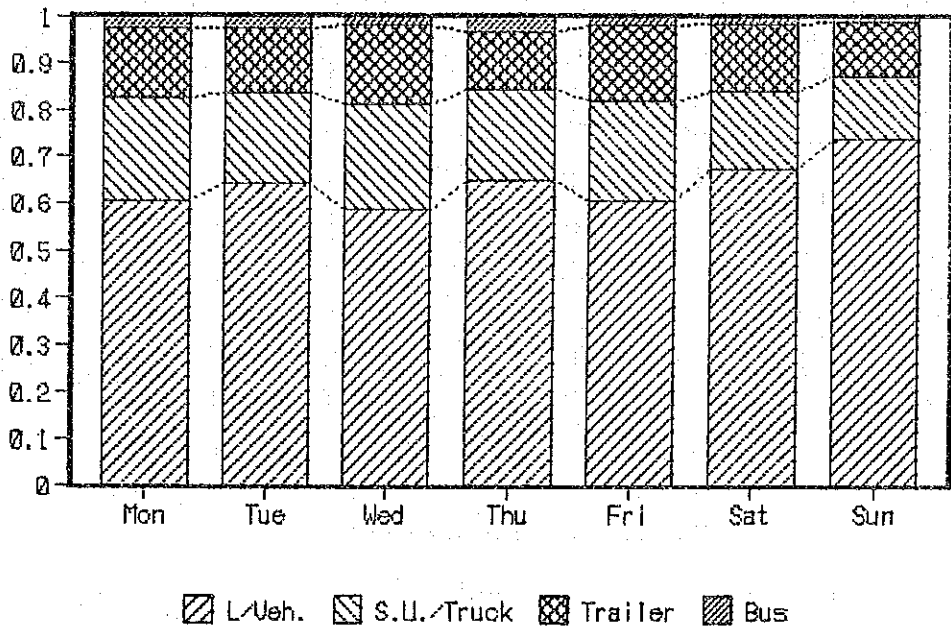


Fig. 3-5 Percentage of Weekly Variation

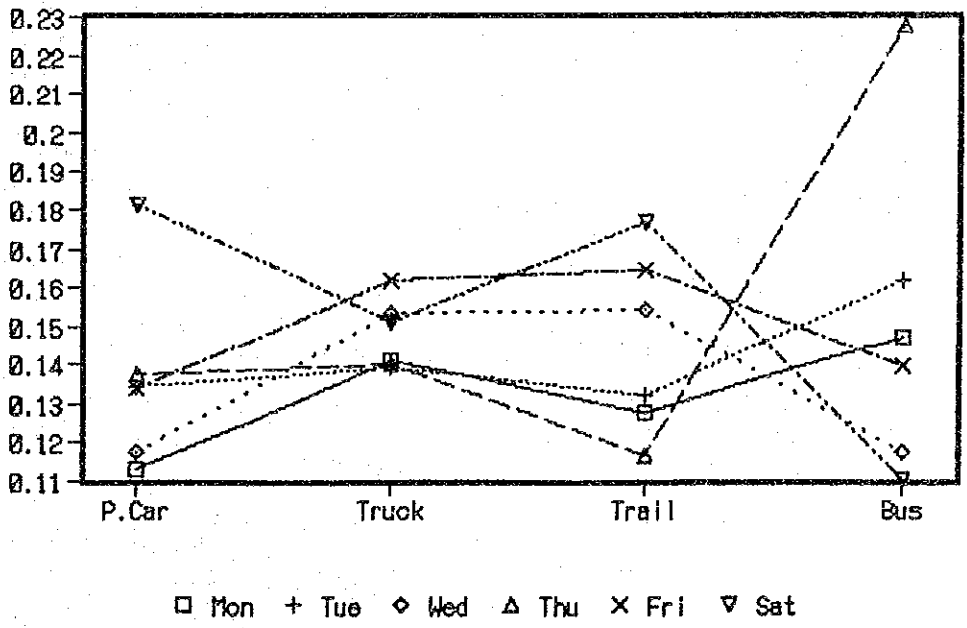


Fig. 3-6 Percentage of Vehicle Kinds

Table 3-5 Weekly Variation at Kafue Road Bridge

Day	Light Vehicles	Single Unit Truck	Trailer & Semi-Trail	Buses	Total
Mon	467	171	115	20	773
Tue	555	169	119	22	865
Wed	485	186	139	16	826
Thu	567	170	105	31	873
Fri	553	196	148	19	916
Sat	748	183	159	15	1105
Sun	752	137	115	13	1017
Total	4127	1212	900	136	6375
Average	590	173	129	19	911

Table 3-6 Percentage of each kind of Vehicle

Day	Light Vehicles	Single Unit Truck	Trailer & Semi-Trail	Buses	Total
Mon	0.604	0.221	0.149	0.026	1.000
Tue	0.642	0.195	0.138	0.025	1.000
Wed	0.587	0.225	0.168	0.019	1.000
Thu	0.649	0.195	0.120	0.036	1.000
Fri	0.604	0.214	0.162	0.021	1.000
Sat	0.677	0.166	0.144	0.014	1.000
Sun	0.739	0.135	0.113	0.013	1.000
Total Average	0.643	0.193	0.142	0.022	1.000

Table 3-7 Percentage of each day in a week

Day	Light Vehicles	Single Unit Truck	Trailer & Semi-Trail	Buses	Total
Mon	0.113	0.141	0.128	0.147	0.121
Tue	0.134	0.139	0.132	0.162	0.136
Wed	0.118	0.153	0.154	0.118	0.130
Thu	0.137	0.140	0.117	0.228	0.137
Fri	0.134	0.162	0.164	0.140	0.144
Sat	0.181	0.151	0.177	0.110	0.173
Sun	0.182	0.113	0.128	0.096	0.160
Total	1.000	1.000	1.000	1.000	1.000

(3) Results of Traffic Counting Survey

(a) Total Volume

34 At Kafue Road Bridge, the Study Team carried out the 24 hours Traffic Counting Survey on 11th and 14th Dec. 1989. The results of traffic counting is shown as follows.

Table 3-8 Results of Traffic Counting at Kafue Road Bridge

	11/Dec/89				14/Dec/89							
	From Lusaka (Car)	(%)	To Lusaka (Car)	(%)	Total (Car)	(%)	From Lusaka (Car)	To Lusaka (Car)	Total (Car)	(%)	(%)	
1.P/Car	111	20.5	140	24.3	251	22.5	107	18.7	107	19.2	214	19.0
2.Van	216	39.9	227	39.5	443	39.7	229	40.1	219	39.3	448	39.7
3.2Axle	86	15.9	94	16.3	180	16.1	104	18.2	79	14.2	183	16.2
4.3Axle	7	1.3	5	0.9	12	1.1	3	0.5	4	0.7	7	0.6
5.Trail	98	18.1	89	15.5	187	16.8	93	16.3	111	19.9	204	18.1
6.Bus(R)	9	1.7	7	1.2	16	1.4	9	1.6	13	2.3	22	2.0
7.Bus(S)	0	0.0	1	0.2	1	0.1	3	0.5	2	0.4	5	0.4
8.Others	14	2.6	12	2.1	26	2.3	23	4.0	22	3.9	45	4.0
9.Total	541	100.0	575	100.0	1116	100.0	571	100.0	557	100.0	1128	100.0
1+2	327	60.4	367	63.8	694	62.2	336	58.8	326	58.5	662	58.7
3+4+5	191	35.3	188	32.7	379	34.0	200	35.0	194	34.8	394	34.9
6+7	9	1.7	8	1.4	17	1.5	12	2.1	15	2.7	27	2.4

Source Study Team

35 The total traffic volume was 1,116 vehicles on 11th Dec. and 1,128 vehicles on 14th Dec. The number of vans was above twice of the passenger cars and it shares 40% of total vehicles. 2 axles truck accounted for 16% of total vehicles and is equivalent in volume to trailers. Passenger cars and vans shared 60% and trucks and trailers shared 35% of total vehicles. These percentages show the rate of heavy weight vehicles is enormously high. Results are detailed in Appendix-3.

(b) Daily Variation

36 As a whole, two peak hours such as 10:00-11:00 and 3:00-4:00pm are formed. The peak ratios in the morning and evening peak hours accounts for 7.6% and 8.4% of the total traffic volume, respectively.

37 The result shows peak hours vary depending upon type of vehicles. As a matter of fact, peak period of passenger car, truck and trailer are 4:00-5:00pm, 5:00-6:00pm and 10:00-11:00am, respectively.

- 38 Volume of truck and trailer found stable throughout a whole day. Hourly truck volume and peak-hour truck volume are not much different. Volume of trailer heavily fluctuates and is repeatedly up to the midnight. A pattern in daily variation of passenger car is typical and has two (2) peak hours as explained previously.

Table 3-9 Daily Variation at Kafue Road Bridge (Total)
11/Dec/89

Time	P.Car (%)	Truck (%)	Trail (%)	Bus (%)	Total (%)					
7 7-8	26	3.7	2	1.0	9	4.5	4	5.9	38	3.4
8 8-9	29	4.2	14	6.8	18	9.0	1	5.9	62	5.6
9 9-10	40	5.8	12	5.8	6	3.0	1	5.9	59	5.3
10 10-11	54	7.8	11	5.3	20	10.1	0	0.0	85	7.6
11 11-12	48	6.9	13	6.3	13	6.5	0	0.0	74	6.6
12 12-13	36	5.2	16	7.8	14	7.0	2	11.8	68	6.1
13 13-14	41	5.9	18	8.7	9	4.5	2	11.8	70	6.3
14 14-15	53	7.6	17	8.3	15	7.5	1	5.9	86	7.7
15 15-16	63	9.1	15	7.3	15	7.5	1	5.9	94	8.4
16 16-17	65	9.4	16	7.8	12	6.0	0	0.0	93	8.3
17 17-18	55	7.9	20	9.7	7	3.5	0	0.0	82	7.3
18 18-19	49	7.1	10	4.9	13	6.5	2	11.8	74	6.6
19 19-20	37	5.3	6	2.9	12	6.0	0	0.0	55	4.9
20 20-21	18	2.6	5	2.4	4	2.0	1	5.9	28	2.5
21 21-22	14	2.0	0	0.0	8	4.0	0	0.0	22	2.0
22 22-23	9	1.3	0	0.0	3	1.5	0	0.0	12	1.1
23 23-24	4	0.6	1	0.5	1	0.5	0	0.0	6	0.5
24 24-01	2	0.3	0	0.0	0	0.0	0	0.0	2	0.2
1 1-2	1	0.1	1	0.5	2	1.0	0	0.0	4	0.4
2 2-3	1	0.1	2	1.0	0	0.0	0	0.0	3	0.3
3 3-4	2	0.3	2	1.0	1	0.5	1	5.9	6	0.5
4 4-5	3	0.4	3	1.5	2	1.0	2	11.8	10	0.9
5 5-6	11	1.6	4	1.9	6	3.0	2	11.8	23	2.1
6 6-7	33	4.8	18	8.7	9	4.5	0	0.0	60	5.4
Total	694	100	206	100	199	100	17	100	1116	100

Source: Study Team

- Remark: 1. P.Car = Passenger Car + Van
2. Truck = 2Axles Truck + others
3. Trail = Trailer + 3Axles Truck

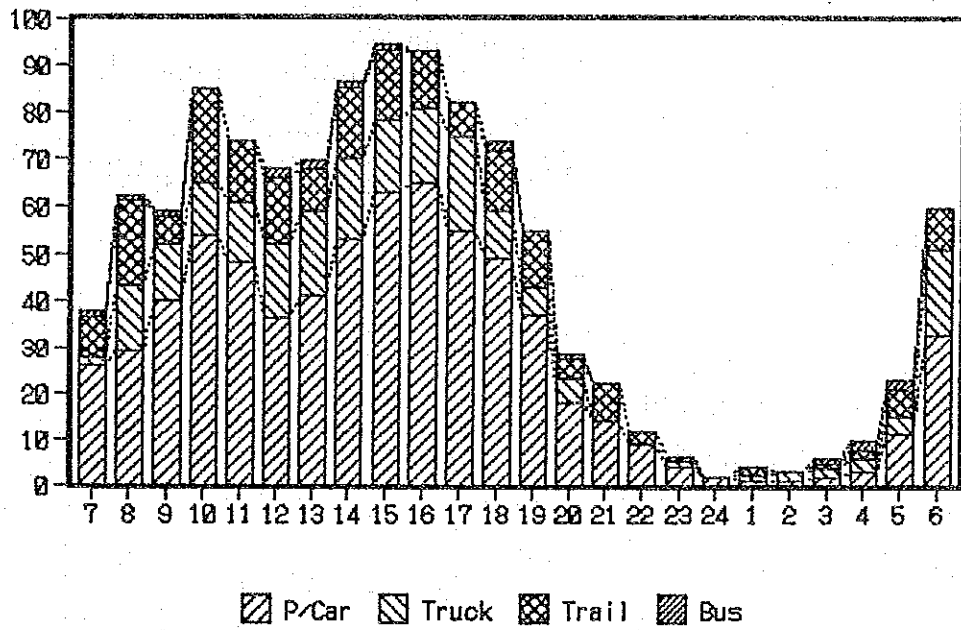


Fig. 3-7 Daily Traffic Variation

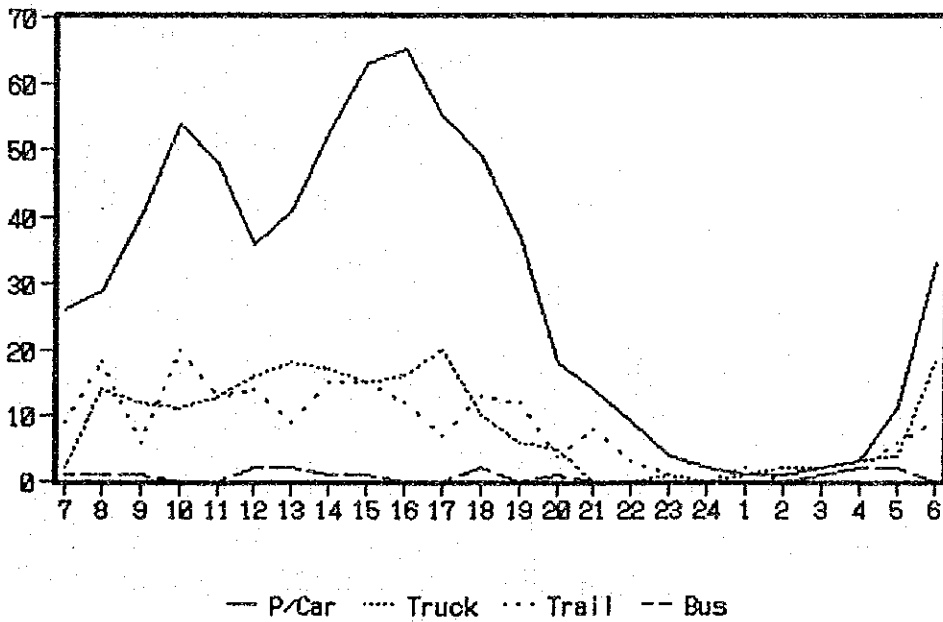


Fig. 3-8 Daily Traffic Variation

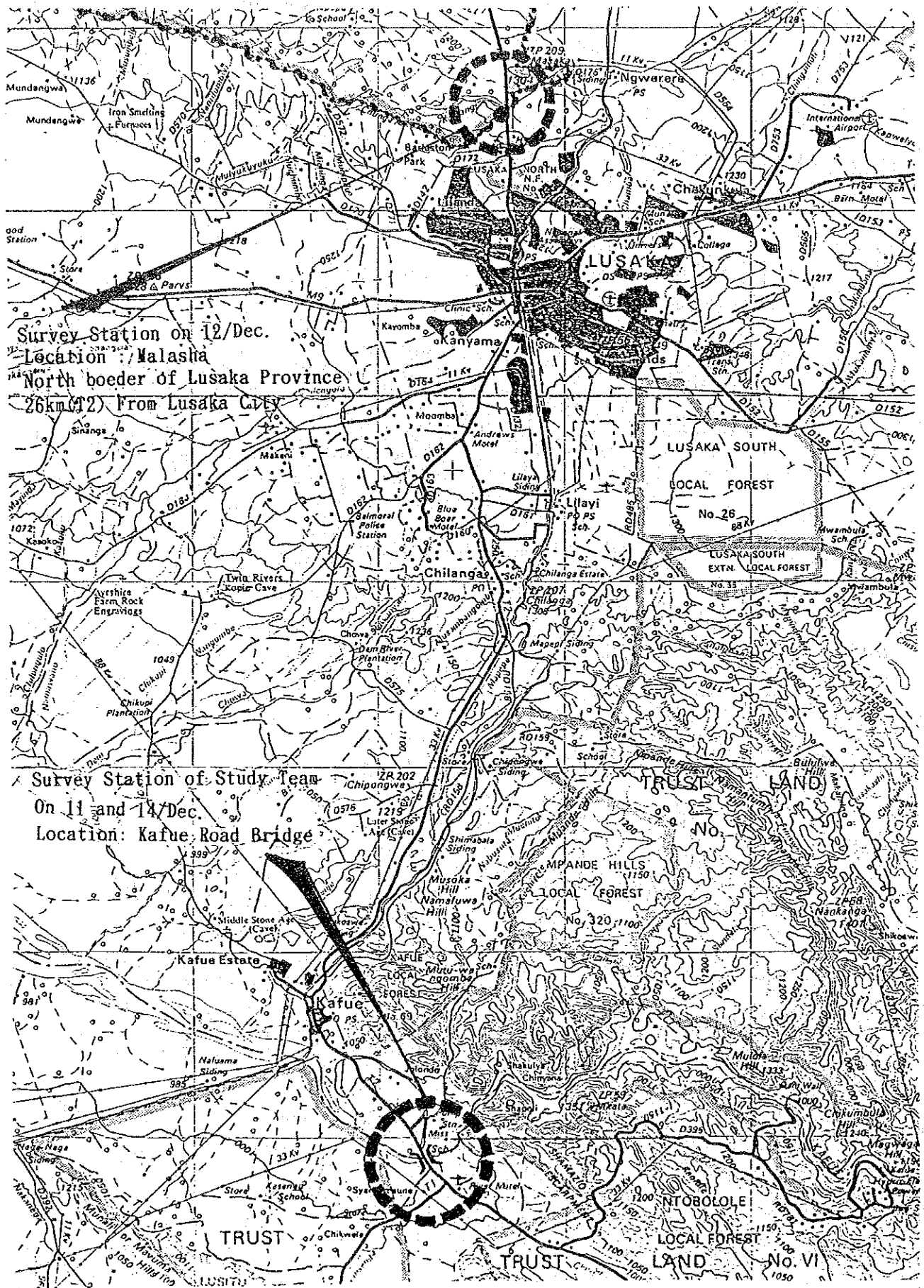


Fig. 3-9 Location of Survey Station

(c) Vehicle Type Structure

- 39 The structure of vehicle types at peak-hour is shown in the following table 3-10.

Table 3-10 Vehicle Type at Peak-hour
(Unit: %)

Time	P/Car	Truck	Trailer	Bus.	Total
10:00-11:00	63.5	13.0	23.5	0.0	100.0
15:00-16:00	67.0	16.0	16.0	1.0	100.0
16:00-17:00	69.9	17.2	12.9	0.0	100.0
17:00-18:00	67.1	24.4	8.5	0.0	100.0
Total	62.2	18.5	17.8	1.5	100.0

Source : Study Team Survey on 11th Dec. 1989

- 40 The percentage of passenger cars shows 62.2% in the average daily traffic volume (total volume). However at the time-period of concentration by a certain kind of vehicles, the passenger cars show higher percentages at every time-period. In the case of truck and trailer, the time-period of concentration by own kind of vehicle shows higher percentage than the percentage of the total volume (the average daily traffic volume). At other time periods, their ratio shows lower percentage than the ratio of the total average volume.

(d) The ratio of 12 hours traffic volume.

- 41 The ratio of 12 hours traffic volume which is surveyed from 6:00 a.m. to 6:00 p.m. to the whole day traffic volume is 1.28.

The ratio of 14 hours traffic volume to the whole day traffic volume is 1.12. These ratios show that traffic volume in night-time shares a large number of percentage, because the subjective road is the main trunk road between inter-cities and international.

Table 3-11 The ratio of 12 hr. traffic volume

Type	Ratio	Remark
Passenger Car	1.28	(24 hr./12 hr. Trips)
Truck	1.19	(")
Trailer	1.42	(")
Total	1.28	

3-B. TRAFFIC SURVEY

(1) Executing Plan

(a) Kinds of Traffic Survey

42 This study has carried out two kinds of survey as follows.

- 1) Roadside Origin-Destination Survey
- 2) Traffic-volume counting Survey

(b) Roadside O-D Survey

43 Content of traffic, namely, the origin and destination of trips between inter-regional and/or intercities, shall be surveyed in order to pursue features of traffic flow. Roadside O-D Survey is most suitable for such purposes.

44 The contents of roadside O-D survey is as follows.

- 1) Kind of vehicle
- 2) Origin of trip
- 3) Destination of trip
- 4) Number of passengers (only for passenger cars)
- 5) Trip purpose (only for the passenger car)
- 6) Classification of loaded materials (only for trucks)
- 7) Tonnage of loaded materials (only for trucks)

45 Prior to commencing the Study, the Team intended to take advantage of the O-D table of DANIDA made in 1985, since roadside O-D survey to be conducted by the Team would possibly rearrange DANIDA's O-D table. Unfortunately, the table was unavailable and the Team was necessitated to change procedures.

(c) Traffic Volume counting Survey on Road-side.

- 46 The number of vehicles on the Kafue Bridge should be clarified in order to analyze daily variation and to check the present O-D Table which has been enlarged using the results of roadside O-D survey.

(d) Date and location

- 47 Both traffic surveys have been carried out on the following dates.

Table 3-12 Survey date and location

Survey	Date	Location	Hours
Roadside O-D Survey	11/Dec./89(Mon)	Kafue Road Bridge	12 hrs. from 7:00 am
Traffic Counting Survey	11/Dec./89(Mon)	Kafue Road Bridge	24 hrs. from
	12/Dec./89(Thu)	Lusaka City Boundary of T2	14 hrs. 6:00 am
	14/Dec./89(Tur)	Kafue Road Bridge	24 hrs.

- 48 These surveys should have been carried out until 15th Dec. 1989. However, because of backgrounds as delineated below, the Survey was not implemented on 15th December, 1989:

- a. Most of private firms closes from 15th December, 1989 to 2nd January, 1990.
- b. A great number of people usually comes back to their hometown.
- c. Thus, trips are increased and goods-flow becomes unusual.

49 The traffic counting stations have been located at 2 points excluding Kafue Road Bridge. They are near the Lusaka city boundary on Route T₂ and T₄, and chosen mainly to verify reliability of forecasting the present and future O-D table. However, as security of the location along Route T₂ toward Copperbelt is extremely bad, the Team had to cease the survey during night-time. However, the Team was forced to relocate the survey station on 14th December from Route T₄ to Kafue Road Bridge.

(2) Weekly Variation

50 In order to set the date of Traffic Survey, the weekly variation was checked through reviewing Traffic Counting results at the Kafue Road Bridge on April 1989 conducted by Roads Department. The main features of weekly variation were as follows.

- a) On Friday, the daily average was most similar to the weekly average.
- b) The passenger cars were increasing gradually up to the end of the week. On the contrary, lorries were constant throughout the week.
- c) Number of trailer was increasing on Friday and Saturday. In the beginning of the week, its share was not so high.
- d) The share of other kinds of vehicle on Monday and Tuesday was similar to the weekly average.

51 From the following points of view, survey dates were set on Monday, Tuesday and Thursday:

- a) The survey dates should represent usual and normal traffic flow.
- b) They should not include 15th December, since the day is the start of year end vacation.

(3) The Classification of Vehicle Type

52 Basically, the classification of vehicles by Roads Department has been given to the Survey Team. Recent classification of Roads Department is as follows.

1. Passenger Car
2. Small van, Pick-up
3. Large van, Carravan
4. 2 axles Lorry
5. 3 axles Lorry
6. Trailer
7. Semi trailer
8. Trailer with 2 or more wheels
9. Bus
10. Tractor or Construction vehicle

53 The classification as set forth herein was adopted solely for the Study, considering subsequent analysis and future forecasting.

- 1) Passenger Cars
- 2) Van, Pick-up, Landrover, Landcruiser
- 3) Lorry/Truck : 2 axles.
- 4) Lorry/Truck : 3 or more axles.
- 5) Lorry/Truck : draw-bar-trailer
- 6) Bus : Regular route bus.
- 7) Bus : Sight-seeing or private use.
- 8) Others

(4) The Classification of Goods

54 Goods-flow was classified in accordance with the socio-economic statistics and the custom officer's assistance. The classification is as expressed in Table 3.13. The survey station was set on the custom check point of the Kafue Toll Gate. The custom officers at the Toll Gate were very cooperative in carrying out the traffic survey. Therefore, collected information from drivers is assumed to be accurate to the best extent.

Table 3-13 Classification of Goods by Study Team

Code-A		Code-B	
0		0	Empty
1			Agricultural goods/materials
	Agricultural Products	101	Cotton
		102	Maize
		103	Cow/Ox
		104	Sugar
		105	Flour (Wheat/Maize)
		106	Beans
		107	Others
2	Mineral Products		Mineral
		201	Copper
		202	Zinc
		203	Riversand
		204	Lead
		205	Others
			Construction Material
		301	Plywood
		302	Steel/Iron (sheet or pile)
		303	Others
3			Chemical production
	Chemical Products	401	Gas
		402	Petrol
		403	Diesel
		404	Oil
		405	Fertilizer
		406	Others
4			Industrial products/ Commercial/goods
	Industrial Products	501	Agricultural machine
		502	Electric equipment
		503	Clothes concerned
		504	Foods
		505	Cigarettes
		506	Groceries
		507	Households goods
		508	Others
5			Miscellaneous
	Others	601	Mixed loading
		602	Not identified
		603	Other categories

(5) Zoning

55 The Kafue Road Bridge is located on the provincial boundary-line of Lusaka and Southern Province. Basically, the characteristics of traffic flow is inter-city/inter-province. From this point of view, the Kafue Road Bridge can be simply zoned as a provincial unit. However, twenty five (25) zones depending on the network condition were established, taking into consideration that Zambia Government may further refer to this O-D table for other traffic planning.

- 1) Lusaka Province
Main traffic generating/attracting area, should be clarified and also the direction of traffic flow should be separated, such as from/to Malawi and from/to Kaom (M9).
- 2) Central Province
Traffic flow from/to Tanzania and Zaire diverge in this area. Zone should depend upon this condition.

Zoning is shown in Table 3-14.

Table 3-14 Zone Code Table

Zone	Zone Name	City and Area
1	Urban area of Lusaka City Kafue area	(Lusaka Province-1) Lusaka city - Urban area (Lusaka Province-2) Kafue town, Shimabala, Chickoswi
3	Chilanga	(Lusaka province-3) Chilanga, Mapepi, Chipongwe Mount-Makulu
4	Lusaka West	(Lusaka Province-4) West part of Lusaka Province Mwembesi, Westwood, Balmoral
5	Lusaka East	(Lusaka Province-5) East part of Lusaka Province Chongwe, Chalimbana, Ngwerere, Kasisi, Chikumbi, Karubwe, Chaiwa, Malaika, Mwenshangombe, Undaunda, Chakwenga, Rufunsa, Katondwe, Kapoche, Luangwa

Table 3-14 Zone Code Table (Continued)

Zone	Zone Name	City and Area
6	Southern Province	Livingstone, Zimba, kalomo, Choma, Pemba, Monza, Mogoye, Mazabuku, Gwembe, Chisekesi, Sisvonga, Chirundu, Maamba, Sinazongwe, Namwala, Itezhi-tezhi
7	Eastern Province	Chipata, Lundazi, Mfuwe Patauku, Katete, Chadiza, Chama
8	Numbwa area	(Central Province-1) Mumbwa, Shibuyunji, Nambala Kasula, Nalusanga, Kabile, Shakumbila
9	Kapiri area	(Central Province-2) Kapiri Mposhi, Kabwe, Chisamba Mulungusi, Lukanga, Chibombo, Litete, Mwachisompola, Chikumbi, Mkushi
10	Serenje area	(Central Province-3) Mukuku, Nasans, Selenje, Mukopa, Serenje, Ndabala, Manjolo, Konona, Chisomo, Nakosa
11	Copperbelt	Ndola, Kitwe, Luanshya, Chigola, Chilabombwe, Mifulita, Twapia, Fisenge, Chibuluma, Kalulushi, Gatneton, Chambrshi, Kansuswa Kasompe, Nchanga, Mpongwe, Bwana-Mkubwa
12	North Western Province	Solwezi, Mwinilunga, Zambezi, Kasempa, Kabompo, Chavuma, Kawana, Kelongwa, Chinyama-Litapi, Ilelenge
13	Western province	Mongu, Kaoma, Lukulu, Kalabo, Senanga, Mulobezi, Katima-Mulilo, Shikongo, Shangombo, Namushikende, Sioma, Mavua
14	Northern Province	Kasama, Mpiki, Chinsali, Isoka Mbala, Mporokoso, Mpulungu, Luwingu, Sabwa, Mayuka, Kapanda Shila, Miwnga, kabuko Nkole, Nsando, Mwenzo, Mkasa
15	Luapula province	Mansa, Kawambwa, Nchelenge, Chembe, Samfya, Matanda, Mununga, Kapata Pen Kapalala, Kashiba, Mwense

Table 3-14 Zone Code Table (Continued)

Zone	Zone Name	City and Area
16	Botswana	
17	Zimbabwe	
18	Tanzania, Kenya	
19	Malawi	
20	Mozambique	
21	Zaire	
22	Angola	
23	Rep. of South Africa	
24	Namibia	
25	Swaziland	

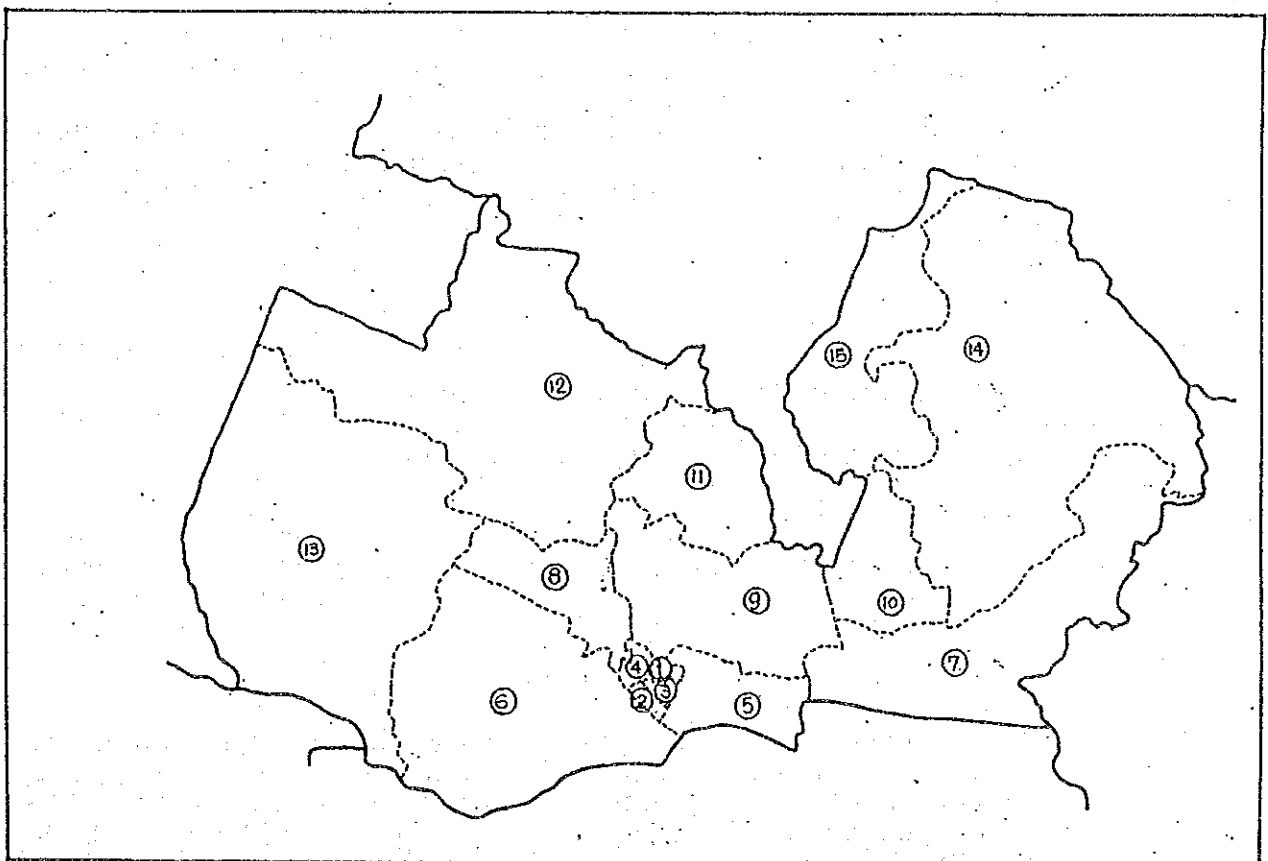


Fig. 3.10 Zone Map

(6) Survey Questionnaire

56 The questionnaire of Roadside O-D Survey is shown in Appendix 3-4. The survey instruction manual for the interviewer is shown in Annex-3-4. The instruction for the interviewer and supervisor (the leader of the interviewer) was done prior to Traffic Survey, using the Instruction manual.

3-C. RESULTS OF ROADSIDE O-D SURVEY

(1) Survey Date

57 Roadside O-D Survey was carried out on 11th Dec. 1989 to interview all vehicles passing through the Kafue road Bridge. However, the interviewing excluded some kind of vehicle, such as Ambulances, Fire engines, Post office car, Police cars, Armed service vehicles, VIP cars, construction vehicles, Regular route buses and Motor cycles etc.

		12 hrs.	24 hrs.
Roadside O-D Survey total samples	876		
	=	0.990	0.785
Traffic Count Survey total vehicles	835		
Passenger cars		0.976	0.805
Truck/Trailers		1.000	0.773
Buses		0.348	0.296

58 Total number of interviewed vehicles was 876 vehicles. Comparing to the number of counted vehicles on same survey station, the complete survey rate is 0.99 for 12 hours survey. Only 1% of total vehicles above mentioned was special mission vehicles.

(2) Origin/Destination of Trip

- 59 Origin and Destination of trips passing through the Kafue Road Bridge concentrate three main areas, Lusaka City urban area, Southern Province and Kafue area. In the case of Origin, these three areas make 88.7% of total origin trips. These three areas make 87.9% of total destination trips.
- 60 50% of those which originated from outside countries come from Zimbabwe, which shares 3.3% of total origin trips. Zimbabwe has also 53% of those which destination is outside countries and 4.3% of total destination trips.

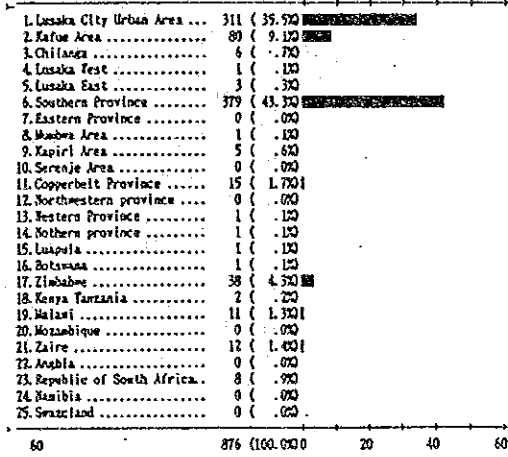
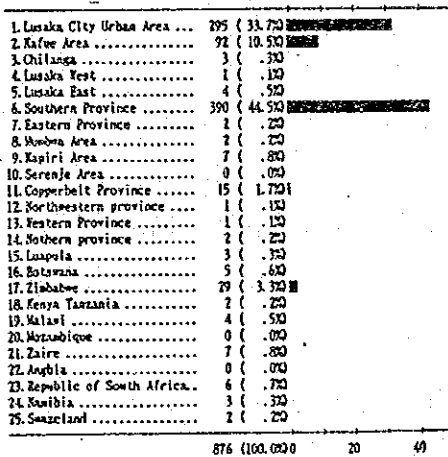


Fig. 3-11 Origin of Trips

Fig. 3-12 Destination of trips

(3) Loaded Tonnage by Truck/Lorry

- 61 81.8% of total vehicles is empty, which means 40.8% of truck/lorry is empty condition. 49.7% of loaded truck/lorry is loading materials more than 10 ton. Then 13.8% of loaded truck/lorry is carrying some goods from 6 ton to 9.9 ton. About 79.2% of loaded truck/lorry is carrying goods more than 4 ton.

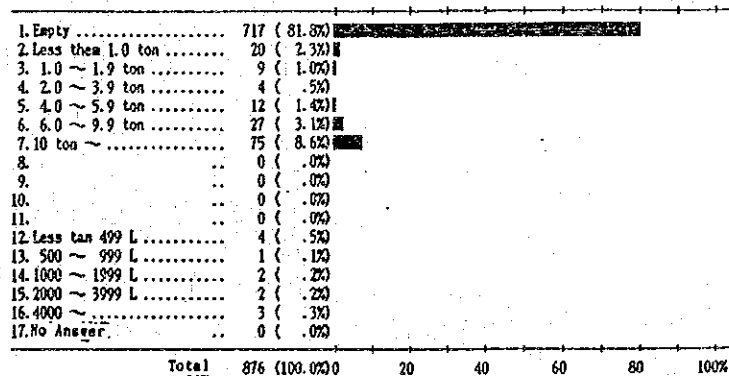


Fig. 3-13 Loaded Tonnage

(4) Trip Purpose

62

50.2% of total trips are taken for business purposes. This involves 45.7% (262 trips) of passenger cars and 85.8% (253 trips) of truck/lorry. 19.9% of total trips are taken for entertainment and pleasure purpose. This involves 26.7% (153 trip) of passenger cars, and 7.1% (21 trips) of truck/lorry. Going to work purpose is only 7.5% (43 trips) of passenger cars and 3.1% (13 trips) of passenger cars involve shopping purposes. This means that personal utilization of vehicles has not been developed yet in Zambia.

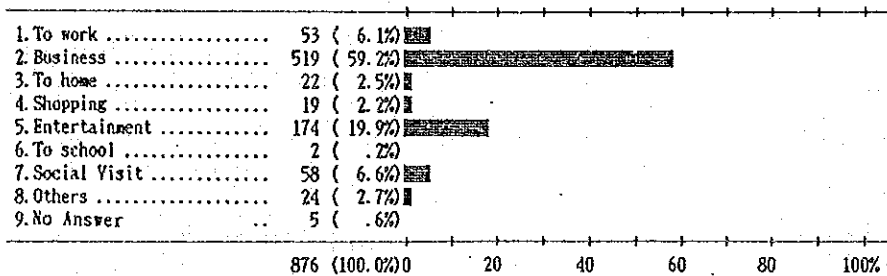


Fig. 3-14 Trip Purpose

63

Concerning the destination by trip purpose, Lusaka city shows a uniform balance for all zones. Southern province shows more weight for sightseeing and Kafue area also indicates more weight for the purpose of "to work".

(5) Loaded Goods

64

The kinds of material/goods transported are mainly as follows.

- Generating from Lusaka : Manufacturing and agricultural goods
- from Southern Pro. : Mineral, agricultural and Manufacturing goods.
- Destination to Lusaka : Mineral, agricultural & manufacturing goods.
- to Southern Pro. : Manufacturing & agricultural goods
- to Kafue : Mineral materials.
- to Zimbabwe : Agricultural goods

The original and destination by kinds of loaded goods are shown in the table in Appendix-3.

Table 3-15 Trip Purpose of Vehicle Type

Vehicle Type	Trip Purpose									
	Total	1. To work	2. Business	3. To home	4. Shopping	5. Entertainment	6. To school	7. Social Visit	8. Others	9.
1. Passenger cars	573 (100.0%)	75 (13.1%)	262 (45.7%)	70 (12.2%)	18 (3.1%)	153 (26.7%)	2 (.3%)	53 (9.2%)	21 (3.7%)	1 (.2%)
2. Truck/Lorry	295 (100.0%)	130 (44.1%)	85 (28.8%)	75 (25.4%)	35 (11.9%)	21 (7.1%)	0 (0.0%)	100 (33.9%)	100 (33.9%)	3 (1.0%)
3. Bus/Others	100 (100.0%)	12.5 (12.5%)	50 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	25 (25.0%)	0 (0.0%)	12.5 (12.5%)
4. No Answer	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
5. Total	876 (100.0%)	53 (6.1%)	519 (59.2%)	22 (2.5%)	19 (2.2%)	174 (19.9%)	2 (.2%)	58 (6.6%)	24 (2.7%)	5 (.6%)

Note: Percentage is shown in ().

Table 3-16 Loaded Material by Weight-Range

Loaded Materials	Loaded Tonnage									
	Total	1. Empty	2. Less than 1.0 ton	3. 1.0 ~ 1.9 ton	4. 2.0 ~ 3.9 ton	5. 4.0 ~ 5.9 ton	6. 6.0 ~ 9.9 ton	7. 10 ton & above	8.	9.
1. Empty	688 (100.0%)	688 (99.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (.1%)	1 (.1%)	0 (0.0%)	0 (0.0%)
2. Agricultural	37 (100.0%)	24.3 (65.7%)	8.3 (22.4%)	2.7 (7.3%)	0 (0.0%)	0 (0.0%)	1.3 (3.5%)	20 (54.1%)	0 (0.0%)	0 (0.0%)
3. Mineral goods	64 (100.0%)	4.7 (7.3%)	0 (0.0%)	3.2 (5.0%)	3.1 (4.8%)	10.9 (17.0%)	26.6 (41.6%)	33 (51.6%)	0 (0.0%)	0 (0.0%)
4. Chemical production	13 (100.0%)	23.1 (177.7%)	0 (0.0%)	7.7 (59.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	23.1 (177.7%)	0 (0.0%)	0 (0.0%)
5. Industrial products	61 (100.0%)	21.3 (34.9%)	11 (18.0%)	6.4 (10.5%)	3.3 (5.4%)	8.2 (13.4%)	8.2 (13.4%)	17 (27.9%)	0 (0.0%)	0 (0.0%)
6. Miscellaneous	13 (100.0%)	30.8 (237.0%)	46.2 (355.4%)	1.7 (13.1%)	0 (0.0%)	0 (0.0%)	7.7 (59.2%)	1.7 (13.1%)	0 (0.0%)	0 (0.0%)
7. No Answer	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8. Total	876 (100.0%)	717 (81.8%)	20 (2.3%)	9 (1.0%)	4 (.5%)	12 (1.4%)	3.1 (.3%)	8.6 (.9%)	75 (8.6%)	0 (0.0%)

Note: Percentage is shown in ().

Loaded Materials	Loaded Tonnage							
	10.	11.	12. Less than 499 L	13. 500 ~ 999 L	14. 1000 ~ 1999 L	15. 2000 ~ 3999 L	16. 4000 ~	17.
1. Empty	0 (0.0%)	0 (0.0%)	1 (.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
2. Agricultural	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.7%)	0 (0.0%)	0 (0.0%)
3. Mineral goods	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
4. Chemical production	0 (0.0%)	0 (0.0%)	23.1 (177.7%)	7.7 (59.2%)	0 (0.0%)	7.7 (59.2%)	7.7 (59.2%)	0 (0.0%)
5. Industrial products	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3.3 (5.4%)	0 (0.0%)	3.3 (5.4%)	0 (0.0%)
6. Miscellaneous	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
7.	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8. Total	0 (0.0%)	0 (0.0%)	4 (.5%)	1 (.1%)	2 (.2%)	2 (.2%)	3 (.3%)	0 (0.0%)

Table 3-17-C Present 0-D Table (Truck/Lorry)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
	ZONE01	ZONE02	ZONE03	ZONE04	ZONE05	ZONE06	ZONE07	ZONE08	ZONE09	ZONE10	ZONE11	ZONE12	ZONE13	ZONE14	ZONE15	ZONE16	ZONE17	ZONE18	ZONE19	ZONE20	ZONE21	ZONE22	ZONE23	ZONE24	ZONE25	TOTAL
(1)	0	0	0	0	3	115	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	144	
(2)	3	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	
(3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
(4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(5)	102	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
(6)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142	
(7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(8)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(9)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(11)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(12)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(13)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(14)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(15)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(16)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(17)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(18)	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(19)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(20)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(21)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(22)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(23)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(24)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL	113	27	1	0	3	133	0	0	3	0	8	0	1	1	1	1	34	3	2	0	13	0	7	0	0	375

Table 3-17-D Present 0-D Table (Others)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
	ZONE01	ZONE02	ZONE03	ZONE04	ZONE05	ZONE06	ZONE07	ZONE08	ZONE09	ZONE10	ZONE11	ZONE12	ZONE13	ZONE14	ZONE15	ZONE16	ZONE17	ZONE18	ZONE19	ZONE20	ZONE21	ZONE22	ZONE23	ZONE24	ZONE25	TOTAL
(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(4)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(5)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(6)	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
(7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(8)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(9)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(11)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(12)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(13)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(14)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(15)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(16)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(17)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(18)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(19)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(20)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(21)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(22)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(23)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(24)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(25)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42

(6) Trip Pattern

61 Traffic flow trip patterns are summarized as follows;

(a) The main traffic flow of total trips is as follows:

1. Lusaka to/from Southern Province: 688 trips (62%)
2. Kafue to/from Southern Province: 219 trips (20%)
3. Lusaka to/from Zimbabwe: 39 trips (4%)
4. Copperbelt to/from Southern Province: 35 trips (3%)

(b) The main traffic flow of passenger cars is as follows:

1. Lusaka to/from Southern Province: 460 trips (67%)
2. Kafue to/from Southern Province: 151 trips (22%)
3. Lusaka to/from Zimbabwe: 14 trips (2%)

(c) The main traffic flow of trucks/lorries is as follows:

1. Lusaka to/from Southern Province: 217 trips (58%)
2. Kafue to/from Southern Province: 56 trips (15%)
3. Lusaka to/from Zimbabwe: 24 trips (6%)
4. Zimbabwe to/from Zaire: 14 trips (4%)
5. Copperbelt to/from Southern Province: 13 trips (3%)

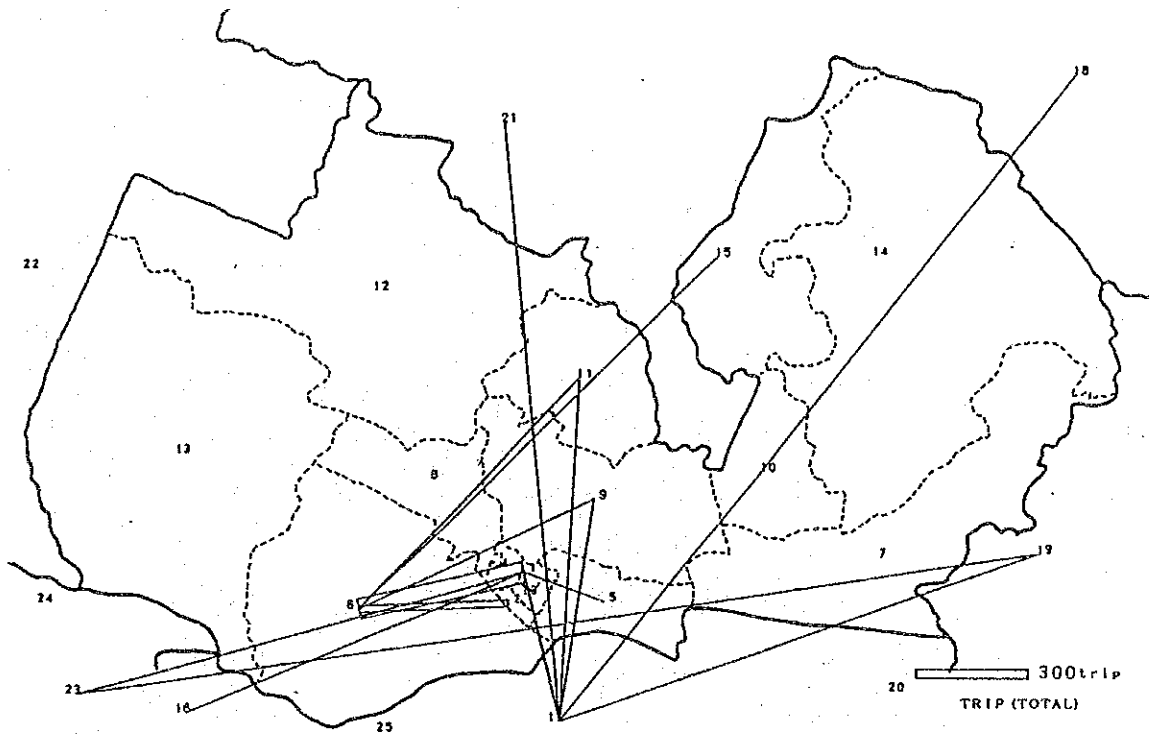


Fig. 3-15 Pattern of total trips

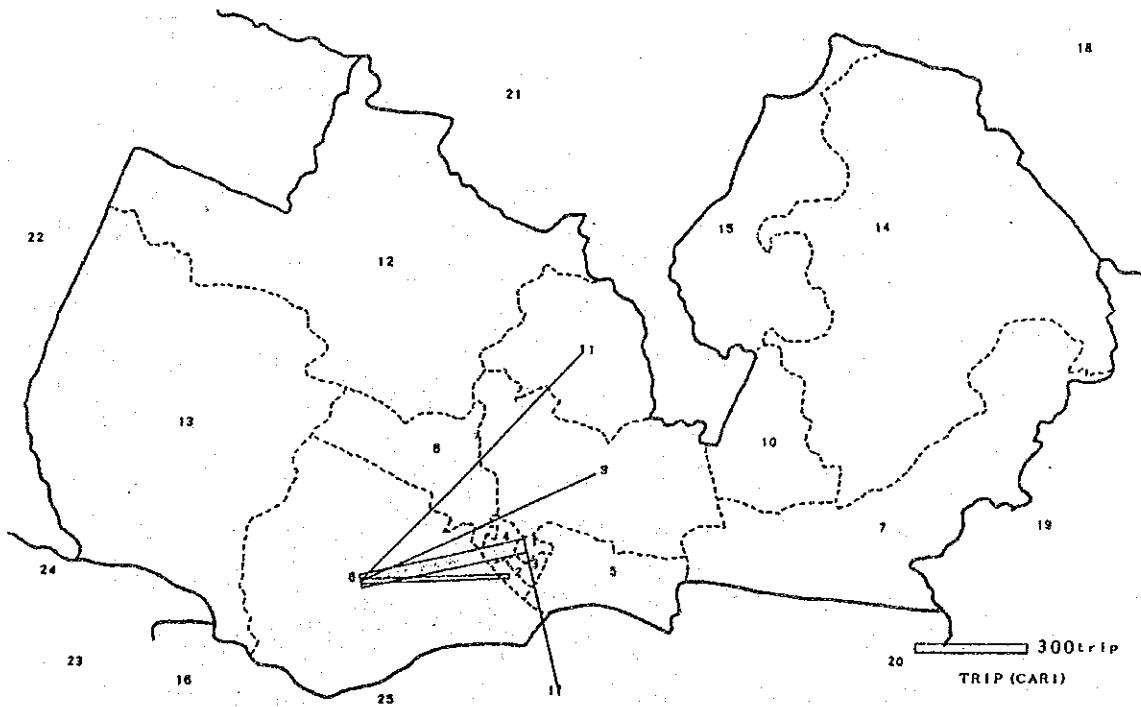


Fig. 3-16 Pattern of Passenger Cars

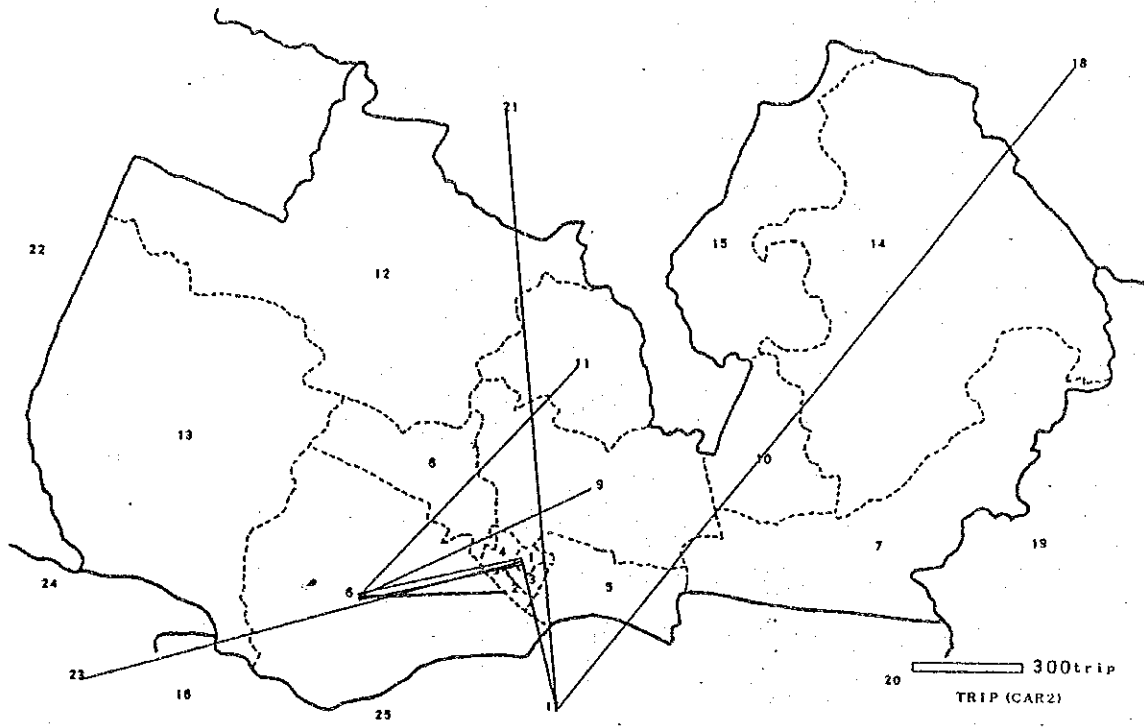


Fig. 3-17 Pattern of truck/lorry

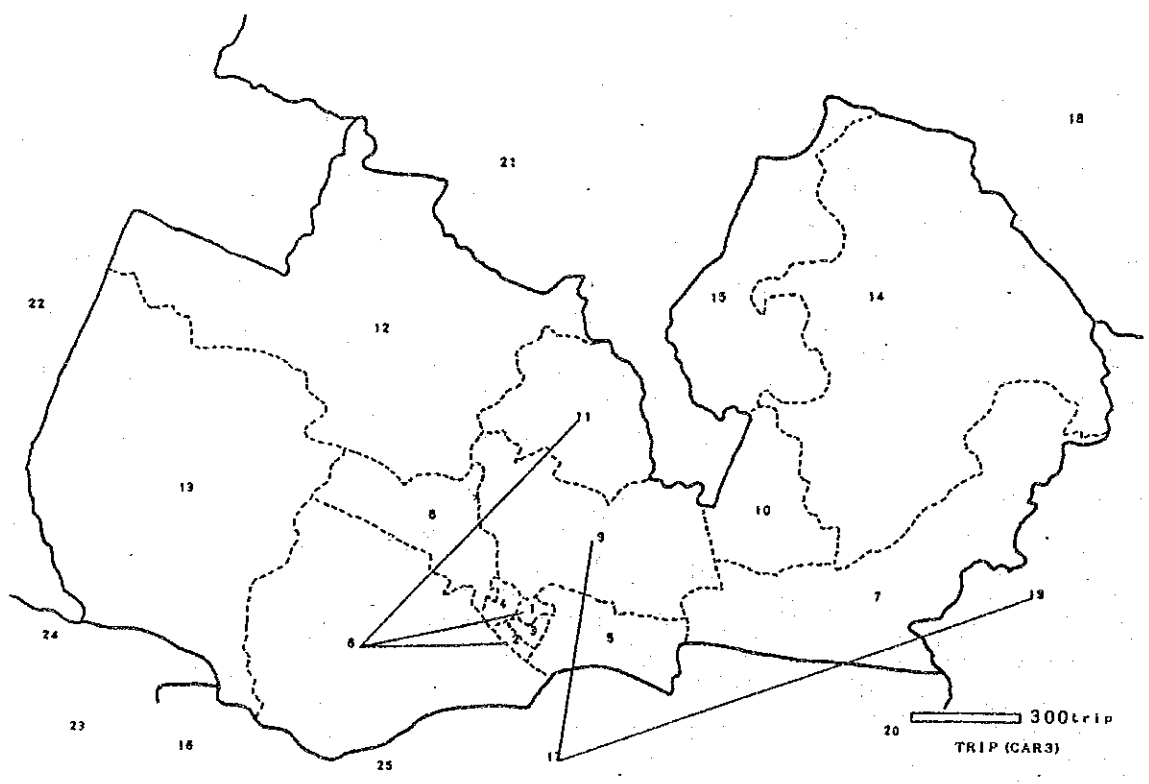


Fig. 3-18 Pattern of Others

(7) Trip Pattern by Loaded Materials

62 The main traffic flows for trip pattern by loaded materials are summarized as follows:

1) Agricultural materials

1. from Southern Province to Lusaka 19 trips (37%)
2. from Lusaka to Southern Province 9 trips (18%)
3. from Lusaka to Zimbabwe 4 trips (8%)

2) Mineral materials

1. from Southern Province to Lusaka 51 trips (51%)
2. from Lusaka to Southern Province 12 trips (15%)
3. from Namibia to Zaire 4 trips (5%)

3) Chemical Products

1. from Zimbabwe to Malawe 7 trips (35%)
2. from Southern Province to Lusaka 6 trips (30%)
3. from Copperbelt to Southern Province 3 trips (15%)

4) Industrial Products

1. from Lusaka to Southern Province 28 trips (36%)
2. from Southern Province to Lusaka 11 trips (14%)
3. from copperbelt to Southern Province 7 trips (9%)
4. from Kafue to Southern Province 6 trips (8%)

The O-D tables by loaded materials are shown in Appendix-3.

3-D. ESTIMATION OF FUTURE TRAFFIC VOLUME

(1) Present O-D Table

- 63 The Present O-D Table, which is the most basic data to estimate the future traffic volume, is applied from results of Roadside O-D survey. As the O-D table that has been surveyed by DANIDA is not available, 12 hours data of the roadside traffic survey by Study Team has been enlarged to 24 hours data by relying on the 24 traffic count data of same data.
- 64 The present O-D table of 1989 shows the exact contents of the present traffic flow at the Kafue road Bridge. However, the traffic contents of other road sections has not been grasped accurately. It will be a part of traffic volume on other road sections. In order to forecast the future traffic volume on the Kafue road bridge, this present O-D table will be utilized on such road sections due to unavailability of alternative detour roads.

(2) Growth Factor of Each Zone

- 65 It can be forecasted that the automobile ownership ratio (per capita automobile) will not change significantly because the growth of Zambia Economy in the forth National Development Plan has been forecast to be static. From this point of view, the growth of passenger cars will be in proportion to the growth of population.
- 66 Population is the most correlative factor with the utilization of passenger cars. Therefore, the growth rate of population has normally been applied to the growth factor of passenger cars volume.

67 The utilization of truck/lorry will depend upon the scale of economic/social activities in the country. In Zambia, the volume of truck movements is generated not only by the industrial activities, but by the necessities of life transported from outside countries. The growth of GDP (Gross Domestic Product) that in general represents socio-economic activities shall be adopted in determining the growth of truck/lorry volume. All other data showing either regional or nationwide economic and social activities in both present and future are unavailable in Zambia.

(a) Growth of population

68 From the census figures, Zambia had 5,577 thousands people in 1980. It is estimated 7,804 thousands in 1989. Recent growth rates of that the population will be 1987/86 and 1988/87 are 4.3% and 3.6%. FNDP (Fourth National Development Plan) uses a target of 3.6% which is equivalent level to the present condition. These are shown in Fig. 3-18.

Table 3-18 Selected Indicators

Item	Unit	1984	1985	1986	1987	1988
1. Population	Mil.	6.42	6.72	6.95	7.27	7.53
2. Growth Domestic Product						
At current purchaser's value	K'mil.	4931.0	7071.9	12963.1	16631.6	22495.1
At 1977 Constant purchaser's value	K'mil.	2011.5	2044.4	2059.3	2105.6	2161.5
At 1977 purchaser's value	K'mil.	1901.9	1988.3	2048.0	2094.1	2094.0
3. Per capita GDP						
At current prices	Kwacha	768.1	1052.4	1863.8	2700.4	2987.4
At 1977 constant prices	Kwacha	313.3	304.2	295.3	289.6	287.1
4. National Income						
At current market prices	K'mil.	3925.7	5430.0	8381.0	14444.9	15541.3
5. Per capita National Income						
At current prices	Kwacha	611.5	808.0	1205.9	1986.9	2063.9
6. Gross National Product						
At current prices	K'mil.	4556.0	6362.8	10622.6	17848.3	19816.4

Source : Monthly Digest Statistics, Oct.-Dec. 1988.
Central Statistical Office

Table 3-19 Population by Province 1989

PROVINCE	DISTRICT	AUGUST 1980 CENSUS			1969	1989
		MALE	FEMALE	TOTAL	CENSUS TOTAL	PROJECTED TOTAL
CENTRAL	KABWE RURA	73499	72796	146295	122570	204976
	KABWE TOWN	69356	66677	136033	65974	209822
	MKUSHI	37040	35150	72190	56992	91042
	MUMBWA	42028	41879	83907	60138	115563
	SERENJE	35311	37969	73480	52981	101034
	TOTAL	257234	254471	511905	358655	722437
C/BELT	CHILILABOM	32122	30009	62131	44862	84596
	CHINGOLA	75143	70850	145993	103292	201384
	KALULUSHI	30473	28794	59267	32272	99686
	KITWE	165922	154398	320320	199798	495067
	LUANSHYA	67177	62412	129589	96282	171039
	MUFULIRA	76682	73387	150069	107802	206412
	NDOLA RURA	51084	51410	102494	72215	141074
	NDOLA URBA	143828	137487	281315	159786	467191
TOTAL	642431	608747	1251178	816309	1866448	
EASTERN	CHADIZA	21303	23576	44879	32169	60826
	CHAMA	15792	19567	35359	30887	40863
	CHIPATA	97435	107303	204738	148416	274048
	KATETE	44236	49972	9208	80485	110805
	LUNDAZI	53114	61539	114653	92247	142529
	PETAUKE	72263	84804	157065	125311	197023
	TOTAL	304143	346761	565902	509515	826094
LUAPULA	KAWAMBWA	30049	33255	63304	54706	73646
	MANSA	54323	57114	111437	80342	150245
	MWENSE	30849	34703	65552	52974	81160
	NCHELENGE	38347	41886	80233	56755	109651
	SAMFYA	47106	53334	100440	90807	111625
TOTAL	200674	220292	420966	335584	526327	
LUSAKA	LUANGWA	5559	5903	11462	7925	14093
	LUSAKA RUR	72642	71120	143762	83625	216096
	LUSAKA URB	273804	262026	535830	262425	921061
TOTAL	352005	339049	691054	353975	1151250	
NORTHERN	CHILUBI	14229	19056	33285	32178	34502
	CHINSALI	31459	34715	66174	58015	75990
	ISOKA	43923	50076	93999	77700	113927
	KAPUTA	22155	22576	44731	28425	64969
	KASAMA	70571	77023	147594	107817	196118
	LUWINGU	24670	27926	52596	46986	59314
	MBALA	54304	59631	113935	95633	136177
	MPIKA	38841	42450	81291	59378	107994
	MPOROKOSO	19551	21594	41145	38965	43734
	TOTAL	319703	355047	674750	545097	832725

AUGUST 1980 CENSUS		1969			1989	
PROVINCE	DISTRICT	MALE	FEMALE	TOTAL	CENSUS TOTAL	PROJECTED TOTAL
NORTH-	CHIZERA	4339	4947	9286	9776	8388
WESTERN	KABOMPO	18907	21440	40347	33376	49312
	KASEMPA	14435	16171	30606	22880	40804
	MWINILUNGA	32723	36122	68845	51398	91914
	SOLWEZI	45644	47129	92773	52979	146807
	ZAMBEZI	28031	32780	60811	61324	58871
	TOTAL	144079	158589	302668	231733	396096
SOUTHERN	CHOMA	62942	67474	130416	97980	173492
	GWEMBE	9748	10918	20666	18491	23068
	KALOMO	46952	50225	97177	76571	123894
	L/STONE	36632	34889	71521	49063	102283
	MAZABUKA	56660	55598	112258	80051	155796
	MONZE	53535	56888	110423	79325	152281
	NAMWALA	27546	28512	56058	36600	82795
	SIAVONGA	13983	15650	29633	21231	41012
	SINAZONGWE	20344	23427	43771	36729	52295
	TOTAL	328342	343581	671923	496041	906914
WESTERN	KALABO	43098	55398	98496	93840	104047
	KAOMA	32254	37812	70066	50937	92162
	LUKULU	20260	24540	44800	38194	52480
	MONGU	52375	62030	114405	89495	143417
	SENANGA	46263	55694	101957	88602	117645
	SESHEKE	26934	29797	56731	49019	65732
	TOTAL	221184	265271	486455	410087	575483
	G.Total	2769795	2891808	5576801	4056996	7803774

- 69 Almost half of total population is less than 15 years-old. It is estimated that 1,600 thousands people are under 5 years old in 1989 (1,800 thousands people in 1993), 1,700 thousands people are Primary school children (2,000 thousands people in 1993) and 1,600 thousands people are 15-24 years old (1,800 thousands people in 1993).
- 70 In order to estimate the future passenger cars volume, it is necessary to examine the population by Zone. Zone is basically formed by principal scale. The population of Provinces and their districts in 1969 are shown in Table 3-19 as estimated by Zambia Central Statistical Office. The future projected population by Provinces in 1993 by FNDP is also shown in Table 3-20. Tendency in current urban concentration has fallen down and it is assumed by FNDP that the situation will continue up to 1993. At that time, the future population by Zone is forecasted to divide for the population on 1993 from Table 3-19 by the share (%) of Zone in the province on 1989.
- 71 Moreover, concerning the population in 2000, it does not appear that population growth changes drastically. It will be reasonable to utilize the present population growth. Therefore, the total population is estimated by the annual growth rate of 3.6%. The zonal population can also be figured out by the present zonal ration.

Table 3-20 Projected population 1993

Province	1989	1993	93/89
Central	722,437	849,218	1,175
Copperbelt	1,866,488	2,252,435	1,207
Eastern	826,094	923,590	1,118
Luapula	526,327	586,693	1,109
Lusaka	1,151,253	1,449,151	1,259
Northern	832,723	916,558	1,101
North Western	396,592	448,975	1,132
Southern	906,914	1,042,761	1,150
Western	575,481	618,195	1,074
Total	7,804,309	9,034,582	1,158

Source : FNDP

(b) Gross Domestic Products

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In Zambia, continuous economic recession brought coincidentally by the second oil crisis of 1979/80 has been taken place. The GDP in real terms, at 1977 price, registered only a marginal increase from K. 1986 million to K. 2012 million during 1977-1984, then K. 2106 million in 1987 and K. 2161.8 mil in 1988. Per capita GDP in real terms has been declining since 1977 at an annual average of 3.0 percent from K. 382 in 1977 to K. 296 in 1984 and K. 283 in 1987. The share of copper mining in GDP has fallen gradually since 1964, which is the most primary commodity, due to the declining copper prices. The interaction of low copper prices and recent rising oil price created a foreign exchange problem and also put the Zambian economy under serious pressure. These issues are shown in Table 3.21.

Table 3-21 Basic Economic Indicators

	1980	1984	1985	1986	1987	1988
GDP current price (K'nmillion)	3063.0	4931.0	7071.9	12953.5	18079.8	
GDP constant Price 1977 (K' mil)	1966	2011.5	2044.5	2056.3	2105.6	2161.0
Foreign Debt (Stock at the end of year) (US\$. mil.)	1800	5295.5	4627.0	5300.0	6300.0	
Per capita GDP constant price adjusted for terms of trade	181	296.2	295.9	294.2	283.4	
Trade Balance	2733	508.5	657.5	952.9	2106.9	
Current Account balance surplus (deficit) - BOP	(7842)	(317.0)	(429.2)	2346.0)	(317.6)	
Government Revenue/Grants	13200	1119.9	1602.4	3225.6	3630.6	
Government current expenditure	1082	1302.1	2343.1	4448.0	3787.2	
Current account surplus (deficit)	138	(182.2)	(740.7)	(1222.4)	(156.6)	
Rate of inflation (CPI)	11.6	23.7	53.7	36.7	54.4	
Employees (formal) (1000 persons)	379	364.2	361.5	360.5	356.6	
Labour force (1000 persons)	2699	3122	3247	3376	3486	
Overall Government Budget Deficit	(14.3)	(7.3)	(14.1)	(16.9)	(4.7)	
GDP growth rate over previous year (%)				0.7	2.2	2.7

Source : FNDP - NCDP

- 73 The targets of FNDP on 1993 are shown in Table 3-22. The annual growth rate of GDP in real term at present and on 1993 are -0.2% and 3.0% respectively. The case for the year 2000 is assumed the same situation as FNDP. That is, the growth rate of GDP up to year 2000 will be able to set as 3.0% on the average.

Table 3-22 FNDP Targets

Macro Economic Indicator	1987 Level	FNDP Targets
1. Real GDP Growth rate (%)	-0.2	3.0
2. Population Growth rate (%)	3.6	3.6
3. Government Deficit (as % of GDP)	14	2
4. Money Supply - M3 K'1000	6265	12438
5. Rate of inflation (%)	45	20
6. Overall investment Outlay (K'1000)	3877	2300
(i) Government	1199.2	6088.6
(ii) Parastatal	1666.2	10174.7
(iii) Private	1010.9	6136.7
7. Formal Sector Employment	357000	400000
8. Per capita GDP	2511	3539
9. Share of Non Traditional Exports in total Export	16	20
10. Contribution of Private Sector to GDP (%)	40	45

Source : FNDP - NCDP

(3) Road Network

- 74 The road network for the traffic assignment is composed of main trunk roads of Zambia. Down to the South from Lusaka, T2 Road runs through Chilanga, Kafue and Kafue Road Bridge. Then M2 Road diverges on two directions toward Mazabuka, Livingstone (T2) and toward Chirundu (T1). These directions from Lusaka have no other alternative routes. Traffic to/from Zimbabwe, Botswana, Namibia and Republic of South Africa should pass through these route as the critical (shortest) routes.
- 75 The condition of traffic assignment is set for the running speed as 60 km/h for Passenger Cars and 40 Km/h for trucks. Almost all the links (sections) have been paved and travelled by high speed driven cars even if at the rural area. Considering the lack of alternative routes, at the traffic assignment, the shortes time

Table 3-23-A Future O-D Table (Total Trips 1992)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1)	0	0	5	0	5	364	0	0	0	0	0	0	1	0	0
(2)	1	0	0	0	0	127	0	0	0	0	0	0	0	0	0
(3)	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0
(4)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
(5)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(6)	414	122	2	1	0	0	0	1	4	0	17	0	0	1	1
(7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(8)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
(9)	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
(10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(11)	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0
(12)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(13)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
(14)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
(15)	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
(16)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(17)	15	0	0	0	0	0	0	0	7	0	5	0	0	0	0
(18)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(19)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(20)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(21)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(22)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(23)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(24)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(25)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TOTAL	441	122	8	1	5	528	0	1	11	0	23	0	1	1	1

Table 3-23-B Future O-D Table (Total Trips 1992) (cont'd)

	16	17	18	19	20	21	22	23	24	25	TOTAL
(1)	1	29	0	0	0	0	0	8	0	0	413
(2)	0	0	0	0	0	0	0	0	0	0	128
(3)	0	0	0	0	0	0	0	0	0	0	5
(4)	0	0	0	0	0	0	0	0	0	0	1
(5)	0	1	0	1	0	1	0	0	0	0	4
(6)	0	0	0	0	0	1	0	0	0	0	564
(7)	0	2	0	0	0	0	0	0	0	0	2
(8)	0	0	0	0	0	0	0	0	0	0	2
(9)	0	1	0	0	0	0	0	0	0	0	9
(10)	0	0	0	0	0	0	0	0	0	0	0
(11)	0	3	0	0	0	0	0	1	0	0	23
(12)	0	0	0	0	0	0	0	0	0	0	1
(13)	0	0	0	0	0	0	0	0	0	0	1
(14)	0	0	0	0	0	0	0	0	0	0	2
(15)	0	0	0	0	0	0	0	0	0	0	4
(16)	0	0	0	2	0	0	0	0	0	0	5
(17)	0	0	3	9	0	8	0	0	0	0	47
(18)	0	3	0	0	0	0	0	0	0	0	3
(19)	0	4	0	0	0	0	0	1	0	0	5
(20)	0	0	0	0	0	0	0	0	0	0	0
(21)	0	7	0	0	0	0	0	1	0	0	8
(22)	0	0	0	0	0	0	0	0	0	0	0
(23)	0	0	0	4	0	1	0	0	0	0	7
(24)	0	0	0	0	0	4	0	0	0	0	4
(25)	0	0	0	1	0	0	0	0	0	0	2
TOTAL	1	50	3	17	0	15	0	11	0	0	1240

Table 3-23-C Future O-D Table (Total Trips 2000)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1)	0	0	18	0	19	857	0	0	0	0	0	0	5	0	0
(2)	148	0	0	0	0	163	0	0	0	0	0	0	0	0	0
(3)	15	0	0	0	0	2	0	0	0	0	0	0	0	0	0
(4)	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
(5)	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(6)	638	237	3	2	0	0	0	2	7	0	21	0	0	1	1
(7)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(8)	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
(9)	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0
(10)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(11)	0	0	0	0	0	31	0	0	0	0	0	0	0	0	0
(12)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(13)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
(14)	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
(15)	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
(16)	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(17)	61	0	0	0	0	0	0	0	10	0	17	0	0	0	0
(18)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(19)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(20)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(21)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(22)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(23)	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(24)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(25)	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
TOTAL	883	237	18	2	19	878	0	2	17	0	40	0	5	1	1

Table 3-23-D Future O-D Table (Total Trips 2000) (cont'd)

	16	17	18	19	20	21	22	23	24	25	TOTAL
(1)	3	115	0	0	0	0	0	27	0	0	839
(2)	0	0	0	0	0	0	0	0	0	0	309
(3)	0	0	0	0	0	0	0	0	0	0	17
(4)	0	0	0	0	0	0	0	0	0	0	2
(5)	0	0	0	3	0	7	0	0	0	0	14
(6)	0	0	0	0	0	0	0	0	0	0	912
(7)	0	3	0	0	0	0	0	0	0	0	3
(8)	0	0	0	0	0	0	0	0	0	0	3
(9)	0	3	0	0	0	0	0	0	0	0	15
(10)	0	0	0	0	0	0	0	0	0	0	0
(11)	0	8	0	0	0	0	0	2	0	0	41
(12)	0	0	0	0	0	0	0	0	0	0	2
(13)	0	0	0	0	0	0	0	0	0	0	1
(14)	0	0	0	0	0	0	0	0	0	0	3
(15)	0	0	0	0	0	0	0	0	0	0	6
(16)	0	0	0	4	0	0	0	0	0	0	13
(17)	0	0	5	11	0	6	0	0	0	0	110
(18)	0	5	0	0	0	0	0	0	0	0	5
(19)	0	7	0	0	0	0	0	1	0	0	8
(20)	0	0	0	0	0	0	0	0	0	0	0
(21)	0	10	0	0	0	0	0	1	0	0	11
(22)	0	0	0	0	0	0	0	0	0	0	0
(23)	0	0	0	6	0	1	0	0	0	0	15
(24)	0	0	0	0	0	9	0	0	0	0	9
(25)	0	0	0	2	0	0	0	0	0	0	4
TOTAL	3	151	5	26	0	23	0	31	0	0	2342

route will be already fixed. Therefore, the running speeds will not have effect in this case.

(4) Future O-D Table

- 76 The estimated future O-D table is shown in Table 3-23. The Present O-D Table is shown in Table 3-17.

(5) The Assigned Traffic Volume

- 77 The traffic assignment has been made based on the shortest time route assignment, all or nothing method. The assigned traffic volume at Kafue Road Bridge is estimated as 1,219 vehicles/day in 1992 and 2,126 vehicles/day in 2000. This is shown in Table 3-24.

Table 3-24 Forecasted Traffic Volume at Kafue Road Bridge

Year	1992	2000	1993/2000
Passenger Cars total	824	1335	1.58
Lusaka to Kafue	376	631	1.68
Livingstone to Lusaka	448	755	1.69
Truck/Lorry total	395	740	1.87
Lusaka to Kafue	214	432	2.02
Livingstone to Lusaka	181	303	1.70
Total volume	1219	2126	1.74

- 78 The traffic count survey by Road Department in 1989 shows a total of 911 vehicles per day. In this case, the traffic growth rate of 1992/89 and 2000/89 are 1.338 and 2.334. Traffic Survey by Study Team on Dec. 1989 shown total 1,116 vehicles per day. Comparing with this case, the growth rate of 1992/89 and 2000/89 are estimated 1.092 and 1.905 respectively.

- 79 The heavy weight vehicle ratio which represents the ratio of Truck/Lorry is as shown in Table 3-25. The ratio of heavy weight vehicles does not increase so much in future.

Table 3-25 The Heavy Weight Vehicles Ratio

	1989	1992	2000	2000/89
	(%)	(%)	(%)	(%)
Heavy Weight vehicle Ratio	34.0	32.4	34.8	1.024

80 The contents of assigned traffic volume in 1992 and 2000 are shown in Table 3-26. It shows the main traffic flows are Lusaka-Southern province (778 vehicles/1992 and 1295 vehicles/2000), Kafue-Southern province (249 vehicles/1992 and 400 vehicles/2000) Lusaka-Zimbabwe (44 vehicles/1992 and 176 vehicles/2000) and Copperbelt Southern province (36 vehicles/1992 and 52 vehicles/2000).

Table 3-26 Contents of Traffic on Kafue Road Bridge

	1989	1992	2000
1. Lusaka-Southern Province	688 (62%)	778 (64%)	1295 (61%)
2. Kafue-Southern Province	219 (20%)	249 (20%)	400 (19%)
3. Lusaka-Zimbabwe	39 (4%)	44 (4%)	176 (8%)
4. Copperbelt-Southern Province	35 (3%)	36 (3%)	52 (2%)

CHAPTER 4



SITE INVESTIGATIONS

- 4-A TOPOGRAPHIC SURVEY
- 4-B HYDROGRAPHIC SURVEY
- 4-C GEOLOGICAL SURVEY
- 4-D AXLE WEIGHT TEST

CHAPTER 4 SITE INVESTIGATION

4-A. TOPOGRAPHIC SURVEY

(1) General

- 81 Preliminary assessment was carried out to review extent and accuracy of the existing survey results covering an area around Kafue Road Bridge. 1:5,000 scale topographic map was produced using an aerial photograph of 1:30,000.
- 82 Based upon the topographic map, and the drawings related to raising of Kafue Road Bridge supplied by the Roads Department, and based on survey records of cross section of Kafue River by Water Development & Irrigation Department, the new topographic survey and soundings of Kafue River (over an area covering the existing and new alignment) was prepared. Data from the site reconnaissance was also carefully studied.
- 83 Upon completion of the site reconnaissance, it was found that all stations of triangulation around Kafue Road Bridge were located far from the site and have become inaccessible because of a thick forest. Since these stations were found to be unusable, 5-temporary bench marks made of concrete mortar were established near the Kafue Road Bridge. No. 5 bench mark was given local coordinates of $X=10,000$ and $Y=10,000$. The direction angle oriented from No. 5 to No. 4 was determined to be $319^{\circ}-28'$. The coordinates of each bench mark are also shown in Table 4-1.

Table 4-1 Local Coordinates of Bench Marks

No. of Bench Mark	X	Y
T0	11,499,872	9,355,870
T1	11,083,067	9,483,738
T2	10,928,882	9,536,194
T3	10,455,163	9,697,361
T4	10,223,153	9,809,184
T5	10,000,000	10,000,000

- 84 With the assistance and information by the Department of Survey, bench marks within 3 km from Kafue Bridge were investigated. As a result, it was discovered that most bench marks alongside roads were either destroyed or lost and none of them could be utilized as bench marks. A bench mark on the abutment of Kafue Bridge was relocated when the bridge was raised, and the elevation data was not available.
- 85 Due to these facts, leveling was done with setting a bench mark at Kasaka Gauge Station as a reference point. This bench mark has been set on the basis of the bench mark of Kafue Bridge before raising and another at approx. 1.6 km off the bridge toward Kasaka. Gauge height to Port Elizabeth Datum has been used.
- 86 Terrain surrounding Kafue Bridge is swampy. The waterway and marshes have been influenced by back water of impoundment of Kafue Gorge Dam.
- 87 The topographical survey was entrusted to a local consultant, John Burrow & Partners (Overseas), under the supervision of the survey specialist of JICA Study Team.

(2) Topographic Survey for Kafue Road Bridge

- 88 The topographic survey involved the following:

(a) A 1:100 scale plot by plane table survey was produced at 1 m vertical intervals, for an area of 350 m x 1600 m including existing bridge and approach road.

The plot was supplemented by surveys using optical methods to fix accurately the position of the existing structures including 11 k pylons and telephone poles;

(b) A line traverse at 20 m intervals along the proposed new alignment and/or existing alignment was carried out over a distance of 1.5 km, including the taking of additional levels at the top and bottom of abrupt changes in terrain.

The longitudinal profile, 1:200 scale, was produced based on the results of this work;

(c) A cross sectional survey in a 60 m wide band was carried out along the proposed new alignment. The cross sectional survey covers the cross section of existing alignment within the wide band.

(d) A 1:200 scale plot was prepared to cover an area of 40 m x 40 m at proposed abutments.

4-B. HYDROGRAPHIC SURVEY

- 89 Hydrographic survey has been carried out to investigate river bed topography and flow condition, and to ascertain scouring circumstance of piers based on the investigation.
- 90 The river bed survey at the existing bridge was made using steel tapes with weight when the current was slow. The survey was verified by drill rods afterwards. The same survey was made along the proposed new alignment and it was found that water depth would be approx. 8.0 - 10.0 m and is dependent on discharge of Kafue Gorge Dam.
- 91 4-river bed profiles at 50 m upstream and 50 m, 100 m and 150 m downstream of the existing bridge were surveyed.

4-C. GEOLOGICAL SURVEY

(1) Locations of Boreholes

- 92 Prior to allocating borehole positions, a preliminary assessment was made based on available geological data of the existing bridge and geological data collected for Kafue Rail Bridge in 1980. As far as geological data of the existing bridge is concerned, only log of boreholes were found and physical features were not identified. These were, however, useful to make assessment of subsurface conditions.
- 93 Based on geological data of the existing bridge, it was found that composition of affected earth layer was not too complicated and that bearing stratum was well defined to cover a wide area. However, the river bed around the existing bridge was expected to be severely scoured, judging from results of river bed survey.

94 Based on these assessment results, borehole locations were taken along the center the new alignment. It was also decided to bore as close to existing piers and abutments as possible, since the river bed at the existing bridge location was assumed to have become lower than its original elevation. The location of boreholes is shown in Appendix 4-1.

(2) Borehole and Test

95 15 borings were taken. Standard penetration tests were conducted every 1 m of every borehole as a general rule. Geological profile are as shown in Appendix 4-2 and 4-3.

96 Other surveys as listed below were also made:

- 1) dynamic cone penetration test
- 2) horizontal load test in holes.
- 3) Soil test in laboratory

(3) Outline of Ground Condition

97 Within the river channel, upper layer of gravel and most of sedimentary rock layer made of sand and mud stone were eroded and transported downstream by the water and soft sediment has been deposited afterward. The sediment is approximately 0.2-0.4 m thick at existing bridge and 0.2-2.0 m thick at the new alignment. Soft rock is exposed directly below the sediment.

(a) Gravel

98 Gravel stratum uniformly distributes in the Livingstone side with the thickness of approx. 2 m. This stratum is composed of coarse sand and hard subcircular gravel of size max = 50 mm. N-values vary between 11 and 50, however, compaction seems average.

(b) Sediment

99 The sediment is distributed only in the river. The layer thickness is 2-4 m along the existing bridge and 0.5 - 2 m along the new alignment. Soil is mostly dark grey sandy silt. Consistency is self-penetration by rod weight and extremely soft.

(c) Sandstone/Mudstone I

100 This stratum is made up of sediment rock such as sand and mud stone and is similar to the sandstone/mudstone II (soft rock). Because the layer possesses N-value below 50, the layer was classified and distinguished from the soft rock. The layer distributed around both abutments and along the existing embankment, and is not distributed along the center of the river near existing bridge.

(d) Sandstone/Mudstone II (Soft Rock)

101 This layer is predominant over the site and is composed mainly of fine grained sand stone and mud stone. Its color is pale grey or reddy purple. Solidity at the Lusaka side is high and approx. 30 cm long bar shaped cores were taken.

4-D. AXLE WEIGHT TEST

102 Traffic survey made in December, 1989 indicated that the trucks composed 37.8 % of the traffic. The ratio of heavy vehicles was found to be extremely high.

103 On 29th January, 1990 (Monday), an axle load test was conducted for heavy vehicles. As all of loaded heavy vehicles were heading to Lusaka, vehicles oriented to Chirundu and Livingstone were not tested. 31 vehicles were tested and two (2) among them were not loaded. A detail of loaded vehicles are as follows.

Single Axle Two Wheels	Double Tandem Axle	Tripple Axle
6	8	17

104 The maximum axle weight allowed to Class I (paved) Road by Roads Department is as follows:

Single axle fitted with two wheels	8,000 kg
Single axle fitted with two pairs of wheels ...	10,000 kg
Double tandem axle with weight evenly distributed over four wheels	14,500 kg
Double tandem axle with weight evenly distributed over twelve wheels	16,330 kg
Triple axle with weight evenly distributed over twelve wheels (approximately)	23,000 kg

105 The bulk of tested loaded vehicles were found to be overloaded. The excess load was 30-50% of the allowable weight. Reviewing weighbridge overweight reports collected at 5-truck weighing stations in Zambia, a great deal of vehicles is found to be overloaded, detained, warned and adjusted, accordingly.

106 The road to be surveyed is an international trunk road and vehicles passing by from several nationalities. Therefore, it is impossible to implement an axle load test on every vehicle. This noted that a substantial number of overweight vehicles would come back and forth on the bridge.

107 As 1,200 vehicles per day are counted currently, design loads of floor slab which receive directly the effects of overweight shall include surcharge.

CHAPTER 5



EXISTING BRIDGE INVESTIGATION

- 5-A BIOGRAPHY OF BRIDGE
- 5-B DESIGN PARAMETERS
- 5-C SUBSTRUCTURE AND
FOUNDATION
- 5-D SUPERSTRUCTURE
- 5-E DURABILITY OF BRIDGE AND
RECOMMENDATION

CHAPTER 5 EXISTING BRIDGE INVESTIGATION

5-A. BIOGRAPHY OF THE BRIDGE

(1) Outline of the Existing Kafue Road Bridge

108 The existing Kafue Road Bridge is located approximately 56 km to the south of the capital city, Lusaka, on the international trunk road (so called T 2) running from the northern region to the southern region of the country through to South African countries such as Zimbabwe and Botswana.

The road passing through the Bridge plays a major role in domestic and international traffic demands. In fact, the traffic is anticipated to grow in conjunction with economical development evolved in South African countries.

109 The location of the bridge site is shown in Fig. 5-1 "Location of the Kafue Road Bridge".

(2) History

110 The Kafue Road Bridge was constructed in 1949. According to the commemoration plate embedded in the front column of the Bridge, the Bridge is said to be transferred from somewhere on the Thames River. Though neither an old bridge site on the Thames River nor the time of initial installation are identified, a rumor says that the original construction was in 1941 or 1942 for an emergency need when the city of London was devastated by the war. The original bridge involved five (5) spans. However, two (2) out of the original five (5) spans were transferred to West Uganda, while the remainder was relocated to the present bridge site at Kafue River in Zambia.

112 Construction of the Bridge at Kafue was made possible through a donation by the fund of Alfred Beit to the former Northern Rhodesia. According to drawings in possession of the Roads Department of Ministry of Works and Supply, Freeman Fox and Partners was a designer and a cantilever construction was adopted.

113 In 1968, it became necessary to raise the bridge by 6'-5" (approximately 1.96 m) due to an ascent of water level originated by impounding Kafue Gorge Dam which was located downstream of the Bridge.

114 When raised, upper parts of the substructures were demolished, redesigned and reconstructed, while in the superstructures three single span trusses were tied, reinforced at each truss ends, and lifted by jacks.

115 Carriageway widths used to be 5.5 m, and sidewalks were used to be on both sides of the carriageway. Afterward, these sidewalks were removed and a wider carriageway of 6.1 m was built, coping with both increased traffic and growing size of vehicles.

At the same time, new sidewalks were added to outside of main structures, and guardrails were attached inside.

5-B. DESIGN PARAMETERS

(1) Structure and Geometry

116 In connection with the current site survey made during the Study, and with the help of remaining design drawings, the data related to the structure and geometry of the Bridge were found as follows;

- a. Total Bridge Length 130.496 m
- b. Type of Bridge Pratt-Truss (Through bridge)
- c. Span Length 43.557 m+43.402 m+43.537 m
- d. Height of Main Structure . 5.867 m
- e. Width of Main Structure .. 7.465 m
- f. Overhead Clearance 5.055 m
- g. Carriageway width 6.110 m (between curbs)
- h. Carriageway width 6.400 m (including curbs)
- i. Distance between Guardrails ... 6.600 m
- j. Pavement Asphalt Paving
- k. Sidewalk width 1.100 m

For all other details, see Appendix 5-5 "General Arrangement of the Kafue Road Bridge".

- 117 As is mentioned later, the southern access roads to the Bridge have been upgraded to Class 1B where carriageway widths are 6.70 m in accordance with the Highway Design Standards of the Republic of Zambia. The Standards specify that bridges on Class 1B roads with 6.70 m carriageway shall have 7.30 m carriageway between curbs. This means the present carriageway is not up to standard. As a consequence, many collisions against the Bridge as delineated later have been induced.

(2) Hydrology

- 118 At the upstream and downstream side of the Bridge, it was observed that the river surrounding is primitive and no such structure as embankment exists. There were not any eroded banks as far as could be seen.

When surveyed in late November, 1989 that was the start of the rainy season, the water flow seemed mean and the velocity was approximately 0.2 m/sec. However, in late February, 1980, the water velocity at mid-span of the Kafue Road Bridge was observed to be about 1.0 m/sec.

(a) Water Level :

- 119 In Zambia, water level of primary rivers are continuously observed and recorded by Department of Water Affairs of Ministry of Works and Supply. Though there exists no gauge station adjacent to the Kafue Bridge site, water level at Kasaka which is located approximately 5 km downstream to the Bridge is available. Records have been kept for five (5) years from October, 1983 to September, 1988 at Kasaka. These are shown in Appendix 5-1 and 5-2 "Water Level of Kafue River".

- 120 The observation record implies that despite distinct dry and rainy seasons, variation in water level is merely 2.86 m. It is thought that the discharge control by both Iteshi-Teshi Dam (upstream side) and Kafue-Gorge Dam (downstream side) has resulted in this low variation of water level. The maximum elevation of the water level recorded in these five (5)-years is found El. 3,203.28' (977.884 m).

121 Concerning operation of both Kafue Gorge and Iteshi Teshi dam, the Water Development Board of Zambia gave Zambia Electricity Supply Corporation (ZESCO) the right to impound up to a water level of 976.6 m at Kasaka Gauge Station.

122 Spillway of Kafue Gorge Dam is designed to provide 4,250 m³/sec. Water flow in a return period of 10,000 years are regulated by 4 radial gates. Relations among discharge of the spillway, an attribute to waterhead and return period are reported as follows;

Return Period (years)	Flow (m ³ /sec)	Water Level at kasaka (m)
	2040	
100	2120	
	2270	
	2550	
	2750	- 976.6
	2830	
	3060	- 977.2
	3120	
1,000	3340	- 977.8
	3540	
	3620	- 978.4
	3960	- 979.0
10,000	4250	- 979.6

Considering a return period of 100 years, the flow shall be 2,120 m³/sec. Assuming water level at the Bridge to be 976.6 m, the velocity shall be more than 2.5 m/sec. The indicated current velocity deserves considerable caution against scouring.

(b) Rainfall :

123 Rainfall is observed and recorded by the same Department as well. Rainfall records at Kafue Rail for five (5) years from October, 1983 to September, 1988 are shown in the Appendix 5-3 "Rainfall Record at Kafue Rail".

124 According to the record, annual rainfall is approximately 500-700 mm, and it is found most rainfall occurs over a period from October to the following March.

(3) Clearance

125 The maximum water level ever recorded at Kasaka gauge station took place in July, 1976 to be El. 3,212.05' (978.423 m) by Department of Water Affair. However, two (2) years later, Iteshi-Teshi Dam was constructed upstream of the Bridge and commenced to impound. The maximum water level after the Dam construction is El. 3,208.28' (977.884 m) recorded in December, 1985.

126 Meanwhile, a topographic survey was carried out in December 2, 1989 in order to determine the elevation of the Bridge's road surface and found it to be El. 3,218.65' (981.045 m).

In view of these facts, clearances beneath the Bridge can be figured as follows;

a. 1.662 m above the maximum water level in history recorded in July, 1976.

b. 2.161 m above the maximum water level after the Dam construction recorded in December, 1985.

127 Correlation of these figures is shown in the Appendix 5-4 "Clearance beneath the Kafue Road Bridge".

(4) Permissible Stress

128 Information concerning superstructure of the existing bridge can be obtained by reviewing copy of the original drawings and drawings prepared when the Bridge was raised. However, these drawings do not furnish any information regarding specifications for steel shapes used as main truss members. Members for lateral bracings were replaced when the Bridge was raised and are made of mild steel (B.S. 1E).

129 Metallurgical testing on 16-steel samples taken from the original structure of Kafue Rail Bridge that was constructed in 1906 was carried out during the survey of 1981. 11-tensile tests show the following results: