THE UNITED REPUBLIC OF TANZANIA

FINAL REPORT
ON
FEASIBILITY STUDY AND PRELIMINARY DESIGN
OF
SOUTHERN COASTAL LINK ROAD PROJECT

VOL. 1 MAIN REPORT

September, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

THE UNITED REPUBLIC OF TANZANIA

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PREFACE

In response to the request of the Government of the United Republic of Tanzania, the Government of Japan decided to cooperate with the Tanzanian Government in making the feasibility study on the Southern Coastal Link Road Project, and Japan International Cooperation Agency (JICA) conducted it.

This study is designed to ascertain the feasibility of constructing an all-weather road linking Kibiti, located near Dar-es-Salaam, and Lindi. For the purpose of conducting this study, JICA made the prefeasibility study in December, 1974, and in 1975 the feasibility study was conducted for the period of three months by the team consisting of various experts. In preparing this report, we have conducted not only economic and technical feasibility study but also a preliminary design of the planned road in compliance with the request of the Tanzanian Government.

I am confident that the report would make a great contribution to push forward the development of Tanzania, and hope that our technical cooperation would promote the mutual understanding and friendship between our two countries.

Finally, I would like to take this opportunity to express my heartfelt appreciation to all the people who participated in this study and to all the Tanzanian authorities for their cooperation.

September, 1977

Shinsaku Hogen
President
Japan International
Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

September, 1977

Dear Sir,

It is our great pleasure to submit herewith the Report on Feasibility Study and Preliminary Design of Southern Coastal Link Road Project in conformity with the Scope of Works agreed upon between the Government of Japan and the Government of the United Republic of Tanzania.

The principal purpose of the survey lies in examining both economic and technical feasibility of the Project for constructing the existing Southern Coastal Link Road into an all-weather road, and conducting preliminary design and economic evaluation of the Project on the basis of updated traffic data. A topographic map of 1/2,000 scale was also prepared along the proposed route of the Road.

Aiming at achieving the above-mentioned purpose, the survey team conducted a field investigation from September to November, 1975, under the guidance and supervision of the Technical Supervision Committee. Upon returning home, the team engaged in studying several alternative plans for the all-weather road construction, the results of which were compiled into the Interim Report submitted to the Tanzanian Government in August, 1976.

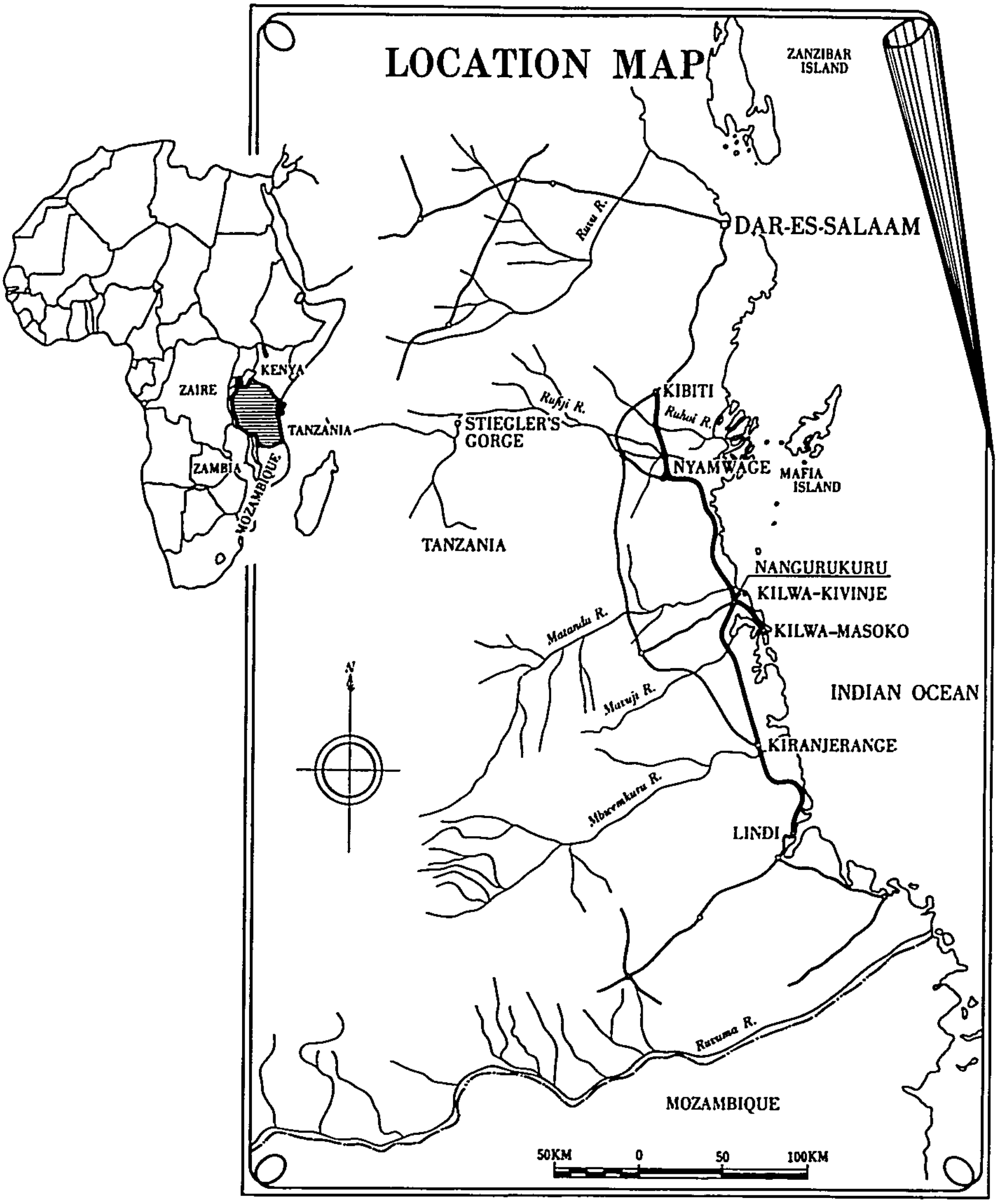
Based on the discussion held with regard to the Interim Report, the Draft Final Report was prepared and submitted to the Tanzanian Government in June, 1977. Mr. J. A. Kassamia, Commissioner of Works, and Mr. A. E. Mboya, Senior Executive Engineer, both Ministry of Works, Tanzanian Government, visited Tokyo in the middle of July, 1977, to have the final discussion on the Report. The comments and opinions raised and agreed upon during the discussion to be incorporated in the Report were examined and fully reflected on the Final Report.

We wish to express, in submitting this Report, our sincere appreciation and gratitude to the personnel of your Agency, the Japanese Embassy in Tanzania, and the Technical Supervisory Committee for their guidance, and to the officials of Ministry of Works, Tanzanian Government, for their courtesy and cooperation extended to the survey team.

Very truly yours,

H. Mori

Hiroshi Mori
Chief
Survey Team of Japan International Cooperation Agency
President, Japan Oversea Consultants Co., Ltd.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TANZANIA
NANGURUKURU
KILWA-KIVINJE
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SUMMARY

SUMMARY

1. Objective of Survey

The objective of this survey lies in examining both economic and technical feasibility of the Project for reconstructing the existing Southern Coastal Link Road into an all-weather road, and conducting for this end preliminary design and economic evaluation of the Project on the basis of updated traffic data. The Project has as its subject the road from Kibiti to Lindi, except a length to be covered by the Rufiji River Bridge Construction Project, and its feeder road from Nangurukuru to Kilwa Masoko.

It is to be noted that, in compliance with a request from the Government of Tanzania, a topographic map of 1/2000 scale was prepared along with eighteen control points set up along the proposed route for the use of the survey. Such achievements in terms of topographic survey will satisfactorily stand further use while the Tanzanian Government pushes forward the Project.

2. Outline of Survey

(1) General Plan

i) The Project Road was divided into the following five sections to facilitate examination.

Table 1. Sections of Project Road

Section	From	To	Road length Planned(km)	Bridge length planned (km)	Total (km)
No. 1	Kibiti	Nyamwage	35.966	0.034	36.00
No. 2	Nyamwage	Nangurukuru	99.513	1.187	100.70
No. 3	Nangurukuru	Kiranjerange	86.109	0.491	86.60
No. 4	Kiranjerange	Lindi	75.453	0.697	76.15
No. 5	Nangurukuru	Kilwa Masoko	30.330	0.020	30.35
Total			327.371	2.429	329.80

ii) The following four pavement plans were examined and compared:-

a) Entire length of the road is paved over two lanes from the beginning;

b) Opened to service as two-lane engineered gravel road and paved when traffic volume has sufficiently increased;

c) Paved over two-lane width only in traffic-heavy No. 1 section at the beginning. As for sections No. 2 through No. 5, only one-lane width is paved at the beginning. After opening to service, pavement over two-lane width is to be completed when traffic volume has sufficiently increased;

d) Basically the same as c), but without bituminous coating on the unpaved width and shoulders.

The results of the above examination were discussed with the Tanzanian Government. Of the four plans, the following two were taken up for further study in accordance with the discussion and ensuing examination conducted here.

Plan A: A stage construction in which the road to be opened for use as two-lane engineered gravel road and to be turned into paved road ten years later. This is regarded as the basic plan.

Plan B: A non-stage construction to complete the entire length into two-lane paved road from the beginning.

Designing, cost estimation and economic evaluation were conducted according to the two plans.

Further economic evaluation was conducted for a case in which only Section 1 is completed into a paved road according to Plan A leaving the other sections in the form of engineered gravel road.

(2) Road Planning

Mainly for the purpose to reduce construction cost, the route was so selected that the alignment follows present topography as much as possible. The width of the road is planned to be 8.9 to 10.1 m, comprising 6.5 m of carriageway and 1.2 to 1.8 m of shoulder on either side.

Pavement was planned to have penetration macadam surface course for economy. Base and subbase courses are planned mostly in cement stabilization. For these, it is desirable to use materials that are available on site as far as possible.

(3) Bridge Planning

New bridges having two lanes are proposed, because the idea to utilize existing single lane bridges and build additional bridges of single lane is recognized inadequate from a long-term viewpoint in hydrology and structural engineering.

The reinforced concrete bridge and steel bridge were examined and compared as alternatives for the main bridges over the three major rivers, the Matandu, Mavuji and Mbwemkuru. Steel bridges are planned to be used as the result of weighing merits and demerits of the alternatives in facility of construction and material reliability as well as costs.

As for other rivers requiring bridges of comparatively short span, it is planned to use reinforced concrete bridges that can utilize materials and technology available in the country.

(4) Project Cost and Construction Plan

The construction costs are estimated both for Plans A and B for each section using prices as of October, 1975. The following shows local and foreign currency portions earmarked for the requirements:

Local Currency - Aggregate materials, Cement, Lumber, Labour cost;

Foreign Currency - Steel materials, Construction equipment, Plant, Fuel, Oil, Asphalt, Engineering fee.

Repair and maintenance costs are for repairing pavement and structures, overlaying the surface course, and repainting steel structures. Such costs were calculated for each of Plans A and B to obtain yearly capital outlay.

As the construction period, both Plans A and B define five years starting from 1978, which is the first construction stage for Plan A. The second stage of Plan A is for pavement to require three years starting ten years after the completion of the first stage, that is 1993.

Table 2 shows the total construction costs.

Table 2 Construction Costs

(1,000 shs.)

Plan	1st-stage construction	2nd-stage construction	Total	Local currency	Foreign currency
A	417,709	182,493	600,202	302,984	297,218
B	567,651	0	567,651	283,851	283,800

The repair and maintenance costs are 312,090,000 Shs. for Plan A and 377,570,000 Shs. for Plan B.

(5) Future Traffic Volume

Annual growth rate of future traffic volume is estimated at 5 % as a result of the examination of present traffic conditions and industrial and economic factors. Case 1 in the economic evaluation to follow assumes future traffic volume based on this rate, the volume being regarded as the basic value. Case 2 was taken up on the assumption that an international bridge will be constructed over the Ruvuma River bordering on Mozambique, and that such a bridge will heighten the rate to 7 %.

For examples to show the results of examination, the estimated traffic volume for 1983, when the inauguration of the road is scheduled, is 192 vehicles per day in traffic-thickest No. 1 section, and 59 vehicles per day in traffic-thinnest No. 5 section for Case 1 of Plan A. In 2012, the thirtieth year after inauguration, No. 1 section has 694 and No. 5 section 213 vehicles per day. The future traffic volume is rather small as seen here.

(6) Economic Evaluation

The road now studied is examined over a thirty-year project life. For reference, it is also examined as having a twenty-year project life.

Table 3 compares yearly costs and benefits for the road as having a thirty-year project life on the basis of future traffic volume estimated in Case 1 of Plan A. The internal rate of return calculated for both Plans A and B is also shown in Table 4.

Table 3 Yearly Costs and Benefits (Case 1, Plan A) - 1/2

(1,000 shs.)

Year		Economic costs			Benefits
		Construction costs	Repair and maintenance costs	Total	
1	1978	54,991		54,991	
2	1979	80,042		80,042	
3	1980	86,035		86,035	
4	1981	90,877		90,877	
5	1982	105,764	1,007	106,771	
6	1983		3,413	3,413	29,931
7	1984		3,413	3,413	31,408
8	1985		3,413	3,413	32,885
9	1986		3,413	3,413	34,361
10	1987		19,937	19,937	35,839
11	1988		19,573	19,573	37,315
12	1989		3,413	3,413	38,793
13	1990		3,413	3,413	40,269
14	1991		3,413	3,413	41,746
15	1992		4,790	4,790	43,223
16	1993	26,796	3,413	30,209	44,700
17	1994	87,626	3,413	91,039	47,528
18	1995	68,071	3,413	71,484	50,354
19	1996		3,413	3,413	61,429
20	1997		28,227	28,227	64,609
21	1998		27,863	27,863	67,790
22	1999		3,413	3,413	70,970
23	2000		3,413	3,413	74,150
24	2001		3,413	3,413	77,330
25	2002		29,240	29,240	80,511
26	2003		27,863	27,863	83,190
27	2004		3,413	3,413	88,613
28	2005		3,413	3,413	92,535
29	2006		3,413	3,413	96,958
30	2007		28,227	28,227	101,380
31	2008		27,863	27,863	105,803

Table 3 Yearly Costs and Benefits (Case 1, Plan A) - 2/2

(1,000 shs.)

Year		Economic costs			Benefits
		Construction costs	Repair and maintenance costs	Total	
32	2009		3,413	3,413	110,225
33	2010		3,413	3,413	114,648
34	2011		3,413	3,413	119,070
35	2012		29,240	29,240	123,493
Total		600,202	312,090	912,292	2,041,056

Table 4 Internal Rate of Return by Plan, Case and Section

(%)

Plan \ IRR	IRR (20 years)		IRR (30 years)	
	Case 1	Case 2	Case 1	Case 2
Plan A:-				
No.1 Section	11.59	14.15	13.45	15.84
No.2 Section	5.46	8.31	8.40	10.98
No.3 Section	-	3.12	4.69	7.47
No.4 Section	-	2.72	4.37	6.85
No.5 Section	1.21	5.37	5.97	9.23
Total	3.30	6.32	6.99	9.55
Plan B:-				
No.1 Section	9.91	12.39	11.72	14.05
No.2 Section	5.03	7.61	7.69	10.11
No.3 Section	0.41	3.29	4.41	6.90
No.4 Section	0.35	2.93	4.11	6.37
No.5 Section	1.04	3.99	4.66	7.37
Total	3.23	5.82	6.32	8.71

Economic evaluation was conducted also for a case in which only Section 1 is to be paved according to Plan A leaving Section 2 and the others in the form of engineered gravel road throughout project life. The result is that the internal rate of return for a thirty-year project life at the future traffic increase rate in Case 1 is 8.55 % for the entire road and within the range of 6.21 to 13.45 % from section to section.

CONCLUSION
AND
RECOMMENDATION

(1) In examining the feasibility of this Project, four construction plans were formulated as described above. Of the four plans, the following two were taken up for detailed comparative examination based on the results of the discussion with the Tanzanian Government.

Plan A: A stage construction in which the road to be constructed as engineered gravel road in the first stage and paved when the increase in traffic justifies this.

Plan B: A non-stage construction to complete the entire length into paved road from the beginning.

It can be said, based on the results of the above examination, that Plan A of stage construction is superior to and more realistic than Plan B of non-stage construction taking into account that a sharp increase in traffic is not expected at present and in the near future.

(2) Even in Plan A, however, the internal rate of return for a thirty-year project life at 5 % traffic increase in Case 1 is 6.99 % for the entire road and within the region from 4.37 to 13.45 % from section to section. As far as this value goes, the Project cannot necessarily be called feasible.

(3) For this reason, the internal rate of return was re-calculated on the assumption that only Section 1 is paved according to Plan A and the other sections are opened for traffic after finished with the first stage, i.e. as engineered gravel road. The result is that the internal rate of return for a project life of thirty years at the traffic increase rate in Case 1 is 8.55 % for the whole sections and ranges from 6.21 to 13.45 % by section, a slight increase over the values for Plan A.

(4) Further, there is a fair chance for the Southern Coastal Link Road to take on a role as an international artery when a bridge is constructed over the river bordering on Mozambique in the future. Naturally enough, this will turn the above-mentioned economic factors into favourable ones so that as a matter of course the Project will be viewed in a different light.

In addition, the completion of the all-weather Coastal Road linking the southern areas to capital Dar es Salaam will produce various effects that are difficult to put into figures but have great social significance, such as: more frequent communication back and forth between the south and the capital and even further northern areas; development and promotion of cashew nut, lumber and other industries; increased administrative efficiency between the central Government and the south; advanced welfare of the regional inhabitants, and so on.
To evaluate all the facets of the Project, the above-mentioned social effects should also be taken into consideration.

(5) In case the Project is pushed forward according to Plan A, it is advisable that the pavement construction which is scheduled to start ten years after opening for traffic of the engineered gravel road be re-examined in the future with the actual increase in traffic volume fully taken into account.

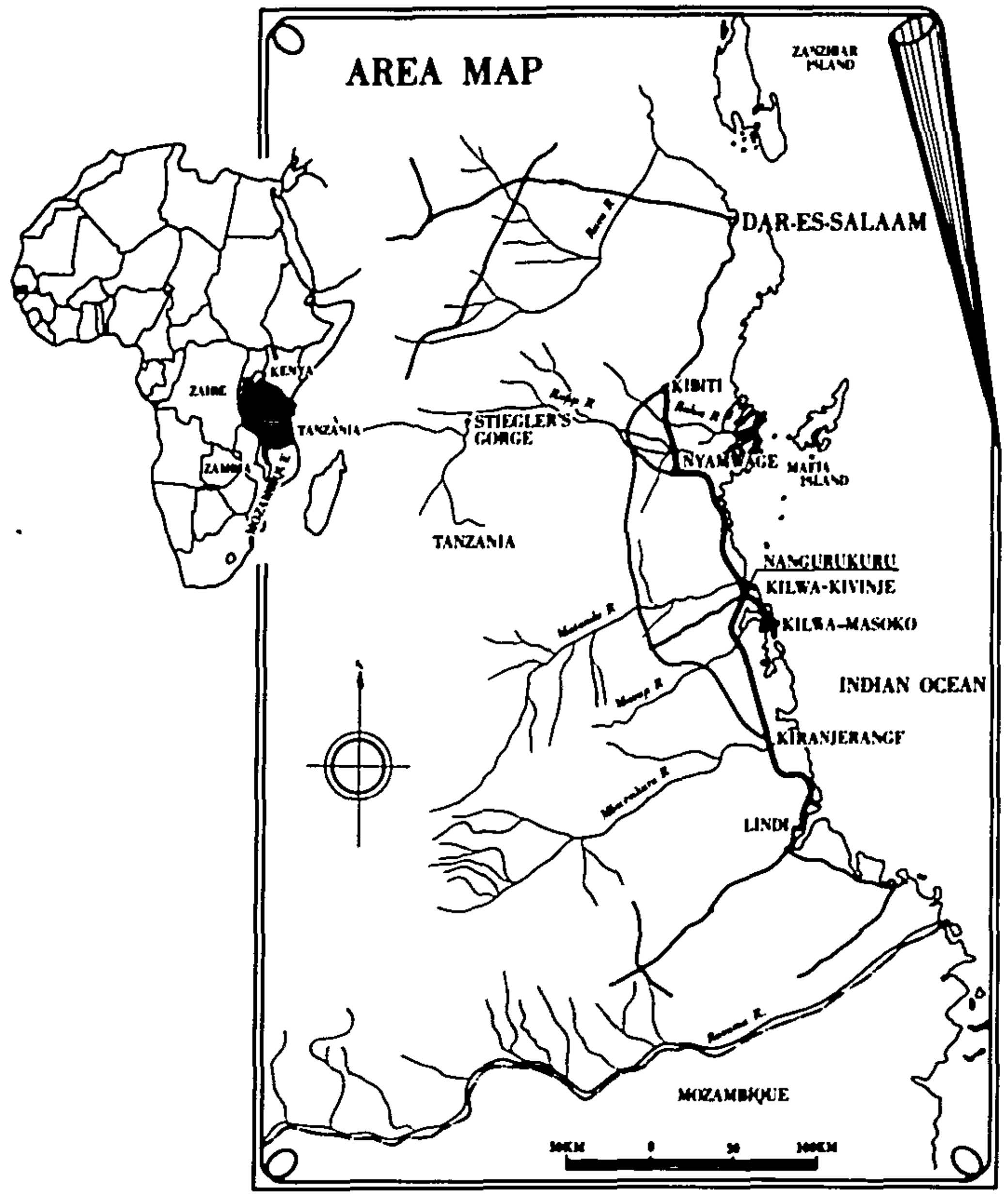
(6) The following order of construction is recommended taking into account the internal rate of return and facility of construction, if the sections are to have different starting dates.

1) Section 1 (Kibiti-Nyamwage)
2) Section 2 (Nyamwage-Nangurukuru)
3) Section 5 (Nangurukuru-Kilwa Masoko)
4) Section 4 (Kiranjerange-Lindi)
5) Section 3 (Nangurukuru-Kiranjerange)

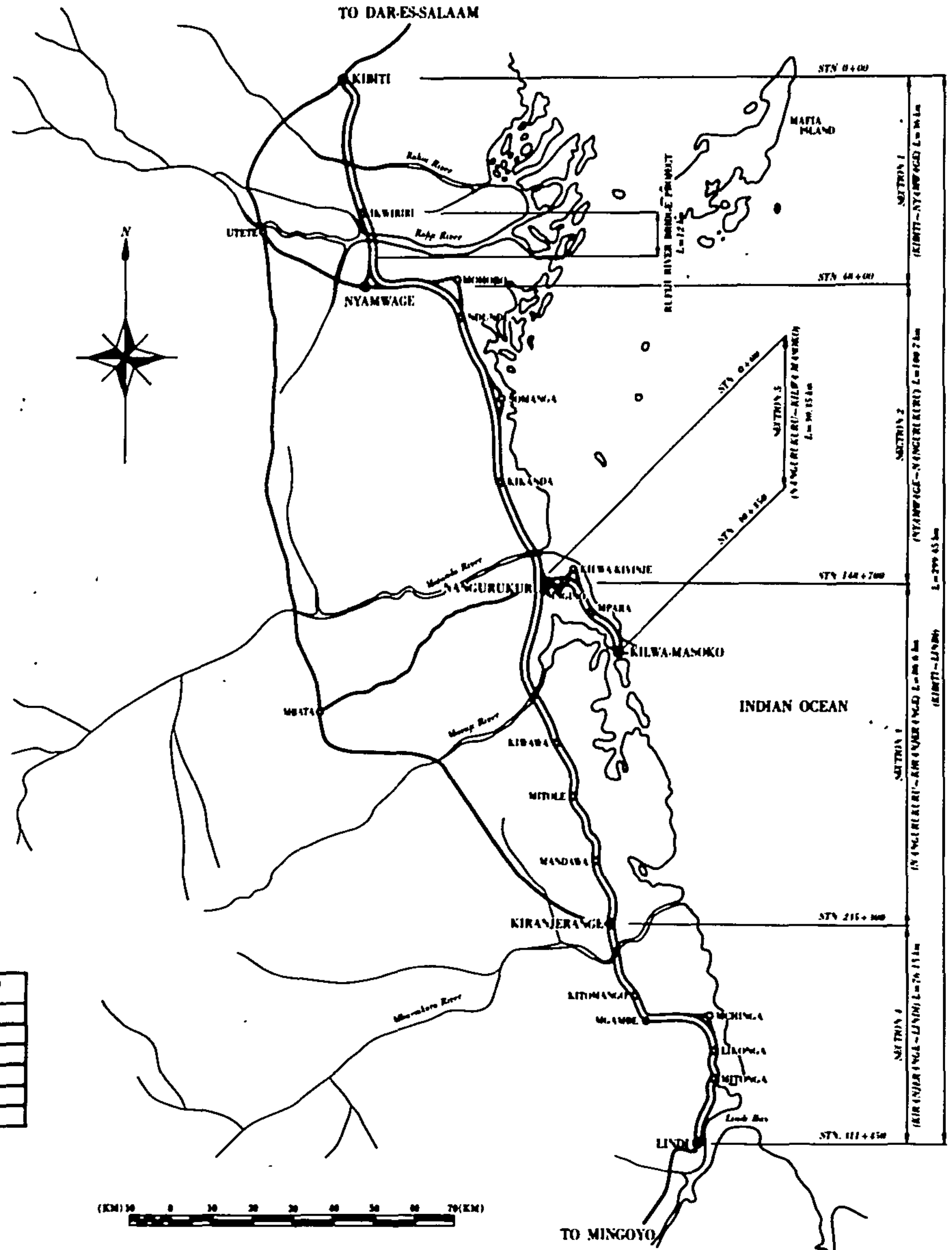
CHAPTER 1

INTRODUCTION

FIG. 1-1



SECTION No.	SECTION			DISTANCE (KM)
1	KIBITI	TO	NYAMWAGE	36.00
2	NYAMWAGE	TO	NANGURUKURU	100.70
3	NANGURUKURU	TO	KIRANJERANGE	86.60
4	KIRANJERANGE	TO	LINDI	76.15
5	NANGURUKURU	TO	KILWA MASOKO	30.35
TOTAL (KM)				329.80



SOUTHERN COASTAL LINK ROAD PROJECT

FIG. 1-1 LOCATION PLAN

CHAPTER 1 INTRODUCTION

1.1 Scope of Survey

Japan International Cooperation Agency conducted a technical and economic feasibility study of the Southern Coastal Link Road Project in Tanzania on the basis of the scope of works agreed upon between the Government of the United Republic of Tanzania and the Government of Japan.

According to the scope of works, the route as envisaged in the Project runs from Kibiti on the Southern Coastal Link Road to Lindi via the junctions of Nyamwage, Nangurukuru, and Kiranjerange, as shown in Fig. 1-1. Included in this route are the distance of 312 km, excluding a 12.0 km section to be covered by the Rufiji River Bridge Construction Project, and the distance of about 37 km between Nangurukuru junction and Kilwa Masoko, which is a feeder road for the Southern Coastal Link Road.

The survey conducted for the Project Road as defined above comprises the following:-

1) Aerial surveying along.the whole route and cross-sectional surveying at the proposed bridge construction sites of the Matandu, Mavuji and Mbwemkuru Rivers;

2) Soil and material investigation;

3) Rivers and hydrologic survey;

4) Routing the road based on (1) through (3);

5) Preliminary design of the Road on the selected route;

6) Preliminary design of bridges;

7) Project cost consisting of construction, maintenance and repair costs;

8) Forecast of traffic volume based on regional traffic and economy;

9) Economic analysis and evaluation of the Project on the basis of expected benefits and costs.

1.2 Review of Past Work for the Southern Coastal Link Road Project

The Southern Coastal Link Road linking Dar es Salaam and Lindi is inundated by a number of rivers time after time in the rainy season, and becomes muddy reducing its trafficability to a great extent. In some particular places, every means of transportation is cut off for about half a year. This is what has been seriously checking the development of regional economy, industry and culture in the southern areas centering around Lindi and Mtwara, and isolating the areas from the capital in terms of efficiency of administration.

The Government of the United Republic of Tanzania, in an effort to save the situation, made a request to the Japanese Government for its technical assistance.

In response to the request, the Government here despatched a nine-member survey team to Tanzania in 1970 for an on-site investigation on the Southern Coastal Link Road Project. The survey was conducted by Overseas Technical Cooperation Agency (hereinafter called OTCA), acting for the Japanese Government, and its survey team was headed by Mr. Hidetake Kurita.

The results of the survey were presented to the Tanzanian Government in "Feasibility Report on Dar es Salaam/Lindi Coastal Link Road Project" in July, 1971. The report compares and discusses the following three routes that were proposed by the Tanzanian Government as alternatives among which one is to be selected for the all-weather road between Kibiti and Lindi.

The proposed routes are:-

Route 1. Kibiti - Utete - Nyamwage - Mohoro - Nangurukuru - Lindi

Route 2. Kibiti - Ndundu - Nyamwage - Mohoro - Nangurukuru - Lindi

Route 3. Kibiti - Utete - Njinjo - Mbata - Kiranjerange - Lindi

The report concludes that Route 2 should be the most advantageous choice to be constructed into the all-weather road incorporating as much as possible the existing road after improvements where necessary.

It also recommends that the execution of the Rufiji River Bridge Construction Project should be given the priority due to the fact that the river has ever been the greatest cause for the traffic paralysis when it floods in rainy seasons.

On the basis of the said conclusion and recommendation, the Tanzanian Government requested the Japanese Government for further technical assistance on the feasibility study of the Rufiji Bridge Project.

OTCA, on behalf of the Japanese Government, organized and despatched to the bridge site a nine-member survey team including Mr. Hiroshi Yamashita as its head in 1971. As the result, "Feasibility Report on the Rufiji River Bridge Construction Project" was submitted to the Tanzanian Government in 1972.

In February, 1974, the Japanese Government agreed to offer a grant to the Tanzanian Government for the detail design of the Rufiji Bridge. Based on this grant, the Tanzanian Government accepted the detail design of the Rufiji Bridge in 1975, employing Japan Oversea Consultants Co.

This is the latest item to conclude the brief explanation of the background of the Southern Coastal Link Road Project preceding the survey of this time.

1.3 Progress of Survey

The survey was conducted by the survey team under the guidance and supervision of a supervisory committee formed by experts from the Japanese Government Agencies concerned.

The survey was conducted in the following sequence.

(1) A preliminary survey team was sent to Tanzania in November, 1974, and had a preparatory discussion with the Tanzanian Government on the scope of works.

(2) A contact mission was despatched to Tanzania in September, 1975, to have a discussion with the Tanzanian Government. The scope of works was concluded as the result.

(3) Under the scope of works, a survey team was sent to Tanzania for about three months from September, 1975. The survey was conducted on: roads; bridges; hydrology; traffic; economy; soil; and aggregate. Also conducted was aerial surveying.

(4) Data and information obtained in the on-site survey were analysed and studied and the results were compiled into an interim report.

(5) A four-member mission, one from the supervisory committee, one from Japan International Cooperation Agency, and the other two from the survey team, visited Tanzania in August, 1976, for briefing on the interim report and engineering consultation.

(6) A draft final report was prepared taking into consideration the results of the above engineering consultation and was submitted to the Tanzanian Government in June, 1977.

(7) The Tanzanian Government gave several comments as to the draft final report during the discussion held in Tokyo. The comments were examined and reflected on this final report.

Following are the member lists of the supervisory committee and the survey teams so far despatched to Tanzania.

(1) Preliminary Survey Mission (November, 1974)

Chief	Masami Kikura, Assistant Director, Maintenance and Facilities Department, Japan Highway Public Corporation
Member	Sukehisa Aoki, Chief, River Control Section, Hokuriku Regional Construction Bureau, Ministry of Construction
Member	Masao Takada, Oversea Cooperation Officer, Construction Promotion Division, Planning Bureau, Ministry of Construction
Member	Satoru Sone, Director, Japan Oversea Consultants Co., Ltd.
Member	Hideki Maruyama, Japan International Cooperation Agency

(2) Technical Supervisory Committee

Chairman	Tsutomu Yamane, Director, Planning Division, Road Bureau, Ministry of Construction
Member	Tetsuo Kunihiro, Chief, Structures and Bridges Dept., Public Works Research Institute, Ministry of Construction

Member	Masami Kikura, Chief, Traffic Technical Section, Technical Department, Japan Highway Public Corporation
Member	Norio Doi, Assistant Chief, Surveyors Guidance Division, Planning Department, Geographical Survey Institute, Ministry of Construction
Member	Masao Takada, Assistant Chief, Construction Logistics Research Room, General Affairs Section, Planning Bureau, Ministry of Construction

(3) Contact Mission and Survey Team (September, 1975)

a) Contact Mission

Chief	Masami Kikura	Member of the Technical Supervisory Committee
Member	Norio Doi	- ditto -
Member	Kazuhisa Matsuoka	Japan International Cooperation Agency

b) Survey Team

Chief	Hiroshi Mori	President, Japan Oversea Consultants Co., Ltd.
Assistant Chief, Road Engr.	Kunimura Nagashima	Director, Mitsui Consultants Co., Ltd.
Assistant Chief, Soil Engr.	Satoru Sone	Director, Japan Oversea Consultants Co., Ltd.
Member, Surveyor	Sukenobu Aiga	Chief Surveying Engineer, Asia Air Survey Co., Ltd.

Member, Road Engr.	Harumi Nishikawa	Mitsui Consultants Co., Ltd.
Member, Hydrology	Koji Watanabe	- ditto -
Member, Bridge & Structural Engr.	Katsutoshi Goto	Japan Oversea Consultants Co., Ltd.
Member, Economics	Akira Asahi	- ditto -
Member, Soil Engr.	Yoshihiro Daicho	- ditto -
Member, Soil Engr.	Fumiaki Masumi	- ditto -
Member, Soil Engr.	Yukifusa Nakashima	- ditto -
Member, Aggregate Engr.	Nobuo Takano	- ditto -
Member, Soil Engr.	Takashi Chiba	- ditto -
- ditto -	Kunio Sugaya	- ditto -
- ditto -	Yoshiaki Kawazu	- ditto -
Member, Surveyor	Keiji Mizusawa	Asia Air Survey Co., Ltd.
- ditto -	Teruo Enomoto	- ditto -
- ditto -	Makoto Kikuchi	- ditto -
- ditto -	Tsugio Nemoto	- ditto -

Member, Surveyor	Seiichiro Takahashi	Asia Air Survey Co., Ltd.
- ditto -	Hajime Sakamoto	- ditto -
Member, Pilot	Takeshi Sakabe	- ditto -
Member, Cameraman	Mitsunari Tanaka	- ditto -
Member, Airplane Keeper	Mitsuru Gotoda	- ditto -
Member, Car Mechanic	Nobuyoshi Sugita	Japan Oversea Consultants Co., Ltd.
Member, Coordinator	Masayuki Matsuda	- ditto -

(4) Briefing Mission (August, 1976)

Chief	Masami Kikura	Member of the Technical Supervisory Committee
Member	Hiroyoshi Kurihara	Japan International Cooperation Agency
- ditto -	Kunimura Nagashima	Director, Mitsui Consultants Co., Ltd.
- ditto -	Akira Asahi	Japan Oversea Consultants Co., Ltd.

1.4 Acknowledgements

We should like to express our profound gratitude to the Tanzanian Government, Authorities, Agencies and Municipalities, and also to many individuals for their cooperation in making it possible for the Tanzanian Southern Coastal Link Road Project Survey Team to complete all its assignments with success and prepare this final report.

We are greatly indebted to those officers of the Ministry of Works, the Tanzanian Government, and members of the Japanese Embassy in Tanzania with whom we have collaborated, and who have helped us in numerous ways giving us the benefits of unsparing suggestions and criticisms. Our thanks in this respect are due to:

Ministry of Works

Mr. J.A. Kassamia	Commissioner of Works
Mr. I.N. Kimanbo	Director of Roads and Aerodromes
Mr. A.E. Mboya	Senior Executive Engineer
Mr. V.E.D. Prakash	Senior Executive Engineer
Mr. R.S. Mahalaha	Senior Executive Engineer
Mr. Agrawal	Executive Engineer

In addition, we must make special mention of the personnel of the Japanese Embassy in Tanzania and the following counterpart personnel. Without their assistance the field investigations and preparation of this report would have never been accomplished. Our debt is due to:

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Mr. J. Komba and Mr. A. Mwakalonge for regional economic study,

Mr. M. Temba for topographic survey,

Mr. J. Miema for aggregate investigation,

Mr. A. Halahala, Mr. C. Ndunguru and Mr. M. Kuluva for soil investigation.

CHAPTER 2

PRINCIPAL ASSUMPTIONS FOR SURVEY

CHAPTER 2 PRINCIPAL ASSUMPTIONS FOR SURVEY

The principal assumptions for this survey are:

1) The completion of the Rufiji River Bridge precedes the construction of the road under this survey.

2) Based on the results of the on-site survey and the study that followed, a judgement was made that the entire route should be divided into the following five sections. (See Fig.1-1)

Section No.	Work Section	Distance
No.1	Kibiti - Nyamwage	36.00 km
No.2	Nyamwage - Nangurukuru	100.70 km
No.3	Nangurukuru - Kiranjerange	86.60 km
No.4	Kiranjerange - Lindi	76.15 km
No.5	Nangurukuru - Kilwa Masoko	30.35 km
	Total :	329.80 km

Excluded from the survey is the 12.0 km section to be covered by the Rufiji River Bridge Construction Project.

3) It was foreseen at the outset of the survey that the road will not have any steep increase in traffic volume in the predictable future.

For this reason, several substitutional plans were studied. The gist of the plans is that the cross section of the road should be designed as of the two-lane road from the beginning, but pavement which is relatively expensive can be postponed to a time when the increase in traffic volume justifies it.

The following four substitutional plans were studied for structural design and construction of pavement.

Plan 1 : Two-lane pavement for the entire length of the road from the beginning.

Plan 2 : Non-stage two-lane pavement only in No.1 section where traffic is relatively heavy. Under the plan, one-lane pavement will be provided for sections No.2 through No.5 where traffic is relatively light. The unpaved part of the road as well as road shoulders will be finished with bituminous surface coating until traffic becomes heavier, when the road is paved over the two-lane width as in the case of Plan 1.

Plan 3 : This is almost the same as Plan 2 except for the omission of the surface coating of unpaved parts and road shoulders.

Plan 4 : The entire length of the road will be prepared for use as two-lane engineered gravel road with sodding on road shoulders at the start, and completed into two-lane paved road when traffic volume has sufficiently increased.

The bridges were planned to have a two-lane width from the beginning in the calculation of construction costs for each of the four plans and in their economic evaluation.

After the examination, an interim report was submitted to the Tanzanian Government. It was agreed in the consultation with the Government that Plans 1 and 4 should be adopted for further study.

In the ensuing study, Plan 4 and Plan 1 were renamed Plan A and Plan B respectively with Plan A being regarded as the basic plan.

Plan A : A stage construction in which the road to be opened for use as two-lane engineered gravel road and to be turned into paved road in the future with the increase in traffic.

Plan B : A non-stage construction to complete the entire length into two-lane paved road from the beginning.

Designing, cost estimation and economic evaluation were conducted for the five sections according to Plans A and B so that the most appropriate investment plan can be recommended.

Further, the internal rate of return was also calculated based on the assumption that only Section 1 is paved according to Plan A and the other sections are opened for traffic after finished with the first stage, i.e. as engineered gravel road, to serve throughout project life.

4) The road now studied is to have a 30-year project life. The rate of increase in traffic volume is estimated at 5 %, on which the plans are to be examined as Case 1.

For reference, Case 2 was taken up on the assumption that an international bridge will be constructed over the Ruvuma River bordering on Mozambique, and that such a bridge will heighten the rate of traffic increase to 7 %. Examination was made based also on a 20-year project life of the road.

CHAPTER 3

ROAD PLANNING

CHAPTER 3 ROAD PLANNING

3.1 Basic Principles

1) The geometric design criteria used for designing the road were:

   "Geometric Design Criteria for Rural Roads, United Republic of Tanzania";

   "Standard Specifications for Geometric Design of Rural Highway, AASHO".

2) Horizontal alignment is selected in principle along the existing roads with a relatively dense population thereabout.

3) Longitudinal alignment is selected as far as possible along the lay of the land in order to minimize earthwork.

4) Where the road crosses rivers, the banking height of the access road to the bridge is planned to have the clearance of 1.0 m between the design high water level and the lower subbase course in order to assure safe drain at the design flood discharge.

5) The width of the carriageway is planned to be 6.5 m for two lanes. The shoulder width is planned to be 1.8 m for the typical section and 1.2 m for those sections where the cutting is deep (see Figs. 3-1 and 3-2).

   For towns and villages along the route, a lay-by of 3 m wide is planned on each side to serve as bus stop.

6) Several box and pipe culverts are standardized. An adequate one for a location should be selected according to the design discharge to be determined through hydrologic analyses.

7) The pavement is studied for both Plans A and B. In Plan A, stage construction of the pavement is examined in consideration of the growth in traffic volume from the economic viewpoint. In Plan B, non-stage construction is planned to complete the pavement from the beginning.

8) Numeric calculation, cost estimation and economic evaluation are based on the length of road and bridge of each section shown in Table 3-1.

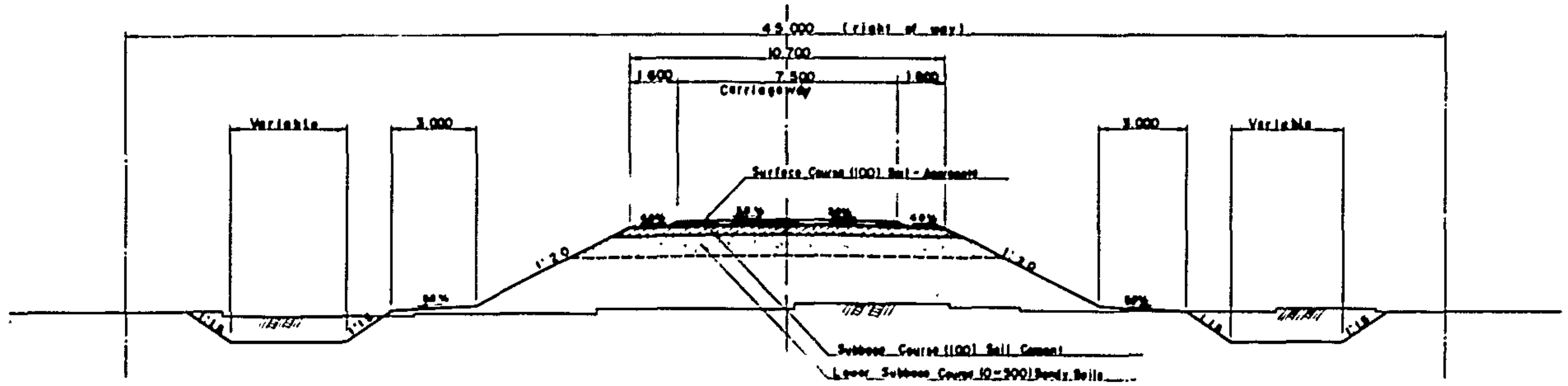
Table 3-1 Length of Road and Bridges by Section

(m)

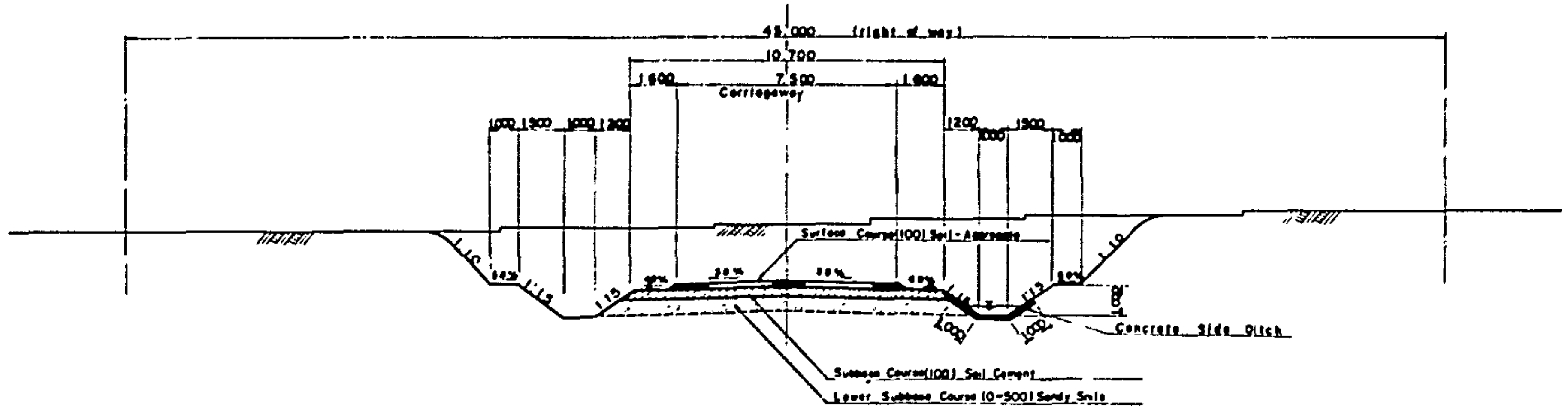
Classification / Section	Road			Bridge	Total
	Flat Terrain	Hilly Terrain	Mountainous Terrain		
No.1	28,466	3,000	4,500	34	36,000
No.2	78,313	8,000	13,200	1,187	100,700
No.3	31,109	24,000	31,000	491	86,600
No.4	32,353	8,900	34,200	697	76,150
No.5	19,030	3,400	7,900	20	30,350
Total	189,271	47,300	90,800	2,429	329,800

FIG. 3-1

EARTH-FILL SECTION



EARTH-CUT SECTION I (SHALLOW CUT)



EARTH-CUT SECTION II (DEEP CUT) deeper than 2 m

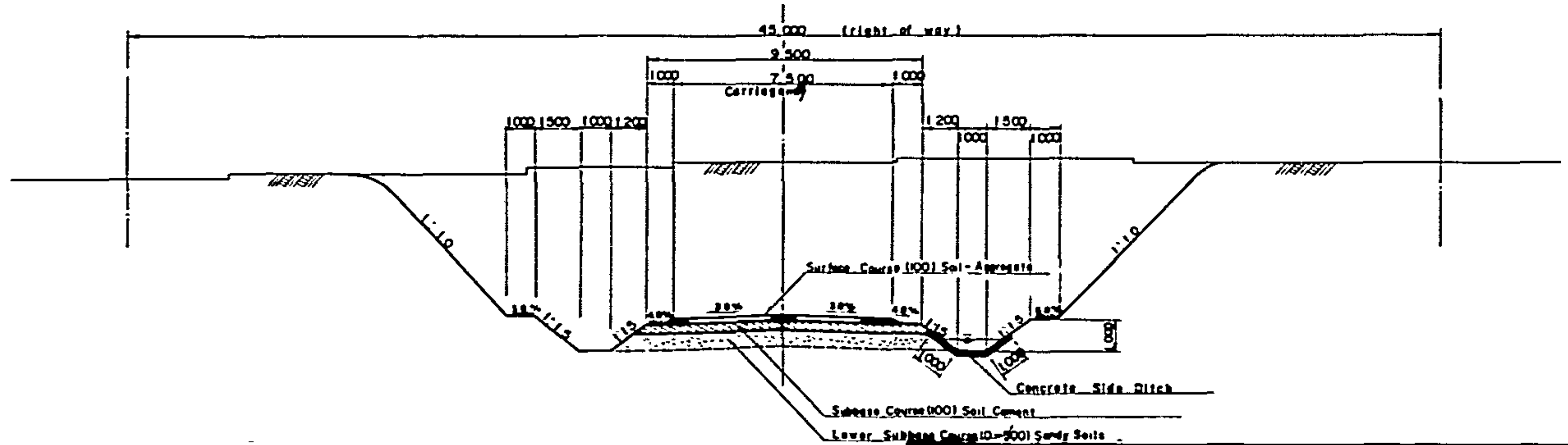


FIG. 3-1	SOUTHERN COASTAL LINK ROAD PROJECT
	TYPICAL CROSS SECTION AT FIRST STAGE FOR PLAN A

FIG. 3-2

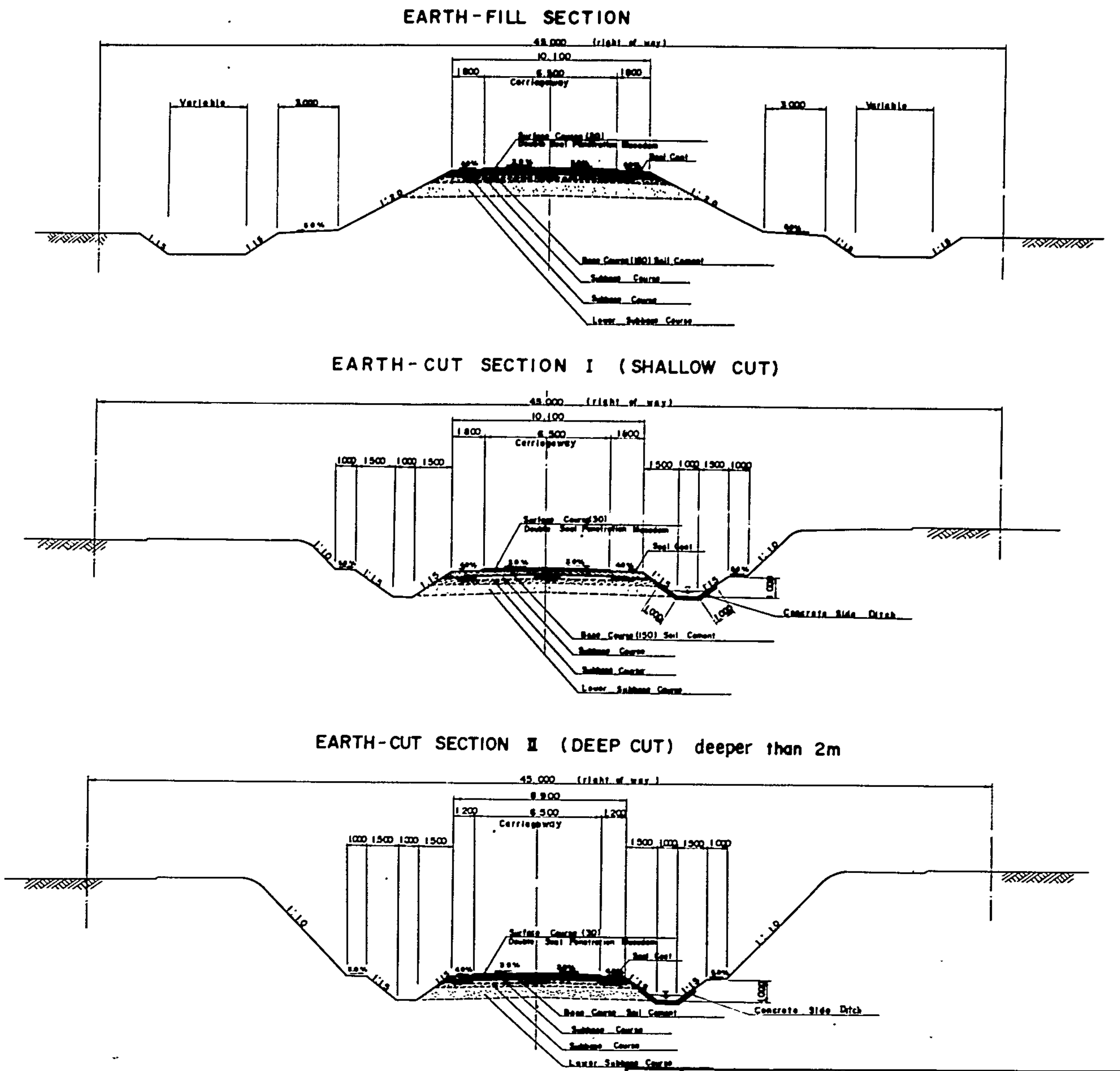


FIG. 3-2	SOUTHERN COASTAL LINK ROAD PROJECT
	TYPICAL CROSS SECTION AT SECOND STAGE FOR PLAN A

3.2 Design Criteria

3.2.1 Design Speed

Flat to rolling terrain	100 km/hr
Rolling to hilly terrain	80 km/hr
Mountainous terrain	60 km/hr

3.2.2 Carriageway Width and Shoulder Width

Carriageway	6.5 m
Shoulder	1.8 m (to be reduced to a minimum of 1.2 m in cuts deeper than 2 m)

3.2.3 Maximum Longitudinal Slope

Flat to rolling terrain	5 %
Rolling to hilly terrain	6 %
Mountainous terrain	8 %

3.2.4 Superelevation

Maximum superelevation rate	8.0 %
Maximum crossfall (normal crown)	3.0 %

3.2.5 Minimum Radius of Horizontal Curves

Flat to hilly terrain	300 m
Mountainous terrain	230 m

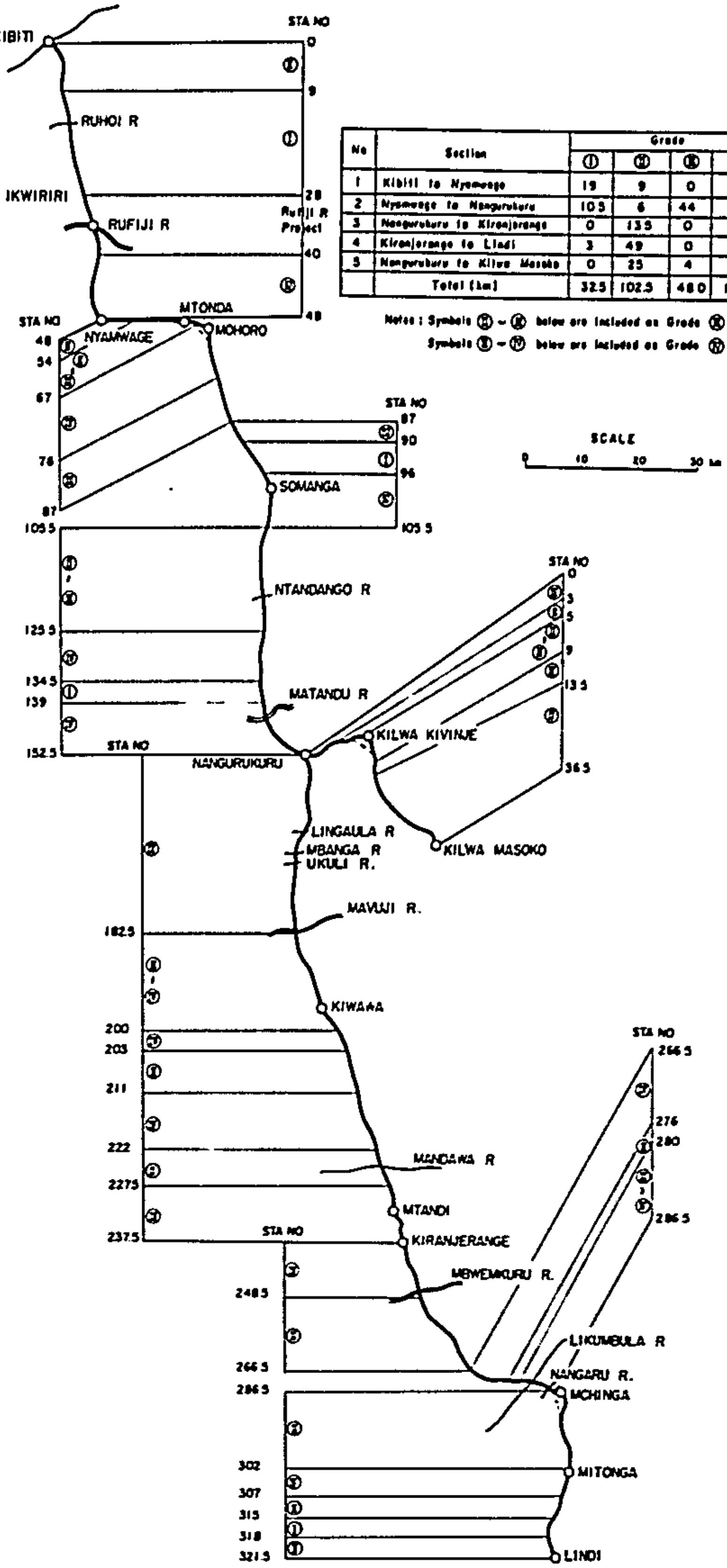
3.3 Soils and Aggregates along the Existing Road

3.3.1 Soil Conditions along the Existing Road

The soils along the existing road are classified as to physical and mechanical properties into four grades, Grade I through Grade IV. Table 3-2 shows their classification and suitability for road construction. Fig. 3-3 shows the soil distribution along the existing road according to the classification.

The soils of Grade I fall under A-1-b, A-3 and A-2-4 according to AASHO Classification, and are in the range of "Good to Acceptable" as subbase course material. These soils, when stabilized with treating agents such as aggregates of proper grain size and/or cement, are generally acceptable as base course material.

The soils of Grade II fall under A-3, A-2-4 and A-2-6. Lateritic soils are classified into A-2-4, A-2-6 and A-6, but are generalized to fall under Grade II. The soils of this grade are acceptable as lower subbase course material if thoroughly rolled with proper moisture control. They are also acceptable as subbase and base course material if stabilized with cement. Also, lime-stabilized soils are possibly acceptable as subbase course material. Of the lateritic soils under this grade, soils classed as A-6 are high in plasticity and not recommendable for use as base course material.



No	Section	Grade				Distance (km)
		I	II	III	IV	
1	Kibiti to Nyamwage	19	9	0	8	36 0
2	Nyamwage to Nangurukuru	10 5	6	44	44	104 5
3	Nangurukuru to Kiranjerange	0	13 5	0	71 5	85 0
4	Kiranjerange to Lindi	3	49	0	32	84 0
5	Nangurukuru to Kilwa Masoko	0	25	4	7 5	36 5
	Total (km)	32 5	102 5	48 0	163 0	346 0

Notes : Symbols [illegible] ~ [illegible] below are included on Grade [illegible] in the list.
Symbols [illegible] ~ [illegible] below are included on Grade [illegible] in the list.

FIG. 3-3

FIG. 3-3 SOUTHERN COASTAL LINK ROAD PROJECT

SOIL DISTRIBUTION ALONG THE EXISTING ROAD

Table 3-2 Classification of Soils Found along the Proposed Route

Grade	Classification Criteria	Suitability for Road Material: For Embankment Material	For Replacement Material	For Subgrade Material	For Subbase Course Material	For Base Course Material	Remarks
I	AASHO Classification A-1-6, A-3 and A-2-4 CBRs = 17∿40 % Estimated CBRm > 25 %	Excellent	Excellent	Excellent	Good to Acceptable	Acceptable when mechanically stabilized by adding granular materials. Acceptable when stabilized with cement. Admixtures of granular materials and these soils are acceptable when stabilized with cement or bituminous materials. Sand near the Ruhoi River is acceptable when stabilized with bituminous materials.	Sandy soils found in flat planes are included in this Grade.
II	AASHO Classification A-3, A-2-4 and A-2-6 Lateritic soils of A-6 are included. CBRs = 3∿8 % CBRm = 10∿25 %	Excellent to Good	Excellent to Medium	Excellent to Good	Acceptable to Unacceptable for Lower Subbase Course	A-3, A-2-4 and A-2-6 groups are acceptable when stabilized with cement. Admixtures of granular materials and lateritic soils of A-2-4 and A-2-6 are acceptable when stabilized with cement. Admixtures of granular materials and these soils of A-3 and A-2-4 are acceptable when stabilized with bituminous materials.	Lateritic soils and some of sandy soils in flat planes are included in this Grade.
III	AASHO Classification A-6 and A-7-6 Excluding lateritic soils of A-6 and black cotton clay and yellowish brown kaolin clay of A-7-6. CBRs = 1∿4 %	Acceptable	Unacceptable	Poor. Recommended to use the material of Grade I or II for upper part of subgrade.	Unacceptable	Unacceptable	Clayey soils of decomposed soft rock in hilly areas are included in this Grade. Some clayey soils in flat planes are also included.
IV	ASSHO Classification A-6 and A-7-6 Excluding soils of Grade III. CBRs ≤ 1 %	To be avoided in principle	Unacceptable	Unacceptable. Recommended to use the material of Grade I or II for upper part of subgrade.	Unacceptable	Unacceptable	Black cotton clay found in both hilly and flat areas is included in this Grade. Yellowish brown kaolin clay in hilly area is also included.

Note: CBRs denotes the CBR value of the soaked specimen compacted under natural moisture content with the compaction effort of 18.4 kg.cm/cm^3.

CBRm denotes the CBR value at soaked condition corresponding to 95 % of the maximum dry density, γ dmax. γ dmax is obtained by compacting sample under the compaction effort of 25.6 kg.cm/cm^3 (the modified Proctor).

The soils of Grade III are clayey. According to AASHO Classification, they fall under A-6 and A-7-6. They are acceptable as embankment materials, but not as subbase and base course materials. Since their CBR value is generally small, the lower subbase course of soils of Grade I or II should be provided for a standard thickness of surface, base and subbase when these soils are used as subgrade material.

The soils under Grade IV are black cotton clay and kaolin clay, and are classified into A-6 and A-7-6. They have no problem when dry, but are sharply degraded in strength when moistened during the rainy season. It is therefore advised not to use these soils for embankment. Even in the case of cut, it is desirable to provide a sufficient thickness of lower subbase course of Grade I or II soils for stable pavement.

3.3.2 Results of Stabilization Tests

1) Cement Stabilization Test

The soils under Grades I and II, including lateritic soils, showed an unconfined compression strength of about 12 to 22 kg/cm^2 when stabilized with 6 to 8 % of cement.

However, sand in the Rufiji which contains less than 10 % of fine particles of 0.074 mm or smaller showed a smaller strength at the same cement ratio than the sand with more fine particles.

Referring to the study conducted by the Road Research Laboratory (O'Reilly and Millard, 1969), even the unconfined compression strength of the Rufiji river sand stabilized with the said percentage of cement corresponds to 130 % to 264 % of CBR value.

2) Bitumen Stabilization Test

Three admixtures were prepared using the sand obtained in the Matandu River with such aggregates as: i) soft sandstone available around Kibiti; ii) hard limestone available around Nangurukuru; iii) the same as ii) available around Mchinga. All the specimens showed, when stabilized with straight asphalt, a Marshall stability higher than 500 kg, a strength satisfactory as base course material.

The mixing ratio of the Matandu River sand to the coarse aggregates taken from three different sites was 62 to 38, and the ratio of straight asphalt to the admixtures was 4 to 6.5 %.

The Ruhoi River sand gave a Marshall stability of more than 250 kg without being mixed with coarse aggregate, if stabilized with emulsified asphalt.

On the other hand, the sands in the Rufiji and around Ntandango were verified to show a Marshall stability of more than 250 kg if mixed with coarse aggregate of smaller sizes, provided that the mixing ratio of sand to coarse aggregate was 60 to 40. The emulsified asphalt used was in the range of 9.5 to 12 %.

3) Lime Stabilization

The survey this time omitted the tests concerning lime stabilization. According to "Laterite and Lateritic Soils and Other Problem Soils of Africa (the U.S. Agency for International Development, June 1971)", it is found that lime stabilization has a favourable effect on almost all lateritic soils in Africa. It is therefore believed that the lateritic soils along the route may be used at least in the upper layer of subbase course when stabilized with lime, and if soil property warrants, as a base course material. Whether or not such soils can be used, however, should be judged after stabilization tests.

3.3.3 Aggregates

1) Coarse Aggregates

Gravel is sparse along the entire route. In many cases, it is found coexistent with soil, denying efficient extraction. The project, therefore, has to rely mainly on crushed stone for the supply of necessary aggregates.

From Nangurukuru to Lindi at suitable intervals, there are promising quarries which mainly consist of limestone, and supply of coarse aggregates is comparatively easy. On the other hand, the area from Nangurukuru to Kibiti lacks quarries to supply the quality and quantity of stone required. Consequently, it is necessary to plan road construction so as to minimize the use of aggregate as pavement material for the length from Nangurukuru to Kibiti.

The relative positions of crushing plants and quarries need to be selected considering the reserves, quality, extractability of rock and the haulage of crushed stone. Their positions selected in Plan A (stage construction) are as shown in Table 3-3 below.

The quarry at Mpingo is about 1 km apart from the existing road, and will require construction of an approach road.

Table 3-3 Location of Crushing Plants and Quarries

Construction Stage	Crushing Plant	Quarry	Reserves of Rock in m^3
1st stage	Nangurukuru	Nangurukuru	100,000
		Mitole	500,000
	Mpingo	Mpingo	1,000,000
2nd stage	Mitole	Mitole	—
	Mpingo	Mpingo	—

The planned crushing sites have such difficulty in obtaining a large quantity of water that the plant facilities should be designed to be of the dry process.

2) Fine Aggregates

On the whole, the particle sizes of sand available for fine aggregates are small. Of them those closest to the grading of fine aggregate usually required for construction purposes are as follows.

Table 3-4 Location and Estimated Volume of Available Fine Aggregates

Section	Fine Aggregate Material
No.1	Rufiji River sand (sufficient to supply the required volume)
No.2	Rufiji River sand (sufficient to supply the required volume) Matandu River sand (available volume: 6,000 m^3)
No.3	Matandu River sand (surplus of the volume required in No.2 Section) Sand near Mpara (sufficient to supply the required volume)
No.4	Sand near Mpara (sufficient to supply the required volume) Sand at borrow pit near Lindi (available volume: 10,000 m^3. Requires to displace overlying soils.)
No.5	Matandu River sand (surplus of the volume required in Section No.2) Sand near Mpara (sufficient to supply the required volume)

3.4 Present Condition of the Existing Road

The existing road comprising the 325 km Kibiti-Lindi section and the 37 km Nangurukuru-Kilwa Masoko section is, for the most part, unimproved earth road as shown in Table 3-5.

Even in the dry season when weather is favourable, the average vehicle-running speed is no more than 30 km/hr. Particularly in sections where black cotton clay is predominant, the road surfaces are hideous, seriously impeding the running of vehicles.

In the mountainous regions, the road follows almost true to the topography, running up and down steep slopes of more than 12 %, with poor visibility. Even a jeep cannot drive its way without difficulties.

3.4.1 Section No.1 (Kibiti-Nyamwage)

With the exception of a longitudinal slope of over 10 % found on the way from the Kibiti heights to the lowlands near the Ruhoi River, the road generally runs flat.

Skirting the hill of Ikwiriri to Nyamwage is a floodplain of the Rufiji River. The road conditions are very bad in the lowlands where black cotton clay is prevailing.

3.4.2 Section No.2 (Nyamwage-Nangurukuru)

From Nyamwage to the Matandu River is a flat near the coastline. However, the area from the Matandu River to Nangurukuru is mountainous. The road surface in the flat from Nyamwage to Somanga is covered with dusty fine sand on which vehicles run with difficulty.

The lowlands near Mohoro leave the ravages by the past flood of the Rufiji River, and the road conditions are extremely poor. The worst is the mountainous area from the Matandu River to Nangurukuru where black cotton clay covers most of the road.

3.4.3 Section No.3 (Nangurukuru-Kiranjerange)

About 8 km south of Nangurukuru is an improved earth road covered with lateritic soil. It also has a fair alignment. The greater part of this section is through mountain ridges and drainage is good.

However, gorges of the Ringakuru River, the Mavuji River and the Mandawa River obstruct passage, and longitudinal alignments around the both ends of existing bridges are very bad.

3.4.4 Section No.4 (Kiranjerange-Lindi)

From Kiranjerange to Mchinga is a mountain path covered primarily by black cotton clay. Although the road is repaired in places by gravel, its surface conditions are not improved yet.

The section from Mchinga to Lindi is improved with lime-stone and laterite, having a comparatively favourable condition.

The section from Lindi to a point about 2 km north is paved in penetration macadam, and both horizontal and longitudinal alignments are good.

The sections from the Mbwemkuru River to the entrance of the mountains, from Mchinga to the plateau in Likonga, and from the plateau in Mitonga down to Lindi Bay form steeps with a longitudinal slope of over 10 % and are very bad in both horizontal and longitudinal alignments.

3.4.5 Section No.5 (Nangurukuru-Kilwa Masoko)

The section from Nangurukuru to Kilwa Kivinje runs mostly through a mountainous terrain, which has several rough spots where longitudinal alignment is poor.

The road surfaces are comparatively favourable due to improvements made with laterite and gravel.

From Kilwa Kivinje to Kilwa Masoko is a flat with a stable road surface. Both horizontal and longitudinal alignments are favourable. The lowlands leading from Kilwa Kivinje show the effects of previous floods, and have several rough spots where the road surface conditions are poor.

Table 3-5 Surface Conditions of the Existing Road

(km)

Item			No.1	No.2	No.3	No.4	No.5	Total
Flat	Paved	Good	-	-	-	-	-	-
		Poor	-	-	-	1.5	-	1.5
		Bad	-	-	-	0.5	-	0.5
	Improved Earth	Good	3.0	-	-	2.0	4.0	9.0
		Poor	2.2	6.0	-	4.0	4.0	16.2
		Bad	2.0	4.0	-	2.0	3.0	11.0
	Earth	Good	5.0	-	-	6.0	-	11.0
		Poor	6.0	2.0	2.5	3.0	5.0	18.5
		Bad	20.0	61.3	12.1	3.6	4.0	101.0
	Subtotal		38.2	73.3	14.6	22.6	20.0	168.7
Hilly	Paved	Good	-	-	-	-	-	-
		Poor	-	-	-	-	-	-
		Bad	-	-	-	-	-	-
	Improved Earth	Good	2.0	-	8.7	1.0	-	11.7
		Poor	2.0	-	8.0	3.0	-	13.0
		Bad	1.0	-	7.0	4.0	2.0	14.0
	Earth	Good	-	-	-	1.3	-	1.3
		Poor	-	4.0	6.0	2.0	1.9	13.9
		Bad	-	16.0	4.0	4.5	3.0	27.5
	Subtotal		5.0	20.0	33.7	16.3	6.9	81.9
Mountainous	Paved	Good	-	-	-	-	-	-
		Poor	-	-	-	-	-	-
		Bad	-	-	-	-	-	-
	Improved Earth	Good	1.0	-	8.0	6.1	-	15.1
		Poor	3.0	1.0	14.5	5.0	2.0	25.5
		Bad	1.5	3.2	5.5	8.0	2.8	21.0
	Earth	Good	-	-	-	-	-	-
		Poor	-	1.0	4.0	2.0	2.0	9.0
		Bad	-	9.0	9.0	18.0	3.0	39.0
	Subtotal		5.5	14.2	41.0	40.1	9.8	110.6
Total			48.7	107.5	89.3	79.0	36.7	361.2

3.5 Alignment and Cross-Sectional Plan

3.5.1 Horizontal Alignment

The horizontal alignment is planned to follow the existing route as far as conditions permit.

The route is planned not to run through the lowlands wherever possible. In the mountainous area, it is selected so as to avoid as far as possible valleys, where rain water is apt to concentrate, and unstable hillsides. While the design standards specify 300 m as a minimum radius of curvature and 230 m as an absolute minimum, the radius of curvature is designed as large as possible where the lay of the land permits, taking account of enabling vehicles to run easily. For the curves falling short of 1,500 m in radius, a transition curve is added.

1) Section No.1

With the exception of Kibiti and its neighbourhood, the flat on the Rufiji River is given an alignment having great radii of curvature along the existing road. In the 10-km section from Kibiti to the mountains lying to the south, there is a difference of about 120 m in altitude. For this reason, several routes of different longitudinal alignments are taken up and compared for the optimum alignment. For the 12-km section in the Rufiji region for which the detail design has already been completed, the designed alignment is directly incorporated into the present plan. For the almost right angle portion in Nyamwage, a large radius of curvature (R=600 m) is provided as a shortcut.

2) Section No.2

Up until the Matandu River, the route runs on a flat near the coastline. The route is selected to run along the existing road. The Mohoro area is in a floodplain of the Rufiji, therefore the route is shifted toward the hills to make a large shortcut.

The road in Somanga meanders with a bad alignment through the villages, and is therefore veered toward the hills to improve the alignment and at the same time to provide a shortcut.

At the crossing of the Matandu River, a straight route is selected between the existing road and the bridge under construction.

The junction of Nangurukuru is atop the highest peak of the existing road. In order to improve the longitudinal alignment of the road, it is rerouted westward toward the comparatively moderate lowlands. With this, both horizontal and longitudinal alignments can be improved.

3) Section No.3

Most of this section lies in the mountains.

The existing road runs through the ridges of terraces with good draining conditions. The route is therefore selected along the existing one wherever possible.

At the crossing of the Mavuji River, the existing bridge takes a circuitous way on the west. A new straight route is selected to the east of the existing bridge. Around the depths of the Mandawa River, the best crossing point is found on the east side of the existing bridge, and an alignment of R=1,500 m is planned in view of the approaches to and from.

4) Section No.4

This section runs through the Mbwemkuru basin and then climbs the mountainous areas broken by the coast near Mchinga and finally reaches Lindi on the coast.

The crossing point of the Mbwemkuru River is selected to the east of the existing bridge in order to provide a straight passage over the River and its floodplain. From Mchinga to a point some 5 km north are several serpentine rivers. The route is selected to avoid them wherever possible.

The sections from the coast near Mchinga up toward the tableland in Likonga and from there down to the coast of Lindi have steeps. After examining several routes, the optimum alignment is finally determined. About 3 km north of Lindi is a broad, well-surfaced road, and the route is directed to make the maximum use of it.

5) Section No.5

This is a feeder road from Nangurukuru to Kilwa Masoko via Kilwa Kivinje.

Because of Kilwa Kivinje, the road makes a large detour. For the route location, a shortcut is provided to bypass Kilwa Kivinje. As a result, a length nearly 8 km is shortened as compared with the existing road.

About 10 km east of Nangurukuru is a mountainous path, and the remainder is through the flat near the coast. The alignment of the existing road on the flat is very good. Therefore, a greater part of the route is selected along the existing road with a few exceptional portions where minor improvements are planned in the alignment.

The 3.75-km section of the existing road, which lies between Kilwa Kivinje and a point some 8 km east of Nangurukuru where the existing road leaves the planned route, is improved as an approach road to Kilwa Kivinje, and its construction costs are estimated.

3.5.2 Longitudinal Alignment

The maximum longitudinal slope is planned to be 8 % in the mountainous terrain, and the minimum in the flat terrain is planned to be 0.2 % from the viewpoint of surface drainage.

The banking height for those sections where soils under Grade IV prevail is set at 1.0 to 1.5 m so that a suitable thickness of pavement can be provided above the ground surface; in sections where soils under Grade I through III prevail the height is standardized at 0.5 to 1.0 m. For the floodplains, the high water level is estimated from traces left by past floods, interview surveys and hydrological analysis, etc. The clearance of those bridges over the three major rivers, the Matandu, Mavuji and Mbwemkuru, is set at 1.2 m above the design high water level; the clearance of those small and medium river bridges at 1.0 m.

The cutting section is planned to minimize the earthwork while giving due consideration to drainage conditions.

1) Section No.1

For the design level of the road in the floodplain of the Rufiji River, the high water level of 17.5 m, specified for the Rufiji River Bridge Project for which detail design has already been completed, is taken. An allowance of 1.0 m is given to determine the design road level of 18.5 m. Also, the design level is planned to coincide with the level at both ends established for the Rufiji River Bridge Project.

The passage in the mountains about 5 km south of Kibiti has so many ups and downs that the maximum longitudinal slope of 8 % is applied.

2) Section No.2

It is said that Mohoro and its vicinity are inundated up to a maximum of 2.0 m when the Rufiji River overflows.

Accordingly, the high water level is set at 10.0 m, and the design road level is given an allowance of 1.0 m to a level of 11.0 m.

For the Matandu River, the high water level is set at 10.5 m judging from the traces of flood, interviews and hydrological analyses.

The mountainous route from the Matandu River to the junction in Nangurukuru is rough, and several steeps with a maximum longitudinal slope of 8 % were necessarily included due to particular topographic conditions.

3) Section No.3

Most of this section is moderately hilly, and the longitudinal alignment selected follows the existing topography.

In this section, however, there are the Lingaula, Mavuji and Mandawa Rivers running down deep gorges. In order to reduce costs for the bridge substructures and the earthwork of the access roads, the longitudinal alignment should be as gentle as possible. The high water level of the Mavuji River is set at 35.00 m.

The maximum longitudinal slope applied in this section is 8 %.

4) Section No.4

The mountains from Kiranjerange to the Mbwemkuru show a moderate topography, and the alignment is adapted to the topography.

The high water level of the Mbwemkuru is set at 24.50 m. The maximum slope of 8 % is applied to the sections from the Mbwemkuru to the entrance of the mountains, to the climb from Mchinga to the tableland of Likonga and to the descent from the plateau of Lindi Airport to the coastline.

The section measuring some 3 km northward from Lindi has favourable road surface conditions and alignment, and the alignment is planned along the existing road.

5) Section No.5

The route from the Nangurukuru junction to the end of the section bypassing Kilwa Kivinje runs mostly in the mountainous terrain. This section is planned to have a gentle longitudinal alignment following the mountainside.

The section of about 20 km from Nangurukuru toward the north is planned to go on and along the existing road which runs in the middle of a flat peninsula. The minimum banking height in this section is set at 0.5 to 1.0 m, taking account of the drainage across the road.

The level of the planned junction at which the route crosses the existing road running toward Kilwa Kivinje is designed to meet that of the existing road.

3.5.3 Cross Section

The typical cross sections were determined on the basis of the arrangement with the Tanzanian Government as illustrated in Figs. 3-1 and 3-2. The width of the carriageway is 6.5 m for two lanes, and the shoulder width is 1.8 m. The overall width is 10.10 m. Where the cutting depth exceeds 2.0 m, the shoulder width is reduced to 1.2 m in order to reduce the earthwork.

In some villages and towns along the existing road, there are provided lay-bys on both sides to serve as bus stops. The lay-by measures 3.0 m in width and 50.0 m in length, and is tapered off into the main carriageway at either end. The crossfall for the standard section is planned to be 3 % for the carriageway and 4 % for the shoulder.

The slope gradient of the bank is planned to be 1:2, and that of the excavated section 1:1, as the standard. Vegetation is considered for protecting the slope.

For those slopes near a bridge or along the coast which are liable to be affected by turbulent flow of running water or waves, special protection by masonry is planned.

3.6 Earthwork Plan

The soil distribution was surveyed in the areas through which the planned route runs. As the result, the soils were classified into four grades, Grade I through IV. The earthwork is also classified in conformity to the said grades as shown in Table 3-6.

In the banking sections where soils of Grades I through III prevail, a side ditch is planned on either side, and the soil dug out is to be used for the banking.

In the banking sections where soils of Grade IV prevail, the subsurface soils become soft in the rainy season. The banking height is, therefore, planned a little higher than normal so that the influence of traffic load to the subsurface soil is reduced thus retaining stable pavement after completion. Embankment and subgrade in these sections are planned to be conditioned with soils of Grade I or II brought from other places.

The soils of Grade IV excavated in the cutting sections cannot be used for embankment or subgrade, and will be disposed of at a suitable dump.

Further, Grade IV soils 30-60 cm deep under the subbase course will be excavated and disposed of according to CBR value and future traffic volume. These portions will be replaced with good soils of Grade I or II.

The amount of earthwork by section and work is as shown in Table 3-7.

Table 3-6 Soil Classification - 1/2

Section	Grade	Subsection		Length(m)	Remarks
No. 1	II	No. 0 ∿	No. 9	9,000	
	I	No. 9 ∿	No. 28	19,000	
		(No. 28 ∿	No. 40)	(12,000)	Rufiji River Bridge Project
	IV	No. 40 ∿	No. 48	8,000	
	Total	No. 0 ∿	No. 48	36,000	Kibiti ∿ Nyamwage
No. 2	II	No. 48 ∿	No. 54	6,000	
	III	No. 54 ∿	No. 63	9,000	
	IV	No. 63 ∿	No. 75	12,000	Mohoro
	III	No. 75 ∿	No. 83	8,000	
	IV	No. 83 ∿	No. 87	4,000	
	I	No. 87 ∿	No. 94	7,000	
	IV	No. 94 ∿	No.104	10,000	
	III	No.104 ∿	No.123	19,000	
	IV	No.123 ∿	No.130+500	7,500	
	I	No.130+500 ∿	No.136	5,500	
	IV	No.136 ∿	No.148+700	12,700	
	Total	No.48 ∿	No.148+700	100,700	Nyamwage ∿ Nangurukuru
No. 3	IV	No.148+700 ∿	No.202	53,300	
	II	No.202 ∿	No.209	7,000	
	IV	No.209 ∿	No.219	10,000	
	II	No.219 ∿	No.226	7,000	
	IV	No.226 ∿	No.235+300	9,300	
	Total	No.148+700 ∿	No.235+300	86,600	Nangurukuru ∿ Kiranjerange
No. 4	IV	No.235+300 ∿	No.244	8,700	
	II	No.244 ∿	No.263	19,000	
	IV	No.263 ∿	No.271	8,000	
	II	No.271 ∿	No.274+200	3,200	
	IV	No.274+200 ∿	No.281+100	6,900	

Table 3-6 Soil Classification - 2/2

Section	Grade	Subsection	Length(m)	Remarks
No. 4 (Cont'd)	II	No.281+100 ∿ No.296	14,900	
	IV	No.296 ∿ No.300	4,000	
	II	No.300 ∿ No.304	4,000	
	I	No.304 ∿ No.308	4,000	
	II	No.308 ∿ No.311+450	3,450	
	Total	No.235+300 ∿ No.311+450	76,150	Kiranjerange ∿ Lindi
No. 5	IV	No. 0 ∿ No. 4	4,000	
	II	No. 4 ∿ No. 7	3,000	
	III	No. 7 ∿ No.12	5,000	
	II	No.12 ∿ No.30+350	18,350	
	Total	No. 0 ∿ No.30+350	30,350	Nangurukuru ∿ Kilwa Masoko
Total	I		35,500	
	II		94,900	
	III		41,000	
	IV		158,400	
	Total		329,800	

Table 3-7 Amount of Earthwork

Section	Work	Amount in m^3	Remarks
No. 1	1. Excavation	130,531	1. Excavation Work Excavated soil is planned to be used for embankment.
	2. Banking (1)	138,310	
	3. Banking (2)	110,844	
	4. Disposing	—	
	Subtotal	379,685	
No. 2	1. Excavation	215,658	2. Banking Work (1) Soil excavated out of side ditch is planned to be used for embankment.
	2. Banking (1)	657,018	
	3. Banking (2)	706,359	
	4. Disposing	270,978	
	Subtotal	1,850,013	
No. 3	1. Excavation	472,078	3. Banking Work (2) Soils of Grade I or II transported from other places are used for embankment.
	2. Banking (1)	—	
	3. Banking (2)	43,535	
	4. Disposing	572,492	
	Subtotal	1,088,105	
No. 4	1. Excavation	761,255	4. Disposing Work Soils of Grade IV in cutting sections are planned to be disposed.
	2. Banking (1)	—	
	3. Banking (2)	—	
	4. Disposing	494,062	
	Subtotal	1,255,317	
No. 5	1. Excavation	79,155	
	2. Banking (1)	—	
	3. Banking (2)	18,205	
	4. Disposing	30,330	
	Subtotal	127,690	
Total	1. Excavation	1,658,677	
	2. Banking (1)	795,328	
	3. Banking (2)	878,943	
	4. Disposing	1,367,862	
	Grand Total	4,700,810	

3.7 Drainage Plan

3.7.1 Ditches

Drainage in cutting sections is designed parallel to the road by providing ditches on either side of the road. The ditches will be earthen where the flow velocity is less than 1.0 m/sec. and be of concrete where the flow exceeds 1.0 m/sec. according to the hydrologic analyses. Concrete ditches will have a standard section with 2.65 m upper width and 1.0 m bottom width and 0.55 m height. The flow in the ditches is designed to drain into some adequate low spots or valleys where available.

On the other hand, drainage in banking sections is provided with earthen ditches located 3 m apart from the toe of slope with the purpose of ensuring the stability of embankment. In case excavated soils fall under Grade I through III, such soils will be used as banking material.

Crossfall for surface drainage is designed 3 % for carriageway and 4 % for shoulder. The gradient of the gutter to collect the water is designed 0.2 % or above even in the flat terrain.

3.7.2 Drainage across Road

For drainage facilities across road other than bridges (see Chapter 4), box culverts are provided for small rivers and pipe culverts for still smaller water channels.

1) Box Culvert

Box culverts are provided at thirty-one places to drain the design discharges of twenty-four small rivers on the basis of hydrological analyses.

The design discharge is based on the Rational formula at a fifty-year probability. (Refer to 4.3 for details.)

These box culverts planned are classified into four types as mentioned below and arranged for use according to the design discharge.

a) 2.0 m x 2.0 m x 2 cells
b) 2.0 m x 2.0 m x 3 cells
c) 2.5 m x 2.0 m x 3 cells
d) 3.0 m x 2.5 m x 3 cells

Necessary particulars for hydrological analyses to determine the dimensions of box culverts are as shown in Table 3-8.

2) Pipe Culvert

Three types of corrugated pipe, $\phi 600$, $\phi 900$ and $\phi 1200$, are planned for a small scale drainage facility at four hundred and three spots in lowlands and other places where rain water is expected to gather due to the regional topography.

Besides the above, pipes of $\phi 600$ are to be laid under the ground at such points that local roads connect to the Project Road and under any passages connecting towns and villages.

The number of pipe culverts required for each section is shown in Table 3-9.

Table 3-8 Design Particulars of Box Culverts

Section	Station No.		Catchment Area Length and Slope			Time of Concentration and Rainfall Intensity		Run-off and Specific Run-off		Box-Culvert (m)	Existing Facility
			Area (km^2)	Length (km)	Slope	Time of Concent. (min)	Rainfall Intensity (mm/hr)	Run-off (m^3/s)	Specific Run-off ($m/s/km^2$)		
2	No.65	No.65+800								3 cell 2.0x2.0	
		No.66+100	18.92	10.7	1/180	221	51.2	81	4.3	3 cell 2.0x2.0	
	No.67	67+ 10								3 cell 2.0x2.0	
		101+442	2.72	3.0	1/250	89	104.2	24	8.8	3 cell 2.0x2.0	
	No.102	102+250								3 cell 2.0x2.0	
		102+700	12.93	9.0	1/165	181	60.5	66	5.1	2 cell 2.0x2.0	
		102+869								3 cell 2.5x2.0	1500mmø corrugated pipe
		111+663	6.40	5.0	1/160	107	91.3	49	7.7	3 cell 3.0x2.5	
		113+150	10.67	8.8	1/160	174	62.0	55	5.2	3 cell 3.0x2.5	
		131+870	3.25	3.6	1/80	62	132.2	36	11.1	3 cell 2.5x2.0	
	No.139	139+725								2 cell 2.0x2.0	400mmøx3 corrugated pipes
		139+930	1.13	1.0	1/15	24	212.7	20	17.7	ø1200x2	
	No.141	141+200								3 cell 2.0x2.0	
		141+300	3.40	3.0	1/50	46	157.2	45	13.2	2 cell 2.0x2.0	
	No.142	142+930								3 cell 2.0x2.0	400mmøx3 corrugated pipes
	No.143	143+250	5.93	5.2	1/60	71	121.3	60	10.1	3 cell 2.5x2.0	
3		185+950	2.20	3.0	1/90	57	139.1	26	11.8	3 cell 2.0x2.0	
		187+366	1.38	1.9	1/100	45	159.1	19	13.8	2 cell 2.0x2.0	
		188+250	2.70	2.3	1/100	50	150.1	34	12.6	3 cell 2.5x2.0	1000mmø corrugated pipe
		189+790	4.12	4.0	1/105	74	118.1	41	10.0	3 cell 3.0x2.5	1000mmø corrugated pipe
		200+ 76	2.77	3.7	1/40	48	153.6	36	13.0	3 cell 2.5x2.0	
	No.201	201+966								3 cell 2.0x2.0	
	No.202	202+ 32	4.51	4.0	1/45	53	145.2	55	12.2	3 cell 2.0x2.0	
		238+480	3.00	2.4	1/65	44	161.1	41	13.7	3 cell 3.0x2.5	500mmøx3 corrugated pipes
4		272+100	2.22	2.5	1/40	39	171.5	32	14.4	3 cell 2.5x2.0	
		278+550	2.12	2.4	1/30	35	180.8	32	15.1	3 cell 2.5x2.0	
		305+565	2.20	2.6	1/30	37	176.0	33	15.0	3 cell 2.5x2.0	4.6m bridge
		307+715	2.53	2.4	1/15	30	194.0	41	16.2	3 cell 3.0x2.5	3.0m arch bridge
		310+ 50	3.30	3.9	1/20	40	169.3	47	14.2	3 cell 3.0x2.5	
5		4+597	1.78	1.6	1/20	28	199.8	30	16.9	3 cell 2.5x2.0	1200mmø corrugated pipe
		15+200	3.33	2.0	1/170	56	140.6	39	11.7	3 cell 3.0x2.5	950mmøx3 corrugated pipes
		18+805	2.20	1.0	1/85	32	188.5	35	15.9	3 cell 2.5x2.0	5.0m bridge

Table 3-9 Length of Pipe Culverts

(m)

Size / Section	φ600		φ900		φ1200		Total	
	Number of places provided	Total length	Number of places provided	Total length	Number of places provided	Total length	Number of places provided	Total length
No. 1	7	126	14	241	7	148	28	515
No. 2	12	229	34	597	65	1,550	111	2,376
No. 3	40	802	44	991	30	902	114	2,695
No. 4	52	996	22	466	21	585	95	2,047
No. 5	20	302	29	471	6	230	55	1,003
Total	131	2,455	143	2,766	129	3,415	403	8,636

3.8 Pavement Plan

"AASHO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURE, 1972" was referred to as a guideline for designing the pavement cross section.

Major conditions for the design are as follows.

1) The traffic volume here is based on the future traffic volume for Case 1 of Plan A as mentioned in "Chapter 6 - Economic Evaluation".
2) Terminal serviceability index was set at 2.0.
3) Regional factor was set at 1.5.
4) Soil support value was estimated from C.B.R.

3.8.1 Pavement Cross Section for Plan A

It is presumed that the road is opened for use as engineered gravel road for the initial ten years from 1983 when traffic volume is small, and that pavement work is to start in 1993.

Following are the results of the examination on pavement structure.

First Stage - Engineered gravel road (See Fig. 3-4.)

Surface course:

A 10-cm layer of gravel or crushed stones. These materials, mixed with some amount of soil, are made into the soil-aggregate. The soil should have liquid limit less than 35 % and plasticity index between 4 and 9. The grading texture is as specified in AASHO M-147-65, and content of fine grained soil passing #200 sieve should be 8 % at the minimum. The course will serve as the subbase course for the second-stage pavement.

Base course:

A 10-cm course of cement-stabilized Grade I or II sandy soil which is available locally. Its unconfined compression strength is to be 6 kg/cm^2 or greater. This course will serve also as the subbase course for the second stage.

Subbase course:

The course is composed of soil with CBR of 10 or more. It will serve as the lower subbase course for the second stage. So the course must be made as thick as required for the pavement cross section in the second stage.

Second Stage - Paved road (See Fig. 3-4.)

Surface course:

The double-seal penetration macadam having a total thickness of 3 cm.

Base course:

The cement-stabilized base course with a thickness of 15 cm. In the areas to the north of Somanga, where aggregate is in short supply, cement-stabilized Grade I or II sandy soil, or soil cement, will be used for the course.

In the areas to the south of Somanga, soil-aggregate cement, or cement-stabilized mixture of aggregate and Grade I or II soil locally available will be used for the course. Unconfined compression strength of soil cement and soil-aggregate cement must exceed 15 kg/cm^2.

Subbase course:

The soil-aggregate and soil cement layers forming the surface and base courses in the first stage is expected to serve as the subbase course. The total thickness is designed to be 20 cm.

Lower subbase course:

The subbase course in the first stage corresponds to this course. It must be composed of soil with CBR of 10 or over.

Its thickness was determined by estimating soil support value of subgrade soil from the grade of soils prevailing along the route and also taking into account future traffic volume forecast for each section. See Table 3-10.

Figs. 3-6 through 3-10 show the pavement cross section design for each section along the route, according to Plan A.

3.8.2 Pavement Cross Section for Plan B

Plan B is for the paved road to be opened for use from the initial year of 1983. The pavement structure is as follows. See Fig. 3-5.

Surface course:

The same as the surface course in the second stage of Plan A.

Base course:

The same as the base course in the second stage of Plan A.

Subbase course:

Soil cement base course with the thickness of 15 cm. Its unconfined compression strength must be 6 kg/cm^2 or greater.

Lower subbase course:

The course is composed of soil with CBR of 10 or more. Its thickness was determined from soil support value of subgrade and future traffic volume. See Table 3-11.

FIG. 3-4

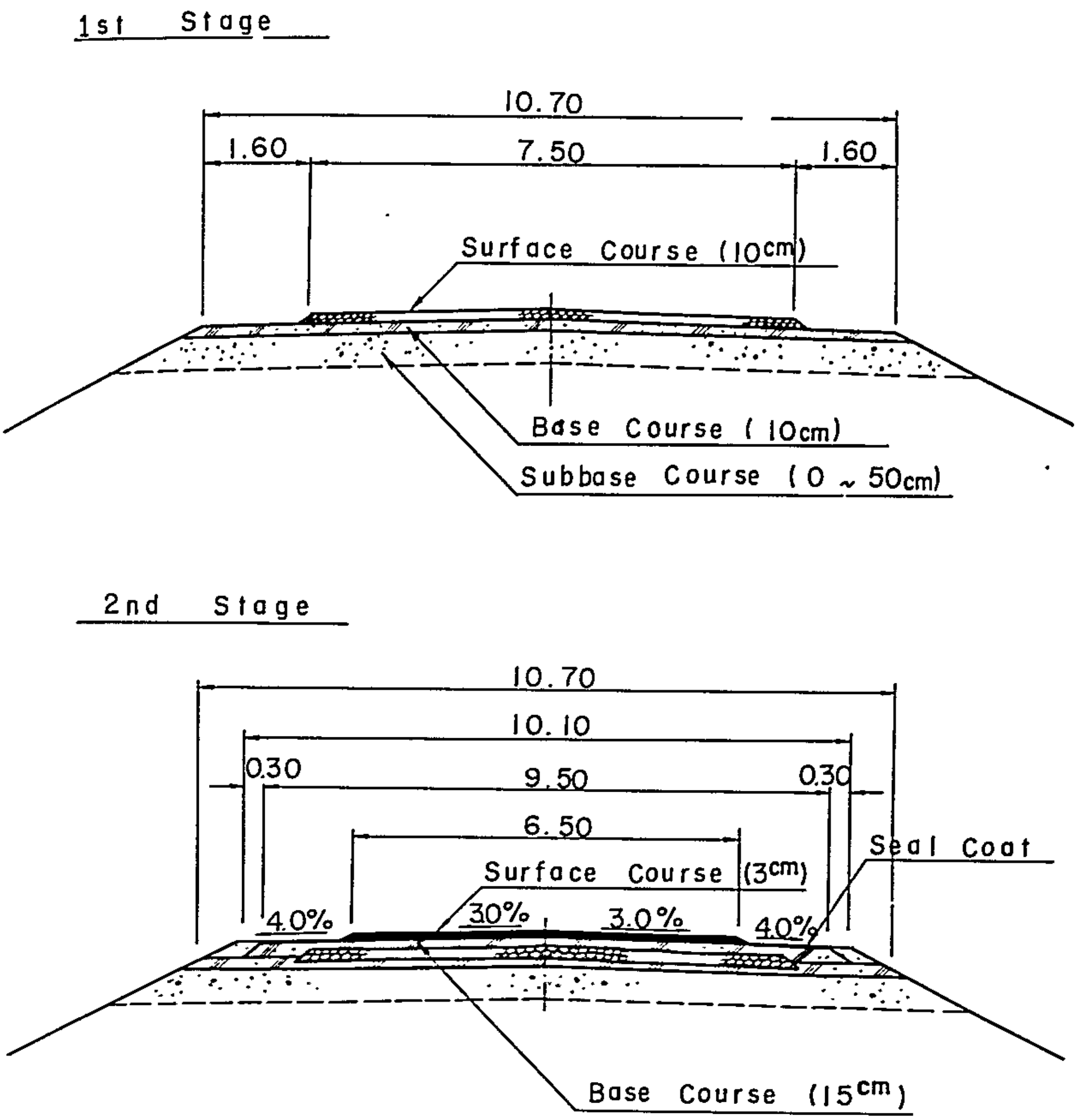
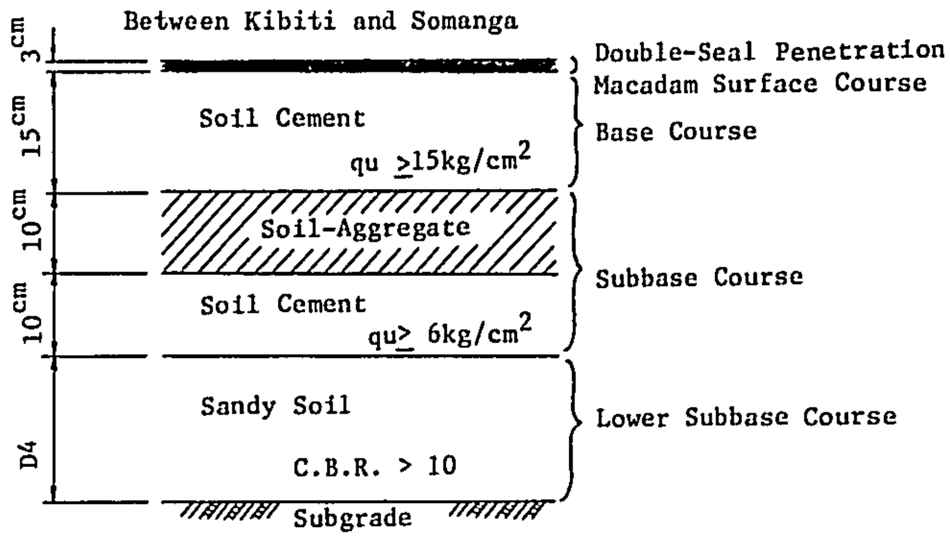
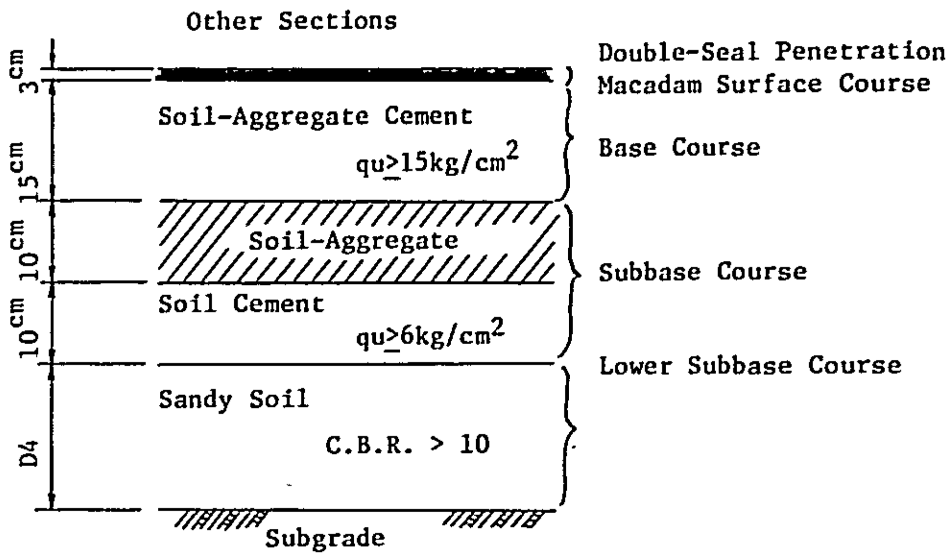


FIG. 3-4	SOUTHERN COASTAL LINK ROAD PROJECT
	PAVEMENT CROSS SECTION FOR PLAN A

Table 3-10 Pavement Cross Section for Plan A





D4 in Centimeters

Section / Soil Grade	No.1	No.2 (NYAMWAGE ∿ SOMANGA)	No.2 (SOMANGA ∿NANGURUKURU) No.3, No.4	No.5
I	0	0	0	0
II	0	0	0	0
III	40	40	20	10
IV	50	50	40	30

FIG. 3-5

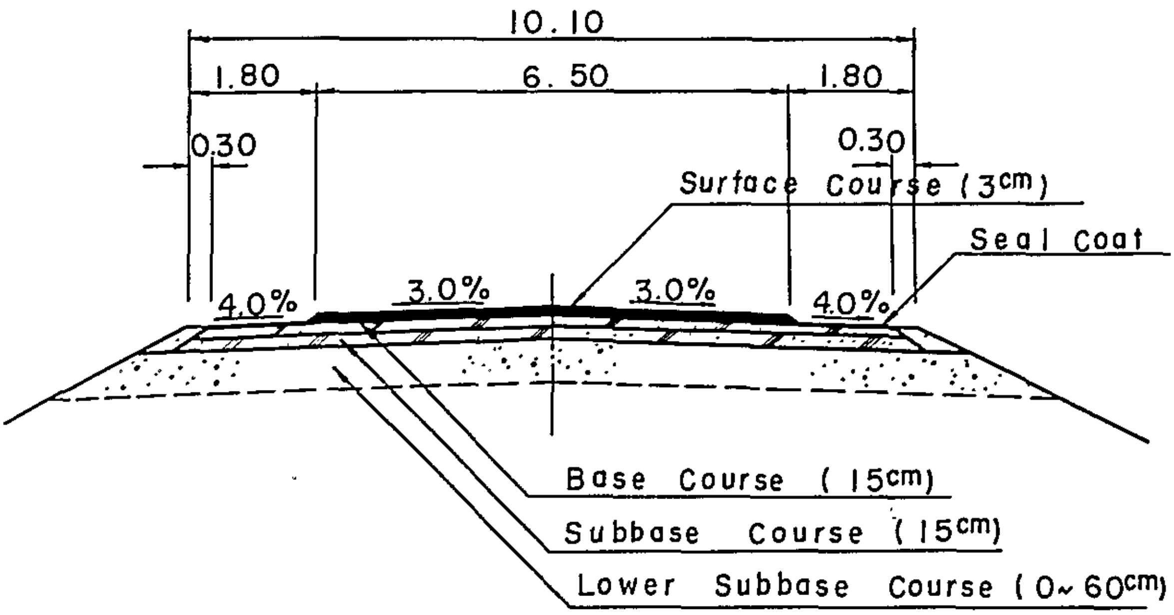
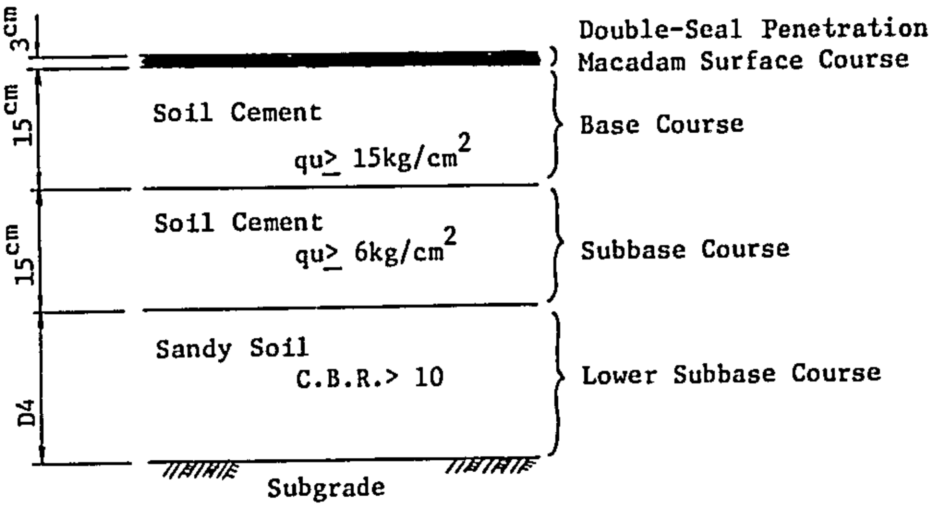


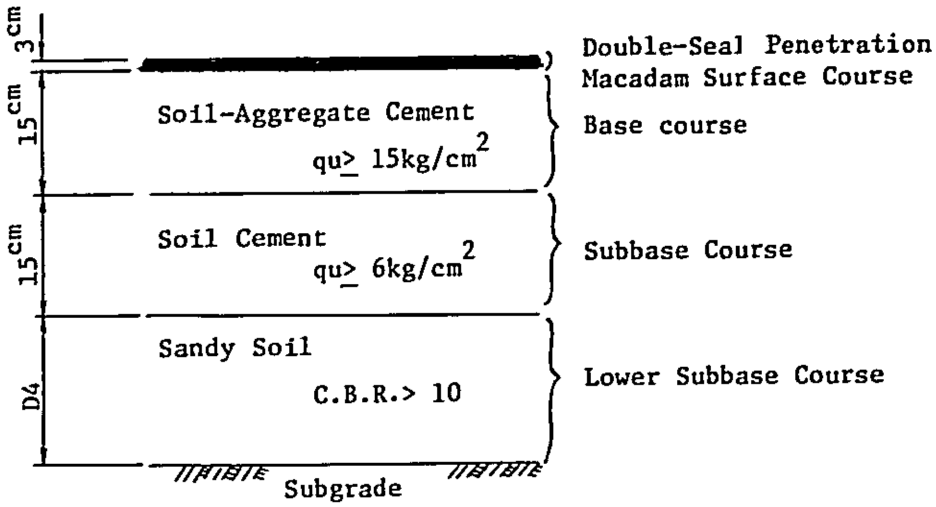
FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
3-5	PAVEMENT CROSS SECTION FOR PLAN B

Table 3-11 Pavement Cross Section for Plan B

Between Kibiti and Somanga



Other Sections



D4 in Centimeters

Section / Soil Grade	No.1	No.2 (NYAMWAGE ∿ SOMANGA)	No.2 (SOMANGA ∿NANGURUKURU) No.3, No.4	No.5
I	0	0	0	0
II	0	0	0	0
III	50	40	30	20
IV	60	60	40	30

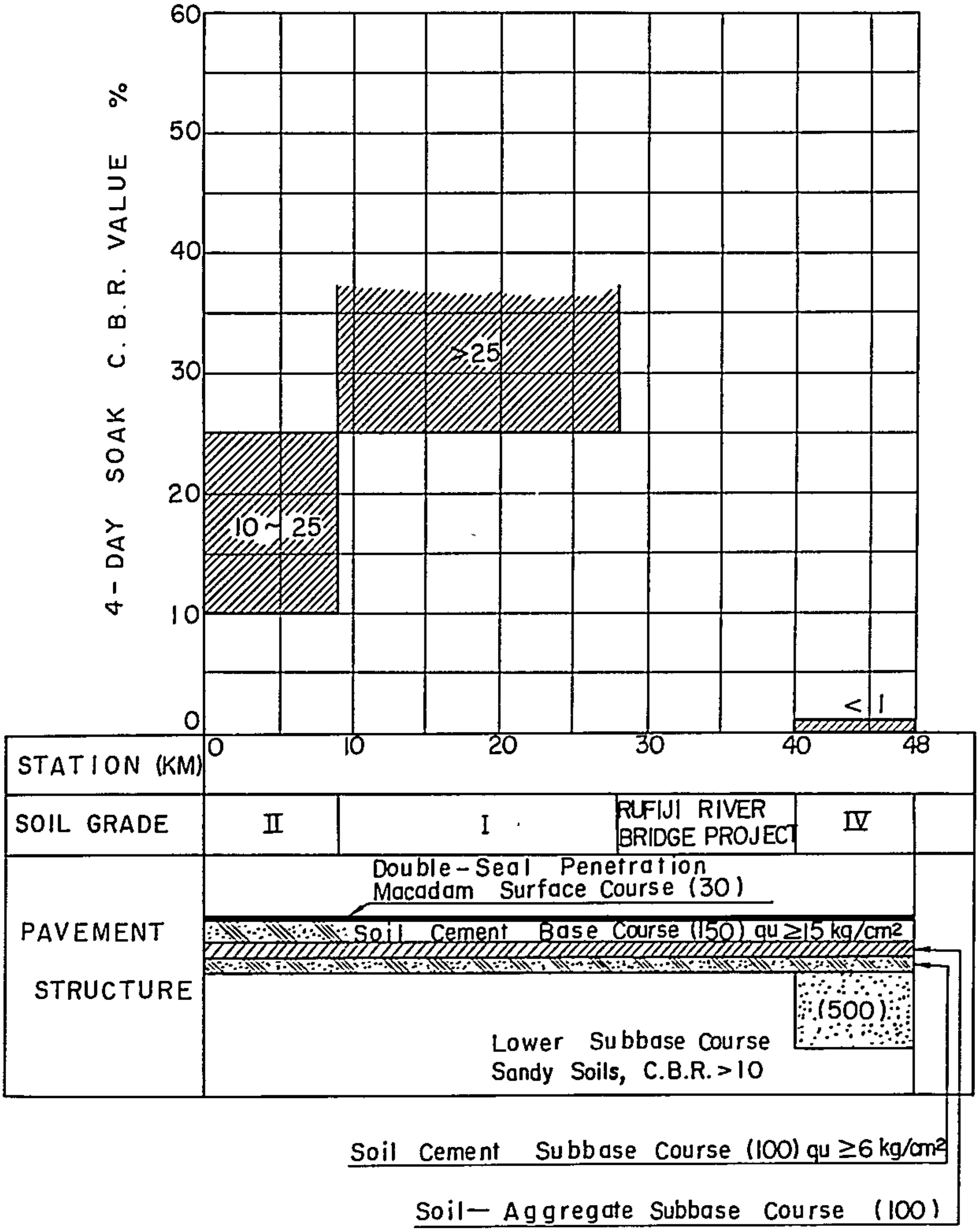


FIG. 3-6	SOUTHERN COASTAL LINK ROAD PROJECT
	SECTION – I (KIBITI ~ NYAMWAGE) PAVEMENT DESIGN FOR PLAN A

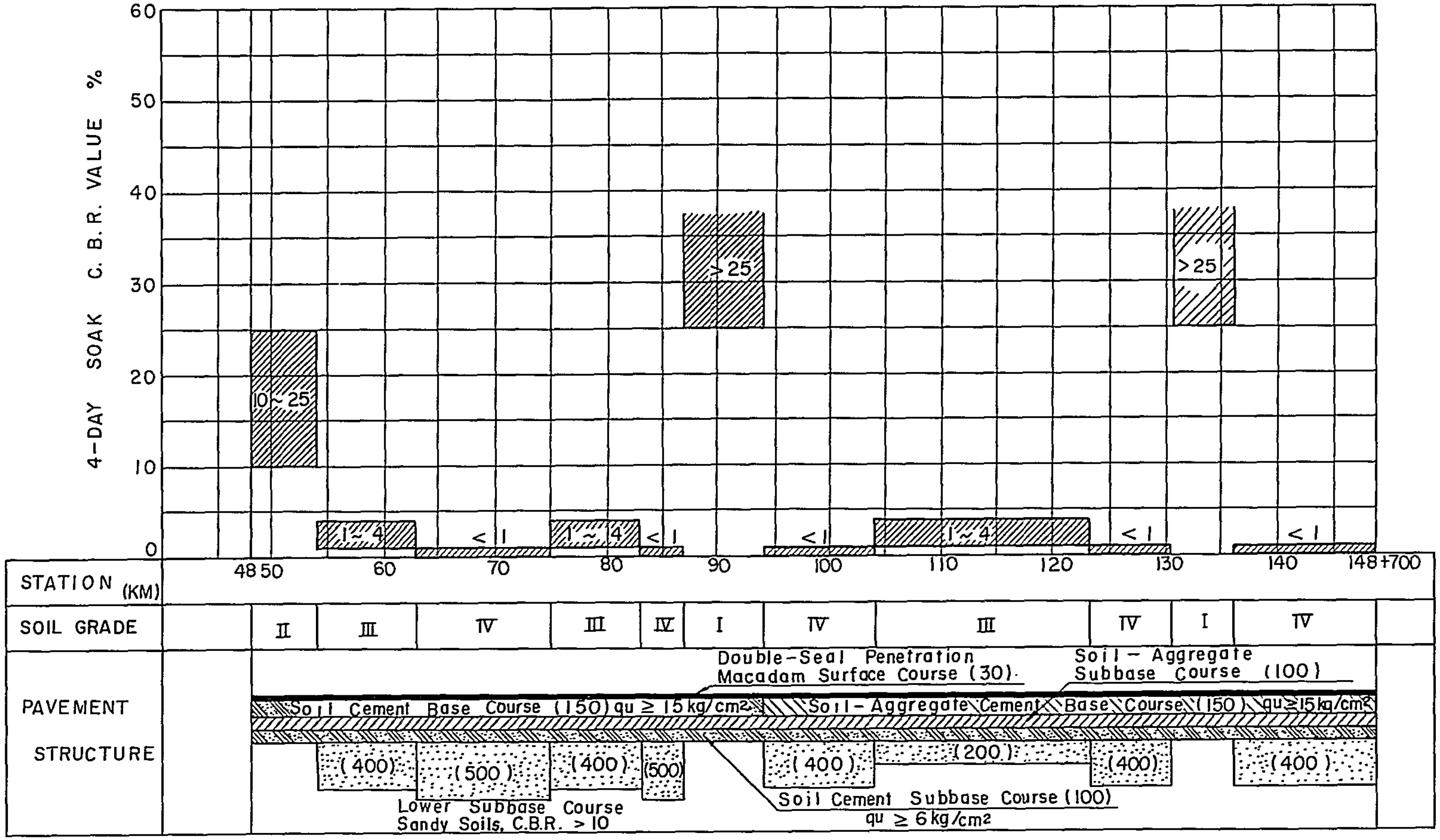


FIG. 3-7	SOUTHERN COASTAL LINK ROAD PROJECT
	SECTION - 2 (NYAMWAGE ~ NANGURUKURU) PAVEMENT DESIGN FOR PLAN A

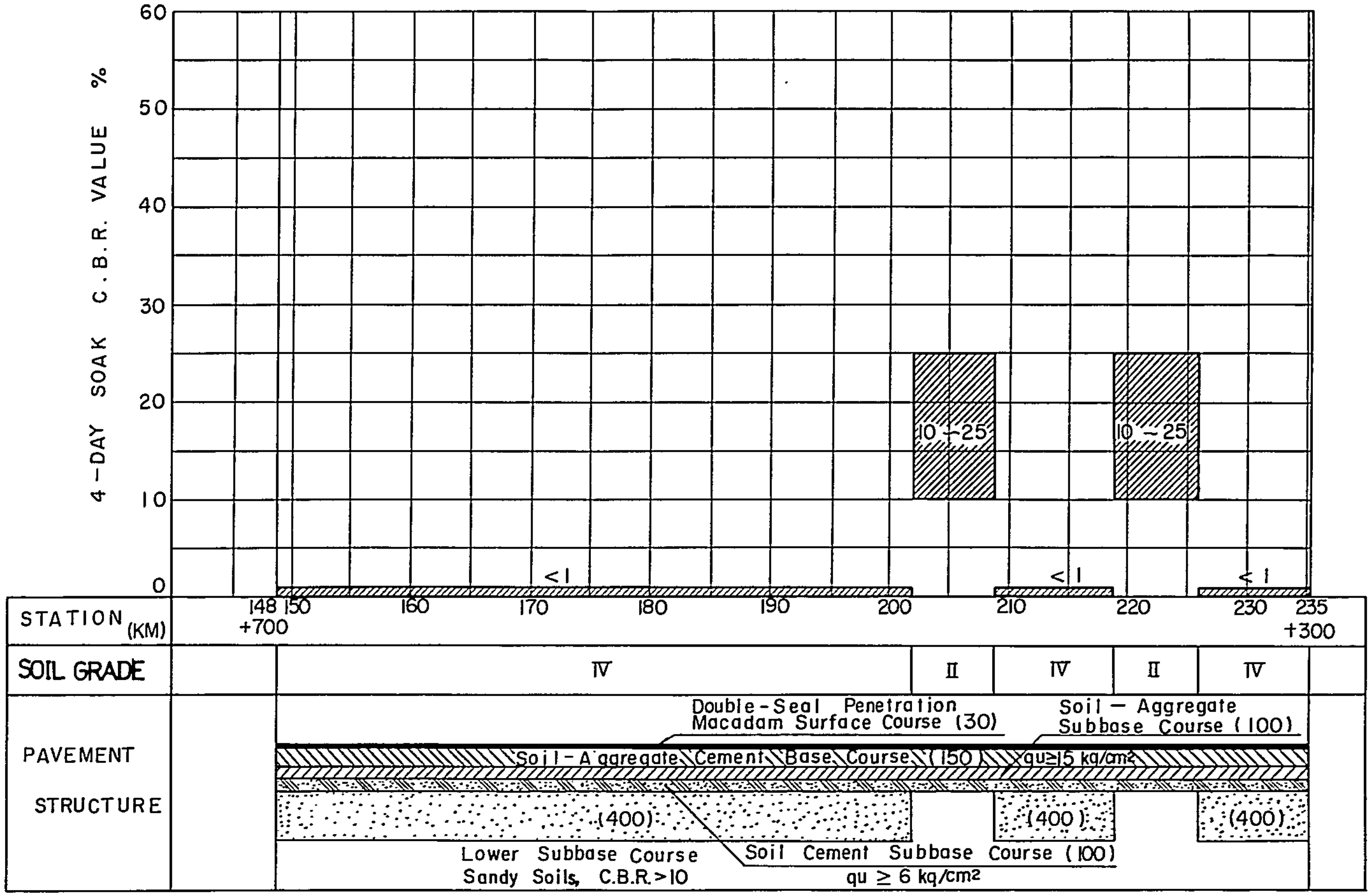


FIG. 3-8	SOUTHERN COASTAL LINK ROAD PROJECT SECTION – 3 (NANGURUKURU ~ KIRANJERANGE) PAVEMENT DESIGN FOR PLAN A

FIG. 3-9

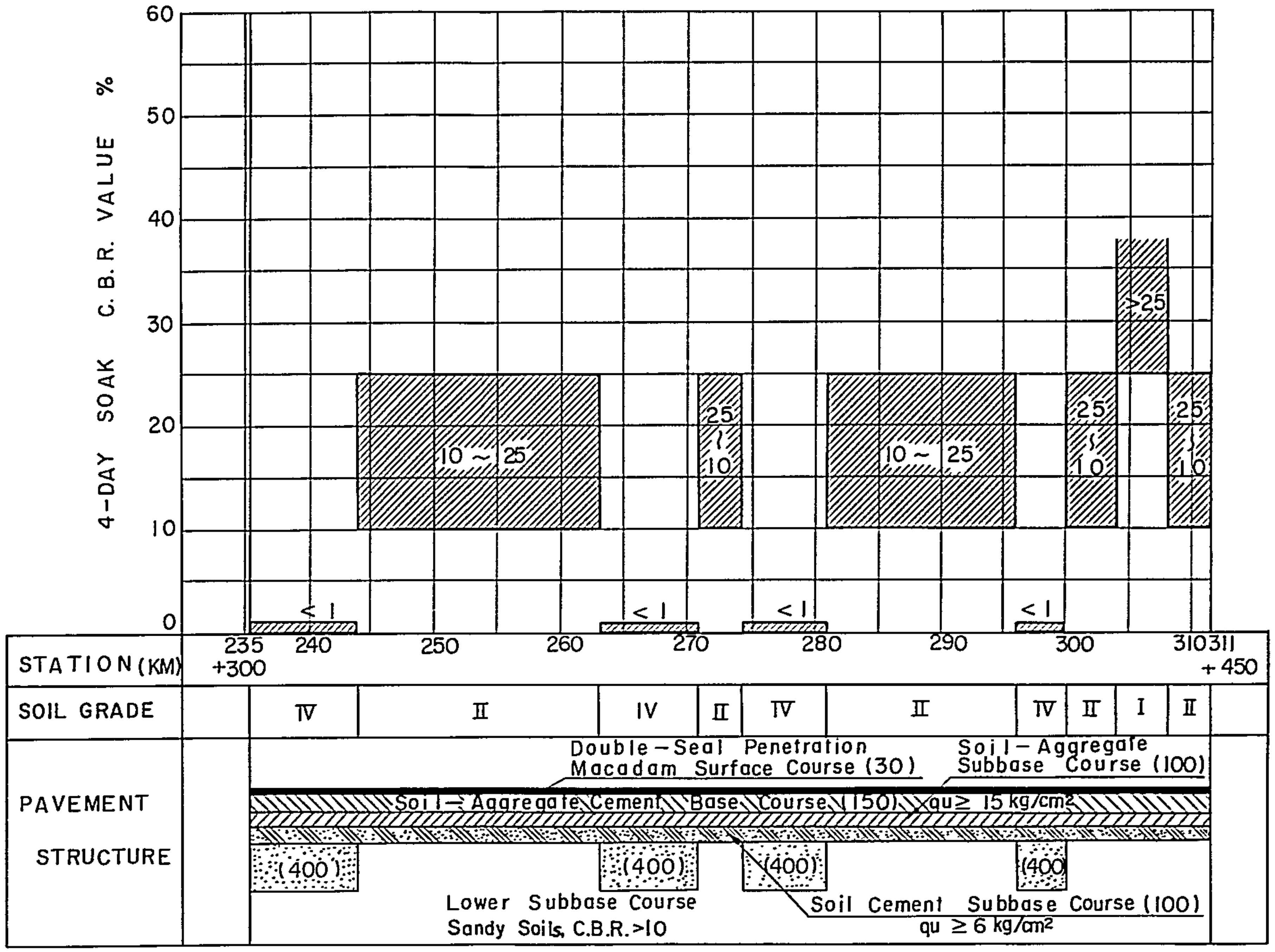


FIG. 3-9	SOUTHERN COASTAL LINK ROAD PROJECT SECTION – 4 (KIRANJERANGE ~ LINDI) PAVEMENT DESIGN FOR PLAN A

FIG. 3-10

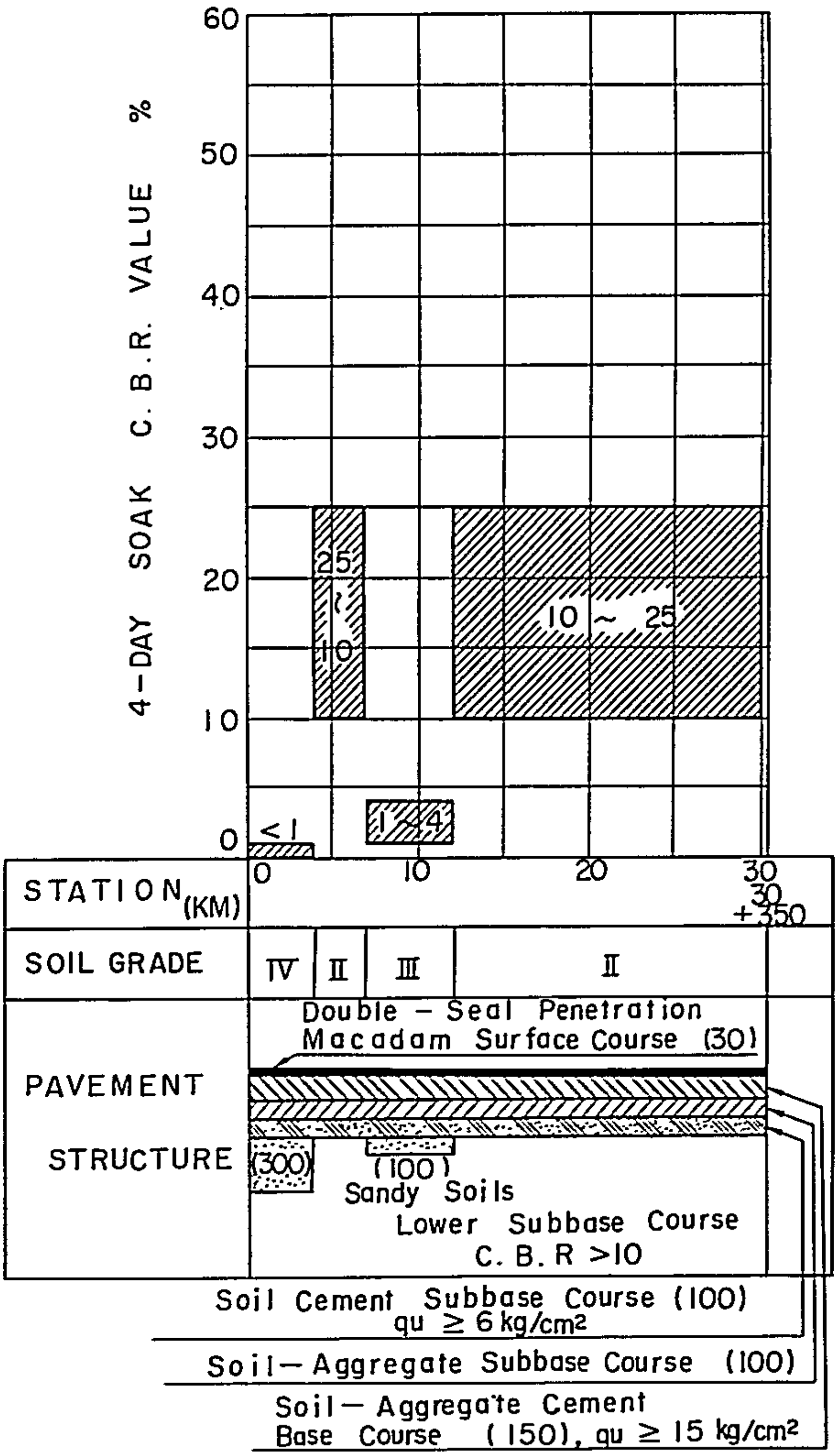


FIG. 3-10	SOUTHERN COASTAL LINK ROAD PROJECT
	SECTION - 5 (NANGURUKURU ~ KILWA MASOKO) PAVEMENT DESIGN FOR PLAN A

CHAPTER 4

BRIDGE PLANNING

CHAPTER 4. BRIDGE PLANNING

4.1 Outline

The proposed route to run from Kibiti to Lindi via Nangurukuru and the feeder road from Nangurukuru to Kilwa Masoko have a number of crossing rivers including the three major rivers, the Matandu, Mavuji and Mbwemkuru. It is one of the most vital phases of the Project to find solutions to the engineering and economic problems for constructing bridges over these rivers.

Here, the rainfall data obtained from the precipitation stations along the proposed route are statistically analysed, and the scale and location of bridges are studied hydrologically. The soil profile at each selected bridge site is outlined, and the soil engineering study of the bridge foundation is made to propose the type and depth of substructure.

Reported in Paragraph 4.5 are the results of a fact-finding survey of various structures along the existing road, which are also evaluated from mechanical and hydrological viewpoints.

The results of the above are also discussed in Paragraphs 4.6 and 4.7 with respect to bridge types, structures and facility of construction in order to work out plans for bridges crossing the proposed route of the Southern Coastal Link Road.

4.2 Design Criteria

Design standards and related conditions for planning bridges are as follows.

4.2.1 Live Load

BS 153 HA Loading and AASHO H20-S16-44 were compared, and whichever gives conservative engineering results is to be adopted.

4.2.2 Materials

1) Steel Materials

JIS steel materials equivalent in strength to BS 4360 Grade 43A (steel plates) and BS 785 (reinforcing bars) are planned.

2) Concrete

A series of concrete compression tests using ordinary Portland cement and the aggregate found in an on-site survey indicated a 330 to 350 Kg/cm^2 unit ultimate compressive strength at a 28-day age. In consideration of the test results and actual working conditions, the allowable bending compressive stress of 60 Kg/cm^2 will be adopted.

4.2.3 Bridge Width

1) Carriageway width: two lanes, 7.5 m

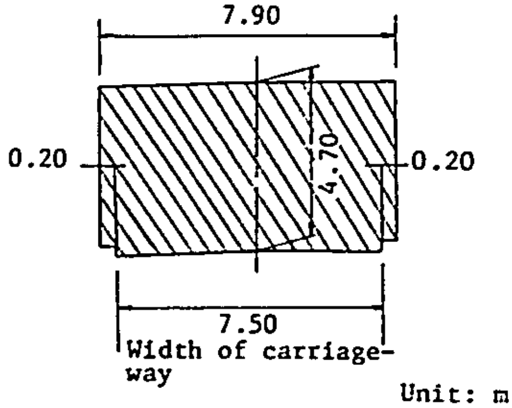
2) Footpath width:

   i) Main bridges of three major rivers - 1.5 m on one side only

   ii) Flood-opening and medium to small bridges (30 m or longer) - 1.0 m on one side only (no footpath for bridges shorter than 30 m)

4.2.4 Clearance Diagram for Bridges

Width: In conformity with AASHO
Height: 4.70 m



4.2.5 Clearance under Bridge Girders

Bridges over three major rivers: 1.2 m above H.W.L.
Other bridges: 1.0 m above H.W.L.

4.3 Hydrologic Survey

4.3.1 Rainfall Data and Statistical Analysis

The annual rainfall in the regions for which the present project is under way is around 1,000 mm. Most rainfall occurs during the rainy season from December to April.

It is characteristic of the regions that violent squalls take place in a comparatively small area.

In the hydrologic survey, daily rainfall records available at precipitation stations in the neighborhood of the planned route were pieced together for statistical analysis. The location of the precipitation stations is shown in Fig. 4-1, and the results of calculation of daily rainfall probability are given in Table 4-1.

Adjacent precipitation stations are 10 km to 50 km away from each other, and their records have little correlation. For this reason, it is difficult to compute the average rainfall in the catchment area of each river. Accordingly, the design rainfall is established using the record at Kilwa Kivinje station which is located around the middle of the route and is one of the stations that show greater volumes of probability rainfall than those at others.

The probable rainfall intensity formula for calculating the discharge of medium to small rivers is derived from the relationship between the depth-duration curve and the probable rainfall both in Fig. 4-2.

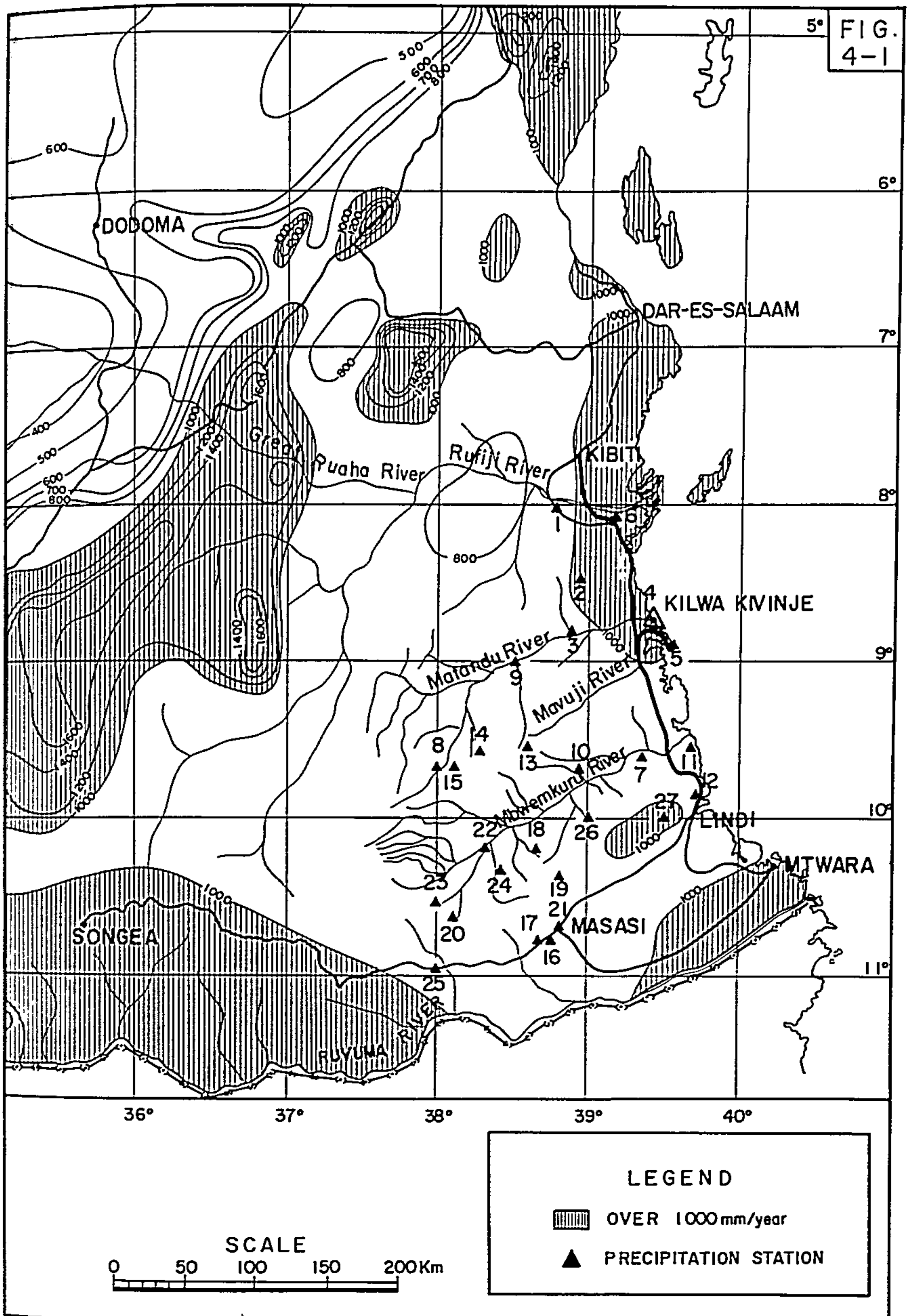


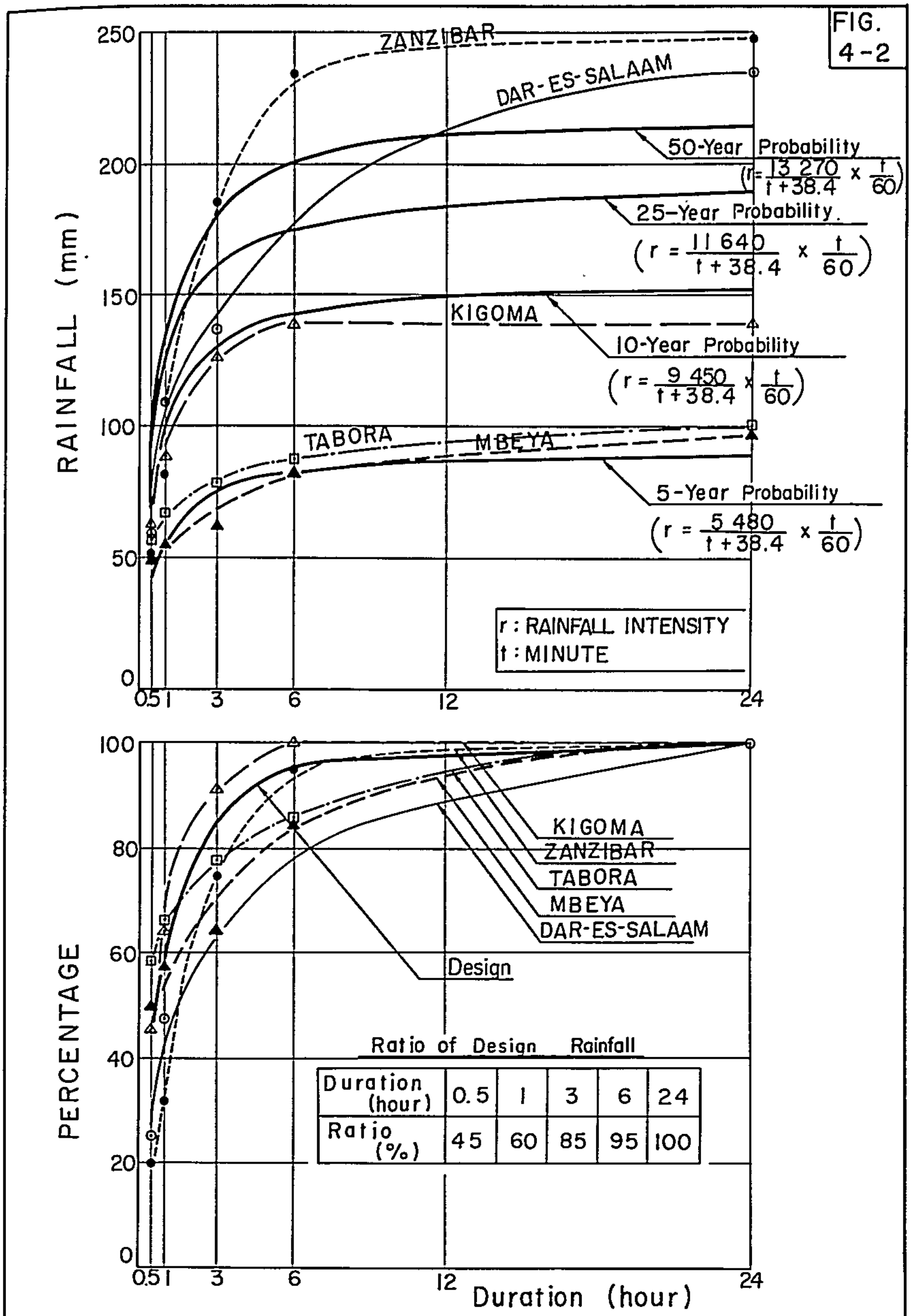
FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-1	MEAN ANNUAL RAINFALL AND PRECIPITATION STATIONS

Table 4-1 Probable Daily Rainfall

Gumbel Method

(mm)

No.	Registered Number		Return Period (1/year)								Remarks
			1/2	1/3	1/5	1/10	1/20	1/25	1/30	1/50	
1	9838002	Utete, District Office	47.9	55.1	63.2	73.4	83.2	86.3	88.8	95.8	15 years records
2	9838004	Kipatimu Mission	66.3	77.0	89.0	104.0	118.5	123.1	126.8	137.1	11 "
4	9839000	Kilwa Kivinje	82.6	102.7	125.2	153.4	180.4	189.0	196.0	215.4	11 "
5	9839004	Kilwa Masoko	84.7	96.6	109.8	126.3	142.2	147.3	151.4	162.8	9 "
11	9939000	Mkoe Plantation	75.9	85.8	96.7	110.5	123.7	127.9	131.3	140.8	7 "
12	9939001	Kikwetu Saisal Estate	85.5	112.7	143.1	181.1	217.7	229.3	238.7	265.0	16 "
16	10038000	Masasi Mission	67.5	77.6	84.6	95.9	106.8	110.2	113.0	120.8	16 "
17	10038002	Masasi District Office	60.5	74.3	89.6	108.9	127.3	133.2	137.9	151.2	15 "
18	10038003	Mnero Mission	75.7	93.5	113.4	138.3	162.2	169.8	176.0	193.2	13 "
19	10038007	Nachingweapart-Timu Station	65.0	77.7	91.9	109.8	126.9	132.3	136.8	149.1	16 "
26	10039032	St. Cyprian College (Negala)	62.0	70.7	80.5	92.7	104.5	108.2	111.2	119.7	12 "



Ratio of Design Rainfall

Duration (hour)	0.5	1	3	6	24
Ratio (%)	45	60	85	95	100

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-2	DEPTH-DURATION CURVE AND RAINFALL INTENSITY CURVE

4.3.2 Study on the Particulars of Three Major Rivers

1) Basic Principles

The rivers, Matandu, Mavuji and Mbwemkuru, are wild and meandering rivers, and have small channels for their catchment areas. They form vast floodplains. The Matandu and Mavuji are noteworthy in this respect; once in a flood they swell up over a vast area, and the Matandu across which there are no bridges to speak of interrupts all traffic during the flood period.

Of the three rivers, the Mbwemkuru has a comparatively stable channel with a large sectional area for discharge than the other two.

In planning the bridges for these respective rivers, the design high water level (H.W.L.) is set higher than the highest level ever recorded, and the bridge lengths are so determined to assure safe discharge at a design discharge.

As for design discharge, the Feasibility Report in 1971 has the values for each river that were established taking account of the catchment area and past flood records.

These values are applied here after re-exanination.

Table 4-2 Principal Particulars of Three Major Rivers

River	Matandu	Mavuji	Mbwemkuru
Catchment area (km^2)	15,210	3,030	16,460
Discharge (m^3/sec)			
Design	2,000	1,000	2,000
Unusual flood	4,530	1,980	4,810

The discharge under the bridge is calculated according to the following formula.

$$v = \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2} \quad \text{..........} \quad \text{i)}$$

$$Q = A \cdot v$$

Where, Q: Discharge (m^3/sec.)

A: Sectional area of river (m^2)

v: Velocity (m/sec.)

n: Coefficient of roughness

* River channel, n = 0.03
* Inundated area, n = 0.045

R: Hydraulic radius (m)

I: Water-surface slope

The clearance between the bridge girder and H.W.L. is set at 1.2 m.

The backwater level due to extraordinary flood is set at 15 cm for the Mbwemkuru and less than 5 cm for the other two rivers, to allow for a rise of about 1.0 m on the downstream side.

2) Matandu River

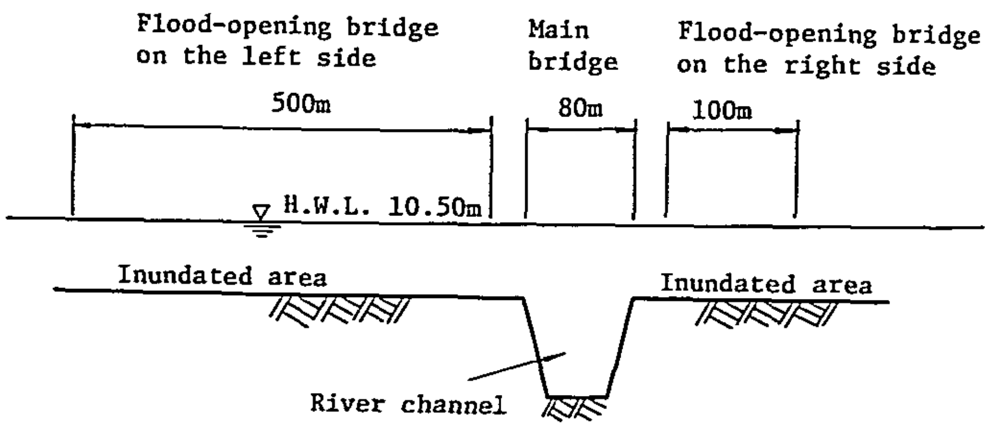
Design discharge, Q = 2,000 m^3/sec.
Design high water level, H = 10.5 m

The design particulars of a bridge should be coordinated with a river improvement plan, if available. Here, the flood-opening bridge system is planned because the river channel will not be improved for the time being.

If the river is to be rechannelled at the bridge site by excavation, the channel width may have to be increased to 200 m, about four times the existing size. Further to this, lengthy funnelling approaches will be necessary both upstream and downstream.

The embankment system, if preferred, will entail a great amount of earthwork because the banks are required to be extended by about 10 km up to gain access to hillsides.

The scale and arrangement of the main bridge and flood-opening bridges are as follows.



The discharge under the bridge is calculated with the river bed slope I = 1/1,000 equated to the water-surface slope.

Table 4-3-1 Discharge under Matandu River Bridge

Particulars	Cross-sectional area, A (m^2)	Velocity, v (m/s)	Discharge, Q (m^3/s)	Remarks
Main bridge	318	2.38	756	Coefficient of roughness, n = 0.03
Flood-opening bridge				
Left	950	1.07	1,016	n = 0.045
Right	250	1.25	312	n = 0.045
Total	1,518		2,084	

The profile and plan of the proposed bridges are illustrated in Fig. 4-3.

The Matandu has a wide floodplain extending over 3 km, and several traces of changes in the channel are found. It is a subject for future study to stabilize the river channel by correcting it approximately 300 m upstream as indicated by dotted lines in Fig. 4-3, and constructing embankments with the protection of masonry at a slope of 1 to 2.

For further reference, here follows the examination of the discharge at shorter return periods, in other words for the bridge of reduced scale, and the corresponding high water level under the same conditions as established above. The values of discharge at return periods shown in Table 4-3-2 are calculated using the results of hydrologic analyses of this time made for medium to small rivers along with the results of the Rufiji River survey in 1971.

Table 4-3-2 Return Period and Discharge

(Q: Discharge in m^3/s)

Return Period / River (Catchment Area)	50-year	25-year		10-year		5-year	
	Q_{50} (m^3/s)	Q_{25} (m^3/s)	$\frac{Q_{25}}{Q_{50}}$	Q_{10} (m^3/s)	$\frac{Q_{10}}{Q_{50}}$	Q_5 (m^3/s)	$\frac{Q_5}{Q_{50}}$
Rufiji (Stiegler's Gorge) (158,000 km^2)	9,800	8,500	0.87	6,800	0.69	5,500	0.56
Likumbra River (No. 277+153) (561.5 km^2)	719	630	0.88	510	0.71	302	0.42
Mean ratio of discharge			0.88		0.70		0.50

Table 4-3-3 shows the Matandu River discharge obtained from the ratios of discharge at 25-year, 10-year and 5-year return periods to that at 50-year return period, i.e. 0.88, 0.70, and 0.50 respectively as shown in Table 4-3-2.

Table 4-3-3 Matandu River Discharge at Different Return Periods

(Q: Discharge in m^3/s)

Return Period / Matandu River (Catchment Area: 15,210 km^2)	50-year Q_{50}	25-year $Q_{50} \times 0.88$	10-year $Q_{50} \times 0.70$	5-year $Q_{50} \times 0.50$
Discharge	2,000	1,760	1,400	1,000

Table 4-3-4 shows the water level for the above-mentioned discharge at different return periods. It should be noted that the discharge is calculated with the length and relative positions of the main and flood-opening bridges unchanged.

Table 4-3-4 Matandu River H.W.L. at Different Return Periods

Return Period	50-year	25-year	10-year	5-year
H. W. L. (m)	10.5	10.3	10.0	9.6

GROUND LEVEL	8.9	9.0	9.1	9.1	9.2	9.0	9.0	9.7	8.0	9.5	8.8	8.8	8.0
ROAD LEVEL	12.95	13.10	13.25	13.38	13.47	13.52	13.53	13.50	13.43	13.32	13.17	12.98	12.75

STATION 138+100 138+200 138+300 138+400 138+500 138+600 138+700

FIG. 4-3	SOUTHERN COASTAL LINK ROAD PROJECT MATANDU RIVER BRIDGE

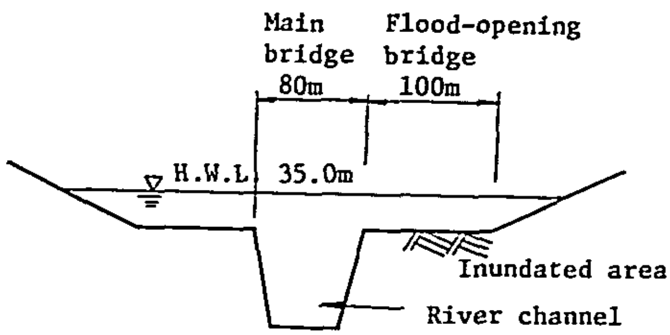
3) Mavuji River

Design discharge, Q = 1,000 m^3/sec.
Design high water level, H = 35.0 m

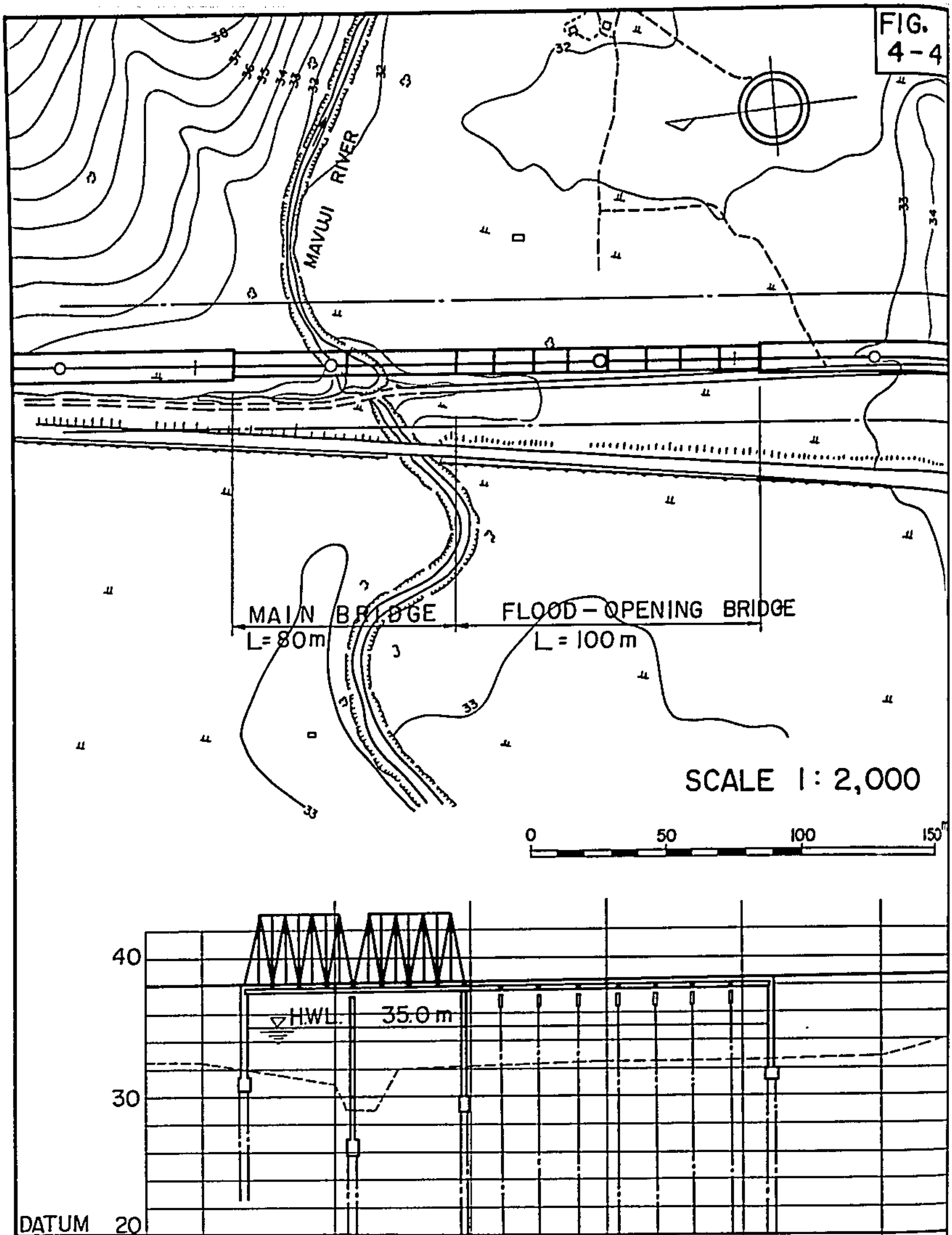
The existing 24-m Bailey bridge should be replaced for its small scale and narrow clearance between its girder and high water levels recorded in past floods.

For this reason, the design high water level for new bridges is set higher than those recorded in past floods but not so high as neighboring houses.

The scale and arrangement of the main bridges and flood-opening bridge are proposed below.



The discharge under the bridge is calculated with the river bed slope I = 1/800 equated to water-surface slope.



GROUND LEVEL	32.5	31.0	32.2	32.5	32.6	33.0
ROAD LEVEL	38.00	38.10	38.20	38.30	38.40	38.50
STATION		178+900		179+000		179+100

FIG. 4-4	SOUTHERN COASTAL LINK ROAD PROJECT
	MAVUJI RIVER BRIDGE

Table 4-4 Discharge under Mavuji River Bridge

Particulars	Cross-sectional area, A (m^2)	Velocity, v (m/s)	Discharge, Q (m^3/s)	Remarks
Main bridge	255	2.45	599	Coefficient of roughness, n = 0.03
Flood-opening bridge	300	1.57	471	n = 0.045
Total	555		1,070	

The profile and plan of the proposed bridges are illustrated in Fig. 4-4.

4) Mbwemkuru River

Design discharge, Q = 2,000 m^3/sec.
Design high water level, H = 24.5 m

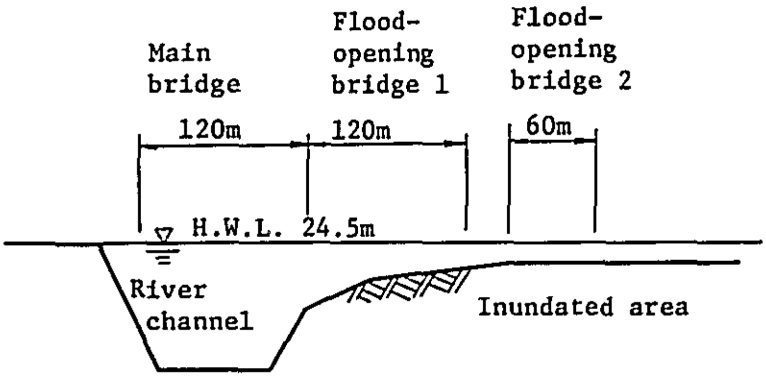
Unlike the other two rivers, the Mbwemkuru has a larger cross-sectional area and its channel is stable.

The existing 118-m Bailey bridges are large and have an ample clearance under them.

The bridges proposed here are to be built on the downstream side of the existing bridge. The main bridge of three spans having an aggregate length of 120 m is designed in anticipation of scouring on the right of the channel.

Flood-opening bridges are to cover the inundated area on the right of the channel.

The scale and arrangement of the main bridge and flood-opening bridges are as illustrated below.



The discharge under the bridge is calculated as follows with the river bed slope I = 1/400 equated to the water-surface slope.

Table 4-5 Discharge under Mbwemkuru River Bridge

Particulars	Cross-sectional area, A (m^2)	Velocity, v (m/s)	Discharge, Q (m^3/s)	Remarks
Main bridge	423	3.73	1,577	Coefficient of roughness, n = 0.03
Flood-opening bridge				
No. 1	220	1.63	358	n = 0.045
No. 2	90	1.41	126	n = 0.045
Total	733		2,061	

The profile and plan of the bridges are as illustrated in Fig. 4-5.

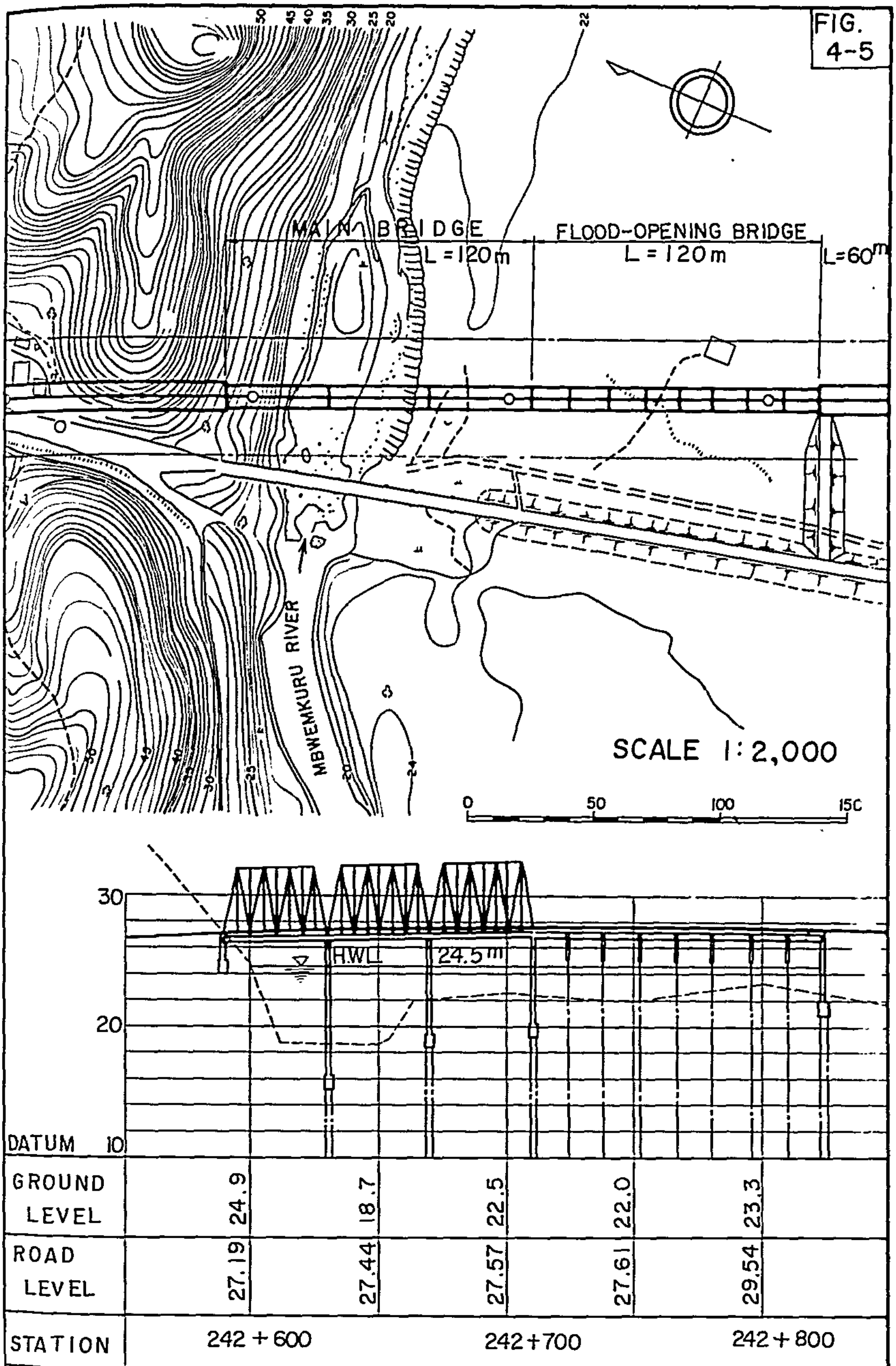


FIG. 4-5	SOUTHERN COASTAL LINK ROAD PROJECT
	MBWEMKURU RIVER BRIDGE

4.3.3 Study of Small and Medium Rivers

Except for the area around Lindi, most small and medium rivers have no bridges, and transportation is provided by installing corrugated pipes or boulders on the river bed. During the rainy season, the road surface is submerged and traffic is interrupted.

The design discharge is calculated, and the length and arrangement of bridges were studied for fifty-two small and medium rivers excluding the three major rivers.

The bridges are designed on the basis of a fifty-year probability.

The design discharge is calculated using the following Rational formula.

$$Q = \frac{1}{3.6} \cdot f \cdot A \cdot r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{ii)}$$

Q: Discharge (m^3/sec.)

f: Run-off coefficient ($f = 0.3$)

A: Catchment area (km^2)

r: Rainfall intensity (mm/hr) at time of concentration (t)

$$r = \frac{13,270}{t + 38.4}$$

The time of concentration (min.) is determined by the following formula.

$$t = \frac{\text{River length (m)}}{\text{Velocity (m/min.)}} + 20 \text{ (min.)}$$

$$= \frac{L}{20 \times I^{0.6} \times 60} + 20 \text{ (min.)}$$

I: Average slope at site

20 min.: Time of influx into river channel

L: River length

The design velocity is set at 2.5 m/s to 3.0 m/s as standard. For larger flow, it is set at 3.5 m/s. Table 4-6 shows the catchment dimensions, design discharge, bridge lengths and the dimensions of existing structures for the rivers.

The clearance between the girder and design high water level is set at 1.0 m.

Table 4-6 Planning Factor of Bridge - 1/2

Section	Station No.		Catchment Area Length and Slope			Time of Concentration and Rainfall Intensity		Run-off and Specific Run-off		Bridge Length (m)	Existing Structure
			Area (km^2)	Length (km)	Slope	Time of Conc. (min)	Rainfall Intensity (mm/hr)	Run-off (m^3/s)	Specific Run-off ($m/s/km^2$)		
1		No. 14+670	21.10	10.0	1/105	156	68.3	120	5.7	14.0	5.0m arch bridge
		24+665	13.27	5.0	1/220	126	80.7	90	6.8	20.0	12.3m arch bridge
2		50+700	55.60	14.5	1/125	239	47.8	222	4.0	34.5	300mmϕx5, 400mmϕx3 corrugated pipes
	No.57 ~ No.58	57+550								28.0	400mmϕx5 corrugated pipes
		58+600	150.00	40.4	1/80	487	25.3	316	2.1	28.0	
		68+700	147.77	32.5	1/95	436	28.0	345	2.3	34.5	
		74+410	115.20	35.0	1/130	561	22.1	213	1.8	23.0	5.0m bridge
		80+366	19.80	8.5	1/70	110	89.4	148	7.5	14.0	
		86+920	64.52	20.6	1/145	360	33.3	179	2.8	20.0	
		87+700	37.70	13.8	1/95	197	56.4	177	4.7	20.0	1200mmϕ corrugated pipe
	No. 98 ~ No.100	98+315								14.0	
		99+450								14.0	
		100+280	365.40	62.5	1/120	941	13.5	413	1.1	14.0	
		100+645								14.0	
		103+325	86.83	20.0	1/105	292	40.2	290	3.3	28.0	
		106+880	219.08	42.4	1/160	762	16.6	303	1.4	28.0	
		116+945	81.15	25.8	1/135	428	28.5	193	2.4	28.0	Ntandngo River
		117+600	8.42	6.0	1/100	99	96.6	68	8.1	14.0	
		120+ 50	19.82	10.3	1/110	164	65.6	109	5.5	14.0	
		126+350	7.10	3.8	1/70	61	133.5	79	11.1	14.0	
		128+150	24.60	12.0	1/85	164	65.6	135	5.5	23.0	
		130+550	67.05	18.3	1/120	290	40.4	226	3.4	34.5	1500mmϕ corrugated pipe
		136+120	8.53	6.8	1/110	115	86.5	62	7.3	14.0	
		144+450	15.95	5.9	1/70	83	109.3	146	9.2	20.0	400mmϕx3 corrugated pipes
3		160+805	338.00	39.0	1/135	637	19.6	554	1.6	34.5	Lingakuru River 54m bridge
		165+573	80.20	23.0	1/85	296	39.7	265	3.3	23.0	Mbanga River 1300mmϕ, 600mmϕ corrugated pipes
		167+ 5	96.40	22.0	1/70	255	45.2	364	3.8	28.0	Ukuei River 11.5m bridge
		169+650	8.60	6.0	1/65	81	111.1	80	9.3	14.0	Namitanba River 1300mmϕx2 corrugated pipes
		182+580	6.67	4.7	1/80	74	118.1	66	9.9	14.0	1400mmϕ corrugated pipe
		186+400	20.60	12.0	1/45	118	84.8	146	7.1	20.0	800mmϕ corrugated pipe
		196+610	76.20	16.0	1/80	205	54.5	347	4.6	34.5	1200mmϕx3 corrugated pipes
		198+970	5.45	4.4	1/40	53	145.2	66	12.1	14.0	
		217+963	157.77	23.5	1/102	314	37.7	495	3.1	28.0	Mandawa River 18.0m Bailey bridge
		224+315	48.00	16.0	1/40	142	73.6	295	6.1	28.0	500mmϕx2 corrugated pipes
	No.225	225+247	33.10	8.8	1/40	87	105.8	292	8.8	14.0	400mmϕ corrugated pipe
		225+425									400mmϕ corrugated pipe
		231+397	8.25	6.0	1/50	72	120.2	83	10.1	11.5	400mmϕ corrugated pipe
		235+60	18.40	7.6	1/55	90	103.3	159	8.6	20.0	600mmϕ corrugated pipe

Table 4-6 Planning Factor of Bridge - 2/2

Section	Station No.	Catchment Area Length and Slope			Time of Concentration and Rainfall Intensity		Run-off and Specific Run-off		Bridge Length (m)	Existing Structure
		Area (km^2)	Length (km)	Slope	Time of Conc. (min)	Rainfall Intensity (mm/hr)	Run-off (m^3/s)	Specific Run-off ($m/s/km^2$)		
4	No. 238+750	9.40	5.8	1/55	74	118.1	93	9.9	14.0	
	239+500	6.62	4.2	1/60	61	133.5	74	11.2	11.5	
	253+580	5.92	4.4	1/35	51	148.4	74	12.5	11.5	
	255+330	8.25	5.3	1/20	47	155.4	107	13.0	11.5	
	257+ 85	3.27	4.4	1/20	42	165.1	45	13.8	11.5	
	270+388	90.77	14.5	1/50	146	72.0	544	6.0	34.5	24.4m Bailey bridge
	270+570	6.10	4.3	1/35	50	150.1	77	12.6	11.5	4.0m bridge
	274+248	7.92	4.8	1/50	62	132.2	88	11.1	11.5	4.0m bridge
	277+153	561.50	51.0	1/135	826	15.4	719	1.3	69.0	35.7m bridge
	285+ 23	10.48	5.3	1/50	66	127.1	111	10.6	11.5	6.0m bridge
	289+855	46.35	12.4	1/60	141	74.0	286	6.2	34.5	12m bridge and another bridge
	292+ 50	6.85	4.9	1/70	72	120.2	69	10.1	14.0	
	295+995	15.10	10.3	1/40	99	96.6	122	8.1	23.0	23.0m bridge
	298+650	112.65	23.5	1/130	383	31.5	296	2.6	34.5	15.8m, 39.0m) bridge
	302+368	1.85	2.2	1/50	39	171.4	27	14.6	11.5	10m bridge
	304+690	4.63	5.0	1/35	55	142.1	55	11.9	28.0	3.0m bridge
	306+450	13.00	4.1	1/20	41	167.1	181	13.9	28.0	Many corrugated pipes
	308+615	7.65	3.6	1/25	41	167.1	107	14.0	23.0	60m bridge
	13+125	17.00	6.5	1/50	77	115.0	163	9.6	20.0	5.0m and 1.1m bridges 600mmø, 1200mmø corrugated pipes

4.4 Subsurface Soil Conditions at Proposed Bridge Sites

4.4.1 Stratification along the Proposed Route

An about 9-km section from Kibiti is situated comparatively high in altitude, and the surfaces are covered with several meters of lateritic soils.

From there to Miteja is a flat plain where the difference in altitude is within about 10 m. This plain is covered with sandy soils, clayey soils and black cotton clay. According to the soil investigation conducted for the detail design of the Rufiji River Bridge Project in 1974, it is found that the proposed bridge site is covered with alluvial loose sand and soft clay to a maximum depth of about 60 m overlying a dense sandy stratum.

From Miteja to a point several kilometers toward Lindi is a hilly to mountainous terrain covered with sandy soils, lateritic soils, clayey soils and black cotton clay. According to the survey this time, it is found that soft rock forms a bed stratum so far as the section between the Matandu and Mbwemkuru Rivers is concerned. The soft rock is decomposed several meters atop, or left quite intact depending on location. The decomposition-free soft rock showed an N-value of more than 50 in a standard penetration test. This fresh soft rock is ideal as bearing stratum. In the Matandu River, the Mavuji River and the Mbwemkuru River, this soft rock is eroded deep and covered with alluvial soils of loose sand and soft clay.

The bridges crossing these rivers should naturally require to be supported by deep foundation. On the other hand, small and medium rivers, such as Lingakuru, Mbanga, Ukuri, Mandawa and Mbanja, have a thin layer of alluvial soils, and soft rock is encountered at a relatively shallow depth. Accordingly, comparatively short piles or footing directly supported by soft rock will do for the purpose of bridge foundation.

The proposed bridge site of the Nangaru River near Mchinga, however, has a deep deposit of alluvial soils; there was no reliable bearing stratum found when investigated to the depth of about 23 m.

There, it will be necessary to support the bridge by friction piles.

Although limited data prohibit precise judgement, the section between Mbwemkuru and Lindi is assumed to have soft rock as a bed stratum, because soft rock was found also by test boring in the Mbanja near Mitonga.

From Nangurukuru to Kilwa Masoko, test boring was conducted near Mpara, and soft rock was also found at a depth of about 13.5 m.

Accordingly, this section is also believed to have soft rock as a bed stratum.

4.4.2 Proposed Bridge Sites of Matandu, Mavuji and Mbwemkuru Rivers

Figs. 4-6 through 4-8 show the soil profiles of the Matandu, Mavuji and Mbwemkuru Rivers, respectively.

Matandu River Bridge

With reference to Fig. 4-6, Cu, Cl and Su strata are alluvial soft clay or loose sand, and cannot support the bridge stably.

It is therefore concluded that bridges shall be supported by piles driven to Sl stratum in those soil conditions which are represented by test borings No. 5B and No. 5, whereas Rs will be the bearing stratum for pile foundation of bridges in those soil conditions which are indicated by test borings No. 5A, No. 6 and No. 7.

Mavuji River Bridge

With reference to Fig. 4-7, Cu and Su strata are alluvial soils which are not suitable as bearing stratum. Sl stratum showed partially an N-value of 30 to 50 on a standard penetration test, which is an acceptable value for a bearing stratum. However, it is found that it includes soft clayey layers and lacks uniformity. For this reason, the abutments and piers are recommended to be supported by piles reaching Rs stratum until future investigations verifies the uniformity of Sl stratum.

Mbwemkuru River Bridge

With reference to Fig. 4-8, Cu, Cl and Su strata are not acceptable as a bearing stratum. The abutment on the left hand can be supported directly by boulder clay stratum Cb. The abutment and piers falling upon those parts which are represented by test borings No. 16 and No. 17 should preferably be supported by piles reaching Rs stratum. The foundation of

Bridge No. 46 falls under this category. As regards Bridge No. 47, there are no test boring data, and the necessary pile length has to be judged from the results of test boring No. 17A nearest to the bridge site.

In accordance with the above consideration, the recommended pile lengths for the proposed bridges are given in Tables 4-7 through 4-9.

In these tables, A denotes the abutment and P the pier. Both abutment and pier are of the wall type. Pb indicates the pile bent type pier.

The pile lengths for A and P refer to the lengths from the bottom of footing to the pile tip, and those for Pb to the lengths from the ground surface to the pile tip. The above explanation concerning the contents of the tables appiles also to the foundation of other bridges.

Table 4-7 Recommended Pile Length for Foundation of Proposed Matandu River Bridge

No. of Bridge	Abutment or Pier	Recommended Bearing Stratum	Recommended Pile Length in Meters
24	A_1	S1 stratum	16
	P_b	ditto	17.3
	A_2	ditto	16
25	A_1	Rs stratum	17
	P_b	ditto	19
	A_2	ditto	18
26 (main bridge)	A_1	ditto	19
	P_1	ditto	12
	A_2	ditto	18
27	A_1	ditto	13
	P_b	ditto	14.3
	A_2	ditto	13

No. 27 bridge site given in the table above lies out of the range of the survey covered by test borings No. 5B through No. 7 shown in Fig. 4-6.

Accordingly, the depth of the bearing stratum is determined by extrapolation of the survey results. So the pile lengths thus estimated for No. 27 bridge may be less accurate than those for No. 24 through No. 26 bridges.

It is therefore necessary to carry out soil investigations for the foundation of No. 27 bridge.

Table 4-8 Recommended Pile Length for Foundation of Proposed Mavuji River Bridge

No. of Bridge	Abutment or Pier	Recommended Bearing Stratum	Recommended Pile Length in Meters
33	Main bridge: -		
	A_1	Rs stratum	17
	P_1	ditto	18
	P_2	ditto	21
	P_b	ditto	20 to 22
	A_2	ditto	17

Table 4-9 Recommended Pile Length for Foundation of Proposed Mbwemkuru River Bridge

No. of Bridge	Abutment or Pier	Recommended Bearing Stratum	Recommended Pile Length in Meters
46	Main bridge: -		
	A_1	Rs stratum	Footing foundation
	P_1	ditto	15
	P_2	ditto	20.5
	P_3	ditto	21.5
	P_b	ditto	25 to 28
	A_2	ditto	27
47	A_1	-	28 (assumed)
	P_b	-	28 (ditto)
	A_2	-	28 (ditto)

Soil survey was not conducted at No. 47 bridge site, and the pile length is estimated from the results of the test boring No. 17A closest to it. The pile length referred to in the table will probably be sufficient, though it should be corroborated by accurate soil survey in the future.

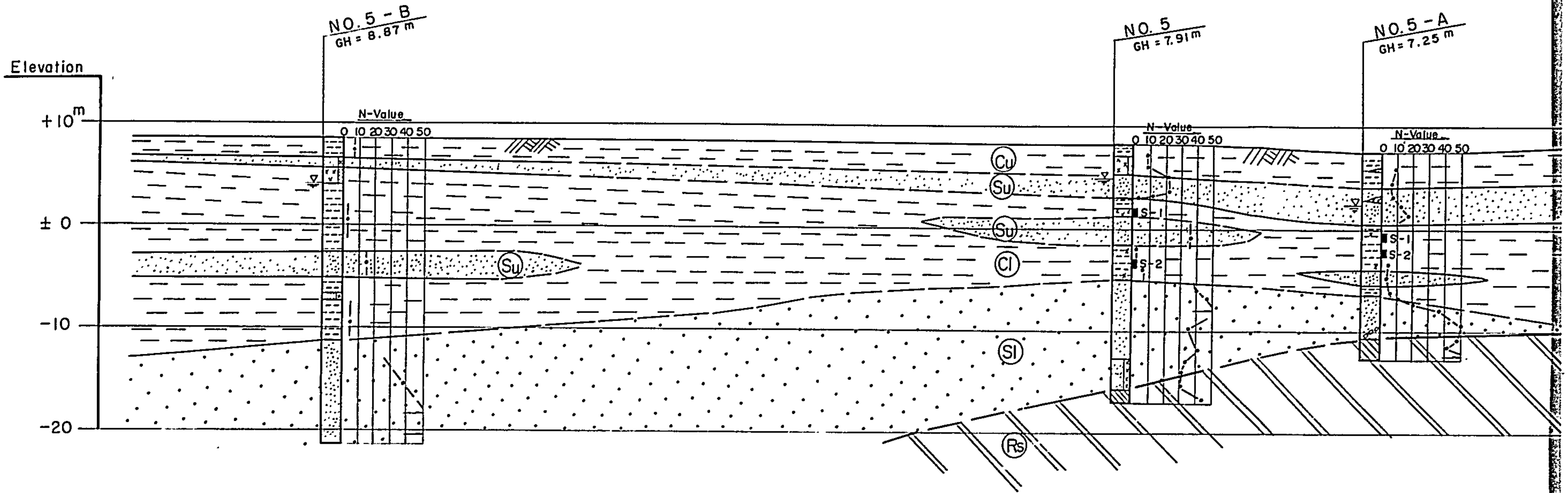
4.4.3 Bridges for Small and Medium Rivers

The small and medium bridges for which test boring was made at their proposed sites or neighborhood are recommended to use the piles as shown in Table 4-10.

In the table, the short piles not exceeding 10 m are given on presupposition that they are to be driven up to a firm stratum having 50 or more in N-value so that they can exhibit their bearing capacity to the full extent.

Table 4-10 Recommended Pile Lengths for Foundation of Small and Medium Bridges

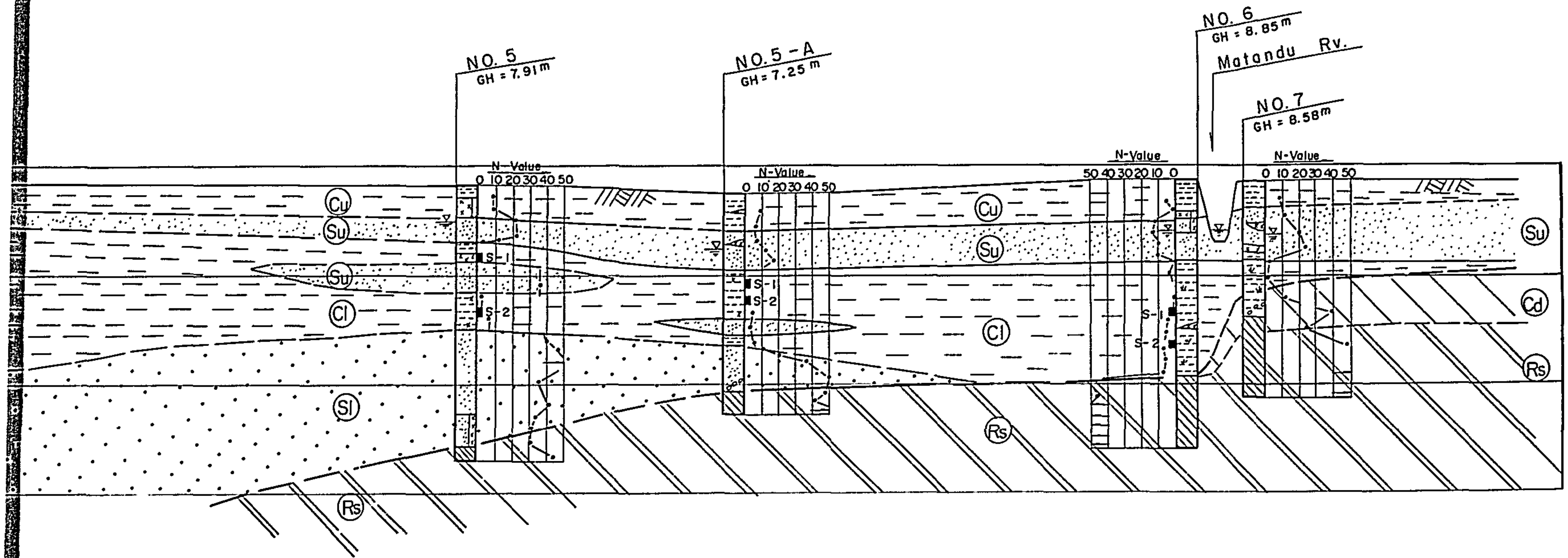
No of Bridge	Abutment or Pier	Recommended Pile Length in Meters	Referred Test Boring
9	A_1	10	No. 2
	P_b	11	
	A_1	10	
17	A_1	14	No. 4
	P_b	14	
	A_2	14	
29	A_1	4	No. 8
	P_1 & P_2	Footing foundation supported by soft rock stratum	
	A_2	4	
30	A_1	7	No. 9
	P_1	3	
	A_2	7	
31	A_1	Footing foundation supported by soft rock stratum	No. 10
	P_1		
	A_2		
38	A_1	4	No. 14
	P_1	Footing foundation supported by soft rock stratum	
	A_2	4	
54	A_1	17	No. 18
	P_b	18	
	A_2	17	
59	A_1	12	No. 19
	P_b	12	
	A_2	12	
64	A_1	10	No. 20
	P_b	10	
	A_2	10	



Elevation
+10m
± 0
-10
-20
NO. 5 - B
GH = 8.87 m
N-Value
0 10 20 30 40 50
NO. 5
GH = 7.91m
NO. 5 - A
GH = 7.25 m
Cu
Su
Cl
Sl
Rs
S-1
S-2

FIG
4

FIG. 4-6

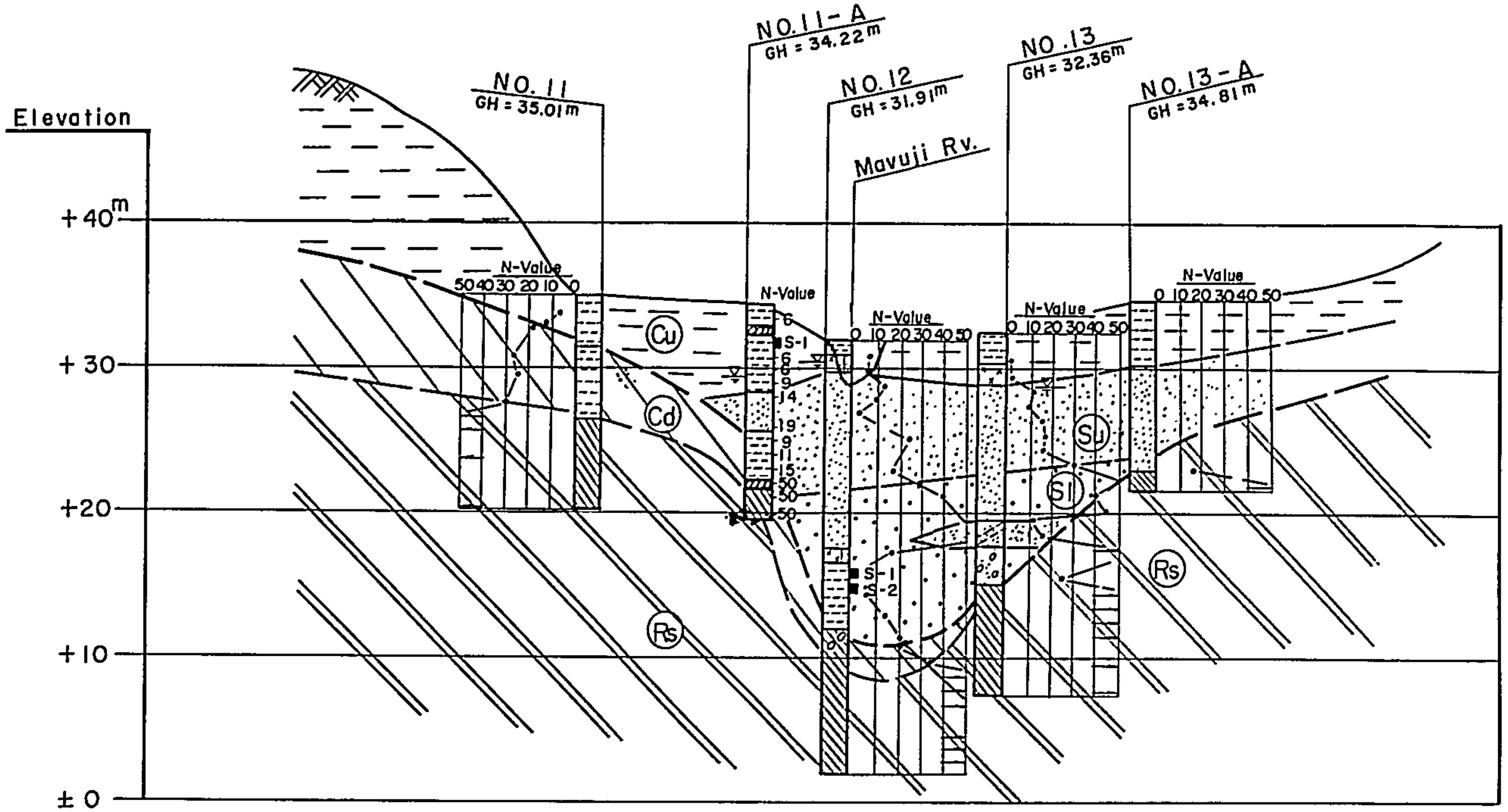


Legend

- Cu : Upper Clay Stratum
- Su : Upper Sand Stratum
- Cl : Lower Clay Stratum
- Sl : Lower Sand Stratum
- Cd : Decomposed Stratum of Soft Rock
- Rs : Soft Rock Formation

Scale { H = 1 : 5.000 / V = 1 : 400

FIG. 4-6	SOUTHERN COASTAL LINK ROAD PROJECT
	SOIL PROFILE AT MATANDU RIVER



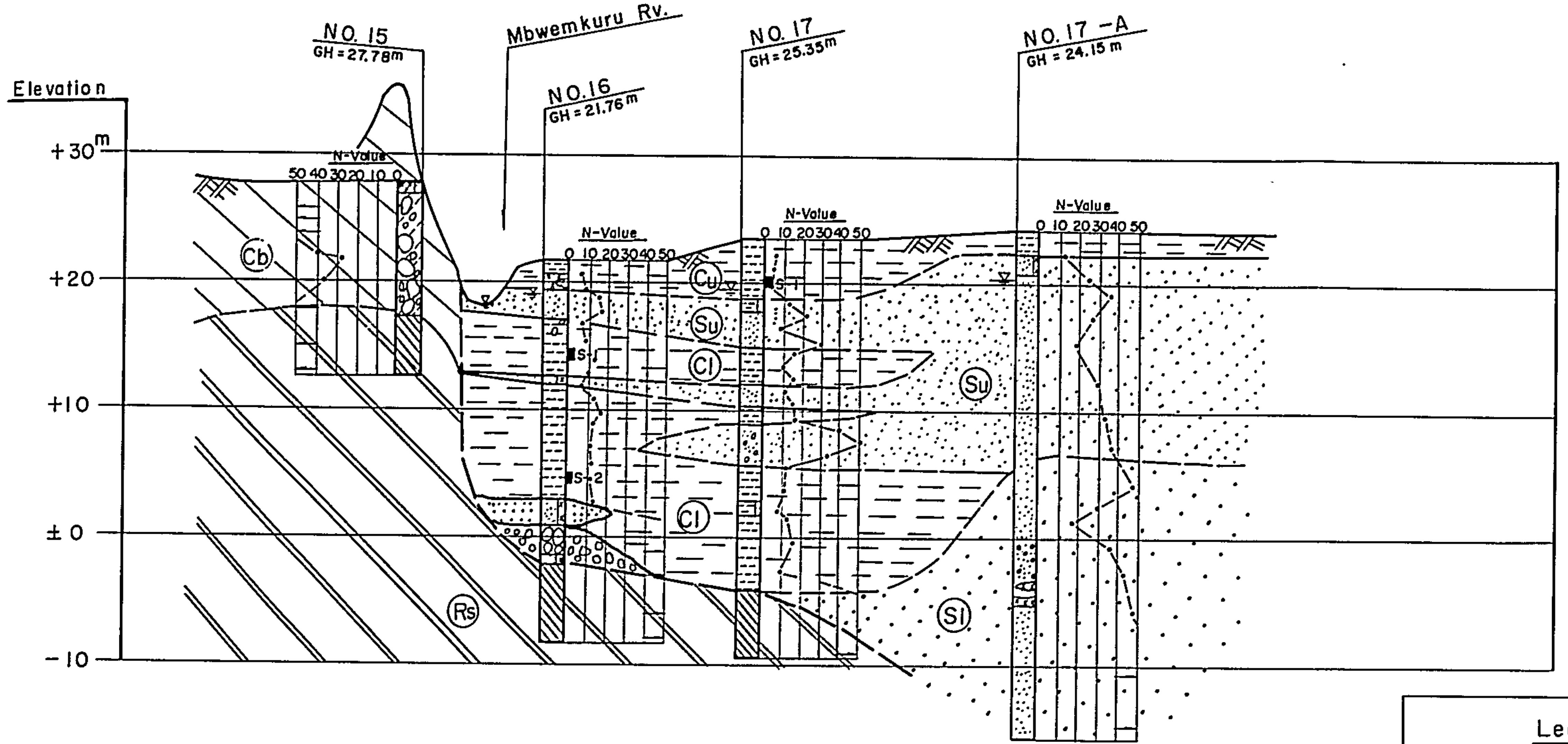
Legend

- Cu : Upper Clay Stratum
- Su : Upper Sand Stratum
- Sl : Lower Sand Stratum
- Cd : Decomposed Stratum of Soft Rock
- Rs : Soft Rock Formation

Scale { H = 1 : 5.000; V = 1 : 400 }

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-7	SOIL PROFILE AT MAVUJI RIVER

FIG. 4-8



Scale { H = 1 : 5.000, V = 1 : 400 }

Legend

- Cu : Upper Clay Stratum
- Su : Upper Sandy Stratum
- Cl : Lower Clay Stratum
- Sl : Lower Sandy Stratum
- Cb : Boulder Clay Stratum
- Sg : Sandy Gravel Stratum
- Rs : Soft Rock Formation

FIG. 4-8	SOUTHERN COASTAL LINK ROAD PROJECT
	SOIL PROFILE AT MBWEMKURU RIVER

4.5 Condition and Evaluation of Existing Bridges

4.5.1 Outline

As regards the existing road structures, three major river bridges, twenty-two medium to small river bridges and thirty-three pipe culverts were reconnoitered and investigated visually.

Nyamwage-Nangurukuru section: Construction of a bridge to straddle the Matandu is under way. In this section, there are few rivers which have bridge structures.

Nangurukuru-Lindi section: The Mavuji and the Mbwemkuru have bridges. There are many bridges and structures near the coast toward Lindi.

Nangurukuru-Kilwa Masoko section: There are few, if any, bridges. Most of structures are pipe culverts. Most of the pipe culverts are makeshifts that were used for replacing bridges lost in floods.

4.5.2 Presuppositions for Evaluation of Existing Bridges

Existing bridges are evaluated based on the following conditions.

1) Planned in this project is a two-lane all-weather road. Accordingly, those existing bridges which are of a single-lane type must be reconstructed into the two-lane type. The cost for reconstruction for this purpose is taken into account for the evaluation. The cost is also estimated for constructing a new single-lane bridge to run parallel to each of such bridges.

2) The superstructures of Bailey type are considered to be replaced with new ones.

3) Existing bridges, if planned to be used as they are, should serve safely throughout the life of this project.

A plan in which the existing bridges are left intact and used for some time until reconstruction is justified due to damage, should be considered separately from the present project for the following reasons.

i) Inconsistent road standards due to differing width and load capacities of present structures.

ii) Difficulties in assessing the term during which existing structures can be safely used.

4.5.3 Study and Evaluation of Existing Bridges

1) Matandu River Bridge

Stepping stones laid on the river bed are the only means to provide passage. Now, a bridge is being constructed on the downstream side of the existing road, and its substructure has been nearly completed. After completion, it will become a single-lane two-span Bailey bridge measuring approx. 32 m in length.

This bridge is discussed in detail below.

The abutment on the left is constructed about 6 m in back of the bank slope in order to make provision against the collapse of the bank slope due to scouring. On the other hand, the righthand abutment is projected from the slope to narrow the river channel. According to a hydrological survey, it was found that the water level reached nearly the top of the righthand abutment in past floods.

The existing bridge is located at a bend of the river, and it is highly possible that the bank slopes will be eroded in the future. Naturally, it can be assumed that the righthand abutment will become unstable.

Two cases are discussed here: one in which the substructure under construction is utilized to provide a two-lane bridge (Case I); and the other in which a new two-lane bridge is installed without using the existing bridge (Case II). Their construction costs are compared. Case I is laid out in Fig. 4-9, and the study results are summarized in Table 4-11.

Table 4-11 Comparison of Construction Costs (Matandu River Bridge)

(1,000 shs.)

Case I		Case II	
Item	Cost	Item	Cost
One-lane existing bridge:-			
Removal of superstructure	19		
Improvement of substructure	78		
New superstructure	381		
Flood-opening bridge	1,150		
Total	1,628		
One-lane new bridge:-		Two-lane new bridge:-	
Superstructure	2,369	Superstructure	3,594
Substructure	854	Substructure	1,479
Total	3,223	Total	5,073
Grand Total	4,851	Grand total	5,073

Notes:

Case I

i) After removal of the existing superstructure, a new bridge (33 m in length and 4.0 m in carriageway width) is installed. (Type: 16-m-span steel H girder)

ii) The existing substructure is raised about 1.5 m to increase girder clearance against the high water level.

iii) In order to attain the same cross-sectional area of flow as in Case II, a 60-m-length by 4.0-m-width flood-opening bridge having an RC girder superstructure will be constructed. Their abutments will be of the wall type supported by H-section steel piles and the piers of steel pipe pile bent type.

iv) A new bridge to be constructed parallel to the existing bridge will be 82 m in length, 4.0 m in carriageway width, and 1.0 m in footpath width. The superstructure will consist of two spans of pony truss, each measuring 40 m in length. The abutments and piers are of the RC wall type supported by H-section steel pile.

Case II

i) The bridge length is 82 m, and the width is as per the design standards. Types of both superstructure and substructure are just the same as in iv) for Case I.

The ratio of the bridge construction costs (Case I/Case II) is 0.95.

The total construction costs including the costs of construction of approach roads are almost the same for both cases.

Case I has some problems: structurally, the bridge has undesirable disunity in standard. The stability of substructure is uncertain, and it is not appropriate hydrologically also.

2) Mavuji River Bridge

This is a 24-m-long, single-span single-lane Bailey bridge. Both superstructure and substructure are temporary works, and the substructure is damaged seriously. Hydrologically, the cross-sectional area of river is too small, and high water levels recorded in the past surpass the road level. The bridge should be reconstructed as promptly as possible. For this reason, a new two-lane bridge is planned.

3) Mbwemkuru River Bridge

This is a six-span single-lane Bailey bridge measuring about 118 m in length. The righthand abutment is a stone masonry supporting the superstructure. The lefthand abutment protrudes from the bank slope, and its foundation is scoured.

The two piers in the channel appear to be comparatively stable, though the construction and depth of embedment of the substructure are unknown.

The other three piers standing outside the river channel have so large a width as to hinder the flood discharge thus causing scouring toward the center of the channel where the flood velocity is high.

Hydrologically, the girder clearance is sufficient, measured against high water levels recorded in the past.

The existing bridges have an insufficient cross-sectional area for discharging flood at a fifty-year probability level.

The two piers in the channel are applicable to this project; all others may have to be reconstructed.

FIG. 4-9

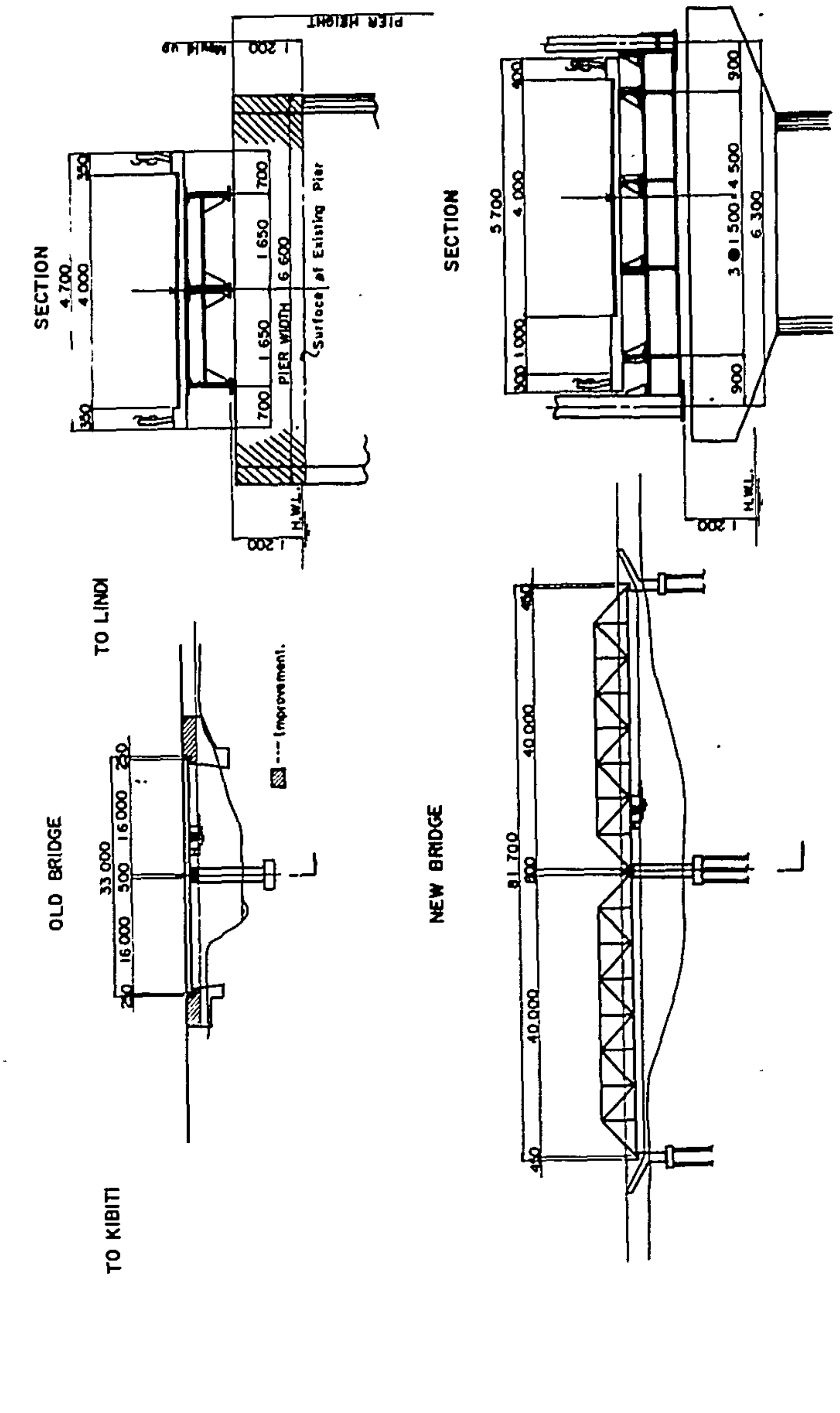


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-9	IMPROVED DESIGN OF THE EXISTING MATANDU RIVER BRIDGE

Construction costs are compared with respect to two cases; one in which a two-lane bridge is constructed using the two existing piers in the channel (Case I), and the other in which a new two-lane bridge is constructed without using the existing bridge (Case II).

Case I is laid out in Fig. 4-10, and the results of a comparison are given in Table 4-12.

Table 4-12 Comparison of Construction Costs (Mbwemkuru River Bridge)

(1,000 shs.)

Case I		Case II	
Item	Cost	Item	Cost
One-lane existing bridge:-			
Removal of superstructure	139		
Improvement and reconstruction of substructure	1,128		
New superstructure	1,183		
Total	2,450		
One-lane new bridge:-		Two-lane new bridge:-	
Superstructure	2,519	Superstructure	5,394
Substructure	1,385	Substructure	1,274
Total	3,904	Total	6,668
Grand total	6,354	Grand total	6,668

Notes:

Case I

i) After the removal of the existing superstructure, six new 16.5-m-span H-section steel girders will be constructed: approximate total length of 102 m with carriageway of 4 m width.

ii) Except for the two piers in the channel, all other substructures will be removed and reconstructed. Both abutments and piers will be of the wall type. The lefthand abutment will be supported by the footing foundation.

The righthand abutment and piers will be supported by H-section steel piles.

iii) The new bridge to be constructed parallel to the existing bridge will measure 119 m in length, 4.0 m in carriageway width and 1.0 m in footpath width. The superstructure will consist of a 50-m-span pony truss and four 16.5-m-span H-section steel girder.

The substructure will be just the same in type as in ii) above.

Case II

i) The bridge length is 122 m, and the width is as specified in the design standards. The superstructure will consist of three spans of pony truss, each measuring 40 m in length.

The type of the substructure will be just the same as in iii) for Case I, except that the pier doundation will be supported by 500ϕ steel pipe piles.

The ratio of construction costs (Case I/Case II) is 0.95. The total construction costs including the costs of constructing approach roads are almost the same for both cases.

In Case I, the foundation of existing piers in the river channel is not stable. According to a soil survey, it is recommended that these piers be supported by piles of 15 m to 20 m deep.

If they are supported by the footing foundation, it can readily be imagined that they will have critical conditions in the future.

Accordingly, construction of a new two-lane bridge is planned.

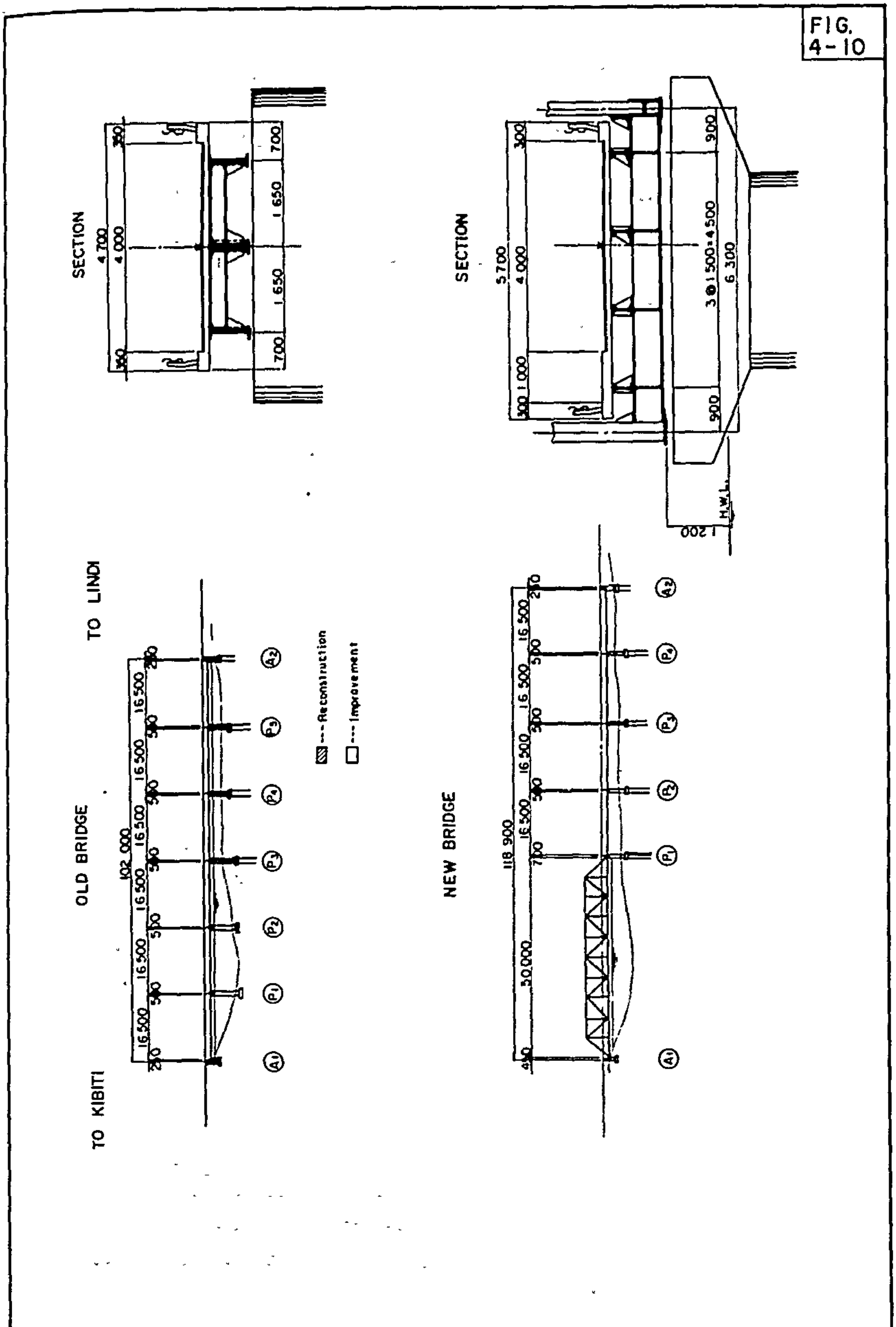


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-10	IMPROVED DESIGN OF THE EXISTING MBWEMKURU RIVER BRIDGE

4) Medium to Small Bridges

Hydrologically, most of the small and medium river bridges are short for the width of the river channels, which means unsatisfactory sectional areas for discharging floods. Naturally, scouring of the foundation by floods is widely evident.

Structurally, the floor system of the superstructure, particularly the slabs directly bearing the live load, has often suffered from damage.

The following shows the results of investigations of typical medium to small bridges. The distance is measured along the existing road.

14.7 km and 24.7 km from Kibiti:

Corrugated arch bridges measuring respectively 5.0 m and 12.3 m in length and 6.0 m in width. These are structurally favourable. As for a fifty-year flood probability, however, the cross-sectional area for discharge is only about 30 % of that required. For this reason, the existing bridges will be used only as the construction road, and new two-lane bridges of 14 m and 20 m long will be constructed instead.

173.2 km (Ukuri River) from Kibiti:

H-section steel girder bridge measuring 11.5 m in length and 3.5 m in width. Structurally favourable. With regard to a fifty-year flood probability, however, the cross-sectional area is short for discharge by about 60 %. A new two-lane bridge of 28 m long will be constructed accordingly.

189.0 km from Kibiti:

A 1,400ø x 1 corrugated pipe; widened recently to two lanes. Structurally favourable, but too small in cross-sectional area for discharge when measured against a fifty-year flood probability. A new two-lane bridge of 14 m long will be constructed accordingly.

224.3 km (Mandawa River) and 277.3 km (Munimbira River) from Kibiti:

Bailey bridges measuring 18 m and 24.4 m respectively in length and 3.2 m in width. Both are of temporary structures. New two-lane bridges 28 m and 34.5 m long will be constructed accordingly.

284.4 km (Likumbura River) from Kibiti:

Steel girder bridge 35.7 m long and 4.3 m wide.
Girder is corroded in some places, and RC slabs are seriously damaged. Preparations for construction of a Bailey bridge are under way.
The cross-sectional area for discharge is too small for a fifty-year flood probability. The alignment of the existing road will be modified, and a new two-lane bridge of 69 m long will be constructed.

297.3 km (Likongo River) from Kibiti:

Steel girder bridge measuring 12 m in length and 3.6 m in width. Structurally favourable. However deep water prevented the investigation of foundation conditions.
The cross-sectional area for discharge is too small for a fifty-year flood probability. A new two-lane bridge of 34.5 m will be constructed.

303.9 km (Mamburu River) from Kibiti:

A 23 m long by 3.8 m wide steel girder bridge. No problem at present, though partial corrosion is seen on the girder because of water leakage from the slabs. This bridge nearly fulfills the requirement of cross-sectional area for discharge as against a fifty-year flood probability. Construction costs are compared with respect to two cases; one in which the existing bridge is modified into a two-lane type (Case I) and the other in which a new two-lane bridge is constructed independent of the existing bridge (Case II). The results are given in Table 4-13.
In case II, the bridge length is planned to be 23.0 m to survive a fifty-year flood probability.

Table 4-13 Comparison of Construction Costs (Mamburu River Bridge)

(1,000 shs.)

Case I		Case II	
Item	Cost	Item	Cost
One-lane existing bridge:-			
Replacement of RC slab	51		
Repainting girder	11		
Pavement	3		
Total	65		
One-lane new bridge:-		Two-lane new bridge:-	
Superstructure	188	Superstructure	291
Substructure	528	Substructure	749
Total	716	Total	1,040
Grand total	781	Grand total	1,040

Notes:

i) The new one-lane bridge will be of 11.0 m-span RC girder type having a carriageway width of 4.0 m (without footpath).

ii) The abutment will be of the RC wall type, and the foundation of the H-section steel piles. The piers will be of the steel pipe pile bent type.

iii) In case I, each bridge will have one lane, and the new bridge will be constructed about 50 m upstream of the existing bridge.

iv) Neither case includes the construction costs of approach roads.

v) Ratio of construction costs (Case I/Case II) = 0.75.

The total construction costs, including the costs of constructing approach roads are almost the same for both cases.

In Case I, the substructure, particularly the foundation of the existing bridge is suspect because they have not yet been investigated. For this reason, a new 23-m-long two-lane bridge is planned here.

306.6 km (Mbanja River) from Kibiti:

A steel girder bridge 39 m long and 3.8 m wide.
The girder is partially corroded. RC slabs leave signs of frequent repairs. The bridge is on a comparatively soft ground, and if it is supported by the footing foundation, the settlement will be inevitable in future.

The cross-sectional area for discharge is smple for a fifty-year flood probability. The same comparison study as the Mamburu River Bridge is made. The results are as follows.

$$\frac{\text{Case I (850,000 sh.)}}{\text{Case II (1,069,000 sh.)}} = 0.80$$

For the same reasons as in the case of the Mamburu River Bridge, the existing bridge is rejected, and a new 34.5-m-long two-lane bridge is planned to replace it.

In addition to the bridges explained above, there are other medium to small bridges and pipe culverts as shown in Table 4-14. There are no perfect structures whatsoever from the viewpoint of hydrology and structural requirement.

It will be very difficult to make repairs in a manner to ensure safe and sound service of the existing bridges throughout the life of the project.

Table 4-14 Existing Bridges and Pipe Culverts - 1/3

Section	Distance from Kibiti	Existing Facility			No./Length of Planned Bridges	Remarks
		Type	Br. Length (m) & Other Particulars	Width in Meter (carriageway)		
1	14.7	Corrugated arch	5.0	6.0	1 ... 14.0	
	24.7	"	12.3	6.1	2 ... 20.0	
2	78.2	Steel girder	5.0	4.0	7 ... 23.0	
	143.2	Bailey truss	32.0	3.2	26 ... 81.7	Matandu Riv.
3	167.1	Steel girder	5.4	3.5	29 ... 34.5	Lingaula Riv.
	171.8	Corrugated pipe	ϕ1,300 x 1 ϕ600 x 1	-	30 ... 23.0	Mbanga Riv.
	173.2	Steel girder	11.5	3.5	31 ... 28.0	Ukuri Riv.
	175.9	Corrugated pipe	ϕ1,300 x 2	-	32 ... 14.0	Namitanba Riv.
	185.1	Bailey truss	24.0	3.2	33 ... 81.7	Mavuji Riv.
	189.0	Corrugated pipe	ϕ1,400 x 1	-	34 ... 14.0	
	200.8	"	ϕ1,200 x 3	-	36 ... 34.5	
	224.3	Bailey truss	18.0	3.2	38 ... 28.0	Mandawa Riv.

Table 4-14 Existing Bridges and Pipe Culverts - 2/3

Section	Distance from Kibiti	Existing Facility			No./Length of Planned Bridges	Remarks
		Type	Br. Length (m) & Other Particulars	Width in Meter (carriageway)		
4	249.4	Bailey truss	118.0	3.2	46 ... 122.5	Mbwemkuru Riv.
	269.9	Corrugated pipe	∅600 x 1		Corrugated pipe	Kilangar Riv.
	277.3	Bailey truss	24.4	3.2	51 ... 34.5	
	284.4	Steel girder	35.7	3.7	54 ... 69.0	Likumbura Riv.
	292.5	"	6.0	3.8	55 ... 11.5	
	297.3	"	12.0	3.6	56 ... 34.5	Likongo Riv.
	303.9	"	23.0	3.8	58 ... 23.0	Mamburu Riv.
	306.3	Concrete slab	15.8	3.7	} 59 ... 34.5	
	306.6	Steel girder	39.0	3.8		
	310.5	"	10.0	3.7	60 ... 11.5	
	312.8	"	3.0	6.2	61 ... 28.0	Mhungo Riv.
	314.0	Concrete slab	4.6	6.8	Corrugated pipe	
	314.9	Corrugated pipe			62 ... 28.0	
	316.2	Concrete arch	3.0	6.3	Box culvert	
	317.1	Concrete slab	6.0	6.8	63 ... 23.0	Likotwa Riv.

Table 4-14 Existing Bridges and Pipe Culverts - 3/3

Section	Distance from Kibiti	Existing Facility			No./Length of Planned Bridges	Remarks
		Type	Br. Length (m) & Other Particulars	Width in Meter		
5	2.4	Concrete box culvert	1.5	7.0	Corrugated pipe	
	2.8	Corrugated pipe	ø900 x 1		"	
	3.5	"	ø1,200 x 1		Box culvert	
	11.4	Steel girder	5.5	3.5	Bypass	
	14.1	Corrugated pipe	ø950 x 1			
	15.1	"	ø1,200 x 1 ø600 x 2			
	15.9	"	ø1,300 x 2			
	16.2	"	ø600 x 2			
	16.8	"	ø1,300 x 1			
	18.2	"	ø600 x 1		Corrugated pipe	
	18.8	Culvert		3.5	64 ... 20.0	
	19.2	Corrugated pipe	ø1,200 x 1			
	21.3	"	ø950 x 3		Box culvert	
	24.9	Steel girder	7.0	5.0	"	

4.6 Structural Plan

4.6.1 Outline

The Southern Coastal Link Road is planned to be completed in five years. Considering the geographical and climatic conditions and the scale of bridges, it has some difficulties to overcome.

The major difficulties are as follows: 1) the bridge sites are widely apart, and the relocation of construction facilities and equipment and transportation of materials will take much time; and 2) in the rainy season, the construction work at bridge sities is interrupted.

In order to perform bridge construction work smoothly, these difficulties should be solved in the stage of structural planning.

With these in mind, the structural design of the bridges is made with emphasis on the following points:-

i) Simplified design for both superstructure and substructure;
ii) Design permitting intensive construction work;
iii) Design capable of reducing the period of suspension in the rainy season;
iv) Design capable of recouping delay if caused, without major change in the design; and
v) Economic design.

4.6.2 Type of Main Bridges over Three Major Rivers

1) Comparison Study of Bridge Types

Unlike the medium to small bridges and flood-opening bridges, the three main bridges should be planned taking account of large design discharge and high velocities of flood. Hydrologically, it is desirable to adopt a long-span bridge in order to ensure the sufficient cross-sectional area for discharge if economy can be disregarded.

As many factors as possible, however, should be pieced together to decide upon the type of a given bridge.

Taken altogether, the three major bridges have much in common regarding the selection of bridge type, although there is some difference in site conditions. Here, the Matandu River Bridge is taken up for the discussion of two plans, steel bridge (Plan 1) and cast-in-place reinforced concrete bridge (Plan 2), with respect to economy, facility of work and structural reliability. (See Fig. 4-11.)

a) Outline of structure

Plan 1 Steel pony truss bridge:

40 m span x 2, with RC wall type substructure using 500ϕ steel pipe piles.

Plan 2 Cast-in-place reinforced concrete bridge:

16 m span x 5, with the same substructure and foundation work as Plan 1.

The main girder for the superstructure will be directly erected by means of a timbering installed in the river channel.

b) Economic comparison

Construction cost:-

Plan 1 - 5,073,000 Shs.
Plan 2 - 5,250,000 Shs.

(The costs for approach roads are not included.)

c) Merits and demerits as viewed from facility of work and structural reliability

Plan 1

Merits:-

i) The construction of both superstructure and sub-structure in the river channel will be completed in one dry season, and measures against flooding in the rainy season can be easily taken.

ii) The work is easy, and the total construction period can be reduced.

iii) The reliability of the bridge structure is high because of strength of steel materials.

iv) The large span provides a large cross-sectional area for discharge in favour of hydrological requirements.

Demerits:-

i) Steel bridges require periodic maintenance, such as repainting, and its cost.

Plan 2

Merits:-

i) Maintenance cost can be reduced if work is done to perfection.

ii) Local materials and labour can be effectively used.

Demerits:-

i) The construction of both superstructure and substructure in the river channel will require two seasons or more, posing a serious problem on the protection of half-done work during the rainy season.

ii) Timbering must be removed from the river channel before the rainy season arrives. Accordingly, the construction of main girder must be scheduled in a manner not to allow any delay due to flooding in the rainy season.

iii) All the jobs are done on site, requiring much time in construction work.

iv) The strength and reliability of the structure are largely affected by weather conditions during construction.

v) There are many piers in the river channel, and the resulting reduction in the cross-sectional area for discharge is highly disadvantageous in the light of hydrology.

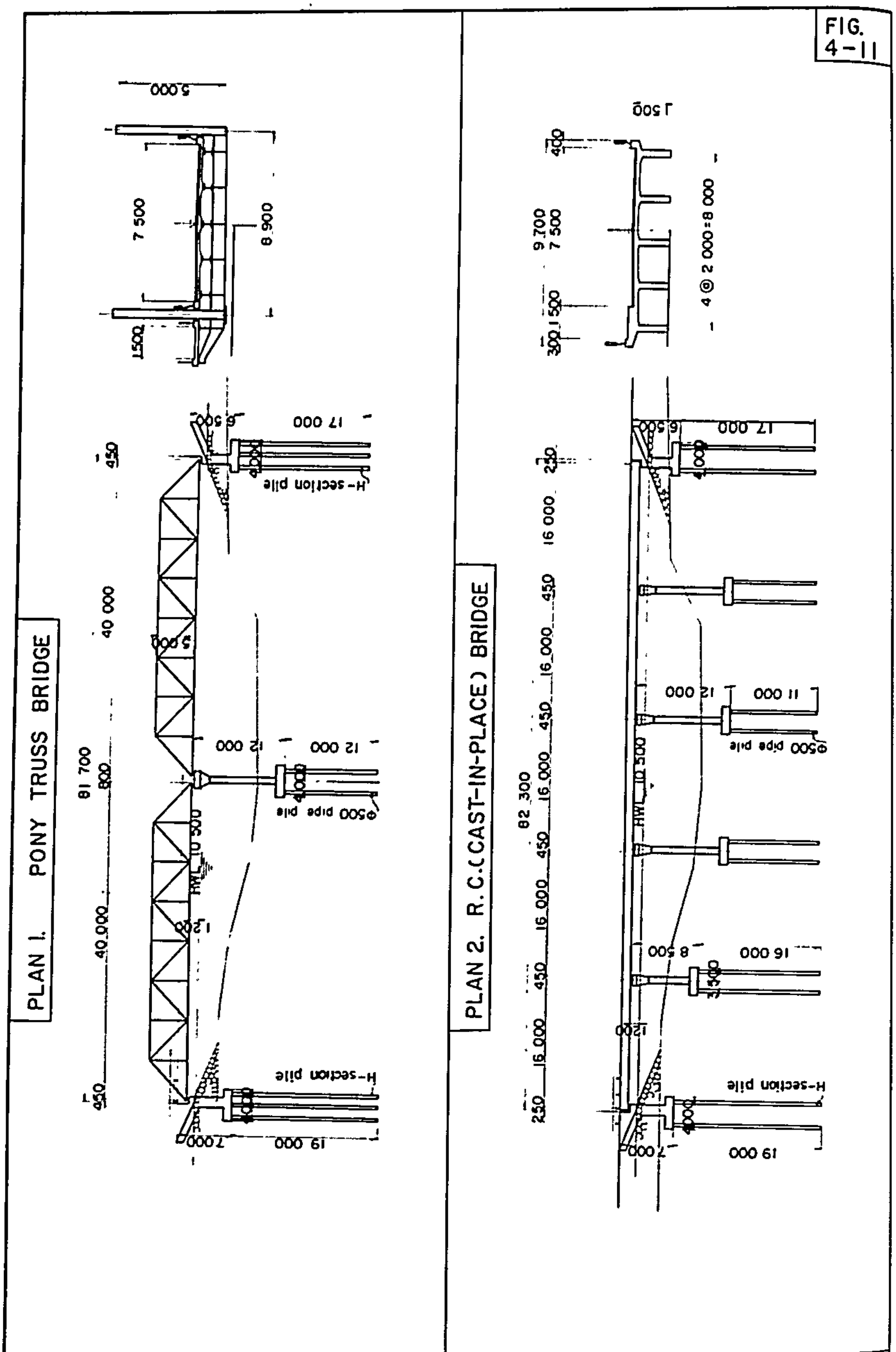


FIG. 4-11	SOUTHERN COASTAL LINK ROAD PROJECT
	COMPARISON OF PLANS 1 AND 2 FOR THE MATANDU RIVER MAIN BRIDGE

2) Determination of Bridge Types

The main bridges for the three major rivers are designed to be of 40-m span steel pony truss type for reasons explained in the foregoing and also in the following (see Figs. 4-12 and 4-13).

i) The bridges over the Mavuji and Mbwemkuru Rivers require long foundation piles, increasing costs for the construction of substructures. Naturally, this disqualifies the RC girder which requires much substructural work.

ii) In the Mbwemkuru River, the timbering is so high that construction costs become great.

4.6.3 Standard Types for Flood-Opening Bridges and Medium to Small Bridges

The flood-opening bridges, and medium to small bridges account for about 90 % of the aggregate length of all the bridges along the proposed route, naturally accounting for the bulk of bridge construction costs.

Usually, the flood-opening bridge does not require so large a span, because it is necessary only to provide a specified cross-sectional area for discharging floods.

The same is true of the medium to small bridges judging from the scale of flooding and velocity.

It is therefore believed that the flood-opening bridges and the medium to small bridges should be planned to have a span length of 10 to 15 m. This is also agreeable from an economic viewpoint.

1) Standard Types of Superstructure

Reinforced concrete superstructures having spans of 9.5 m, 11.0 m and 13.5 m are planned as standard.

These are also classified into cast-in-place type in which the main girder is built on the timbering at bridge site, and precast reinforced concrete type in which the main girder is fabricated at a yard apart from the bridge site, then transported to the site and erected.

a) Cast-in-place reinforced concrete bridge (C-RCT type)

The standard cross sections are shown in Figs. 4-14 and 4-15. Because all jobs are to be carried out at site, construction work takes much time. The construction period is also affected by weather conditions.

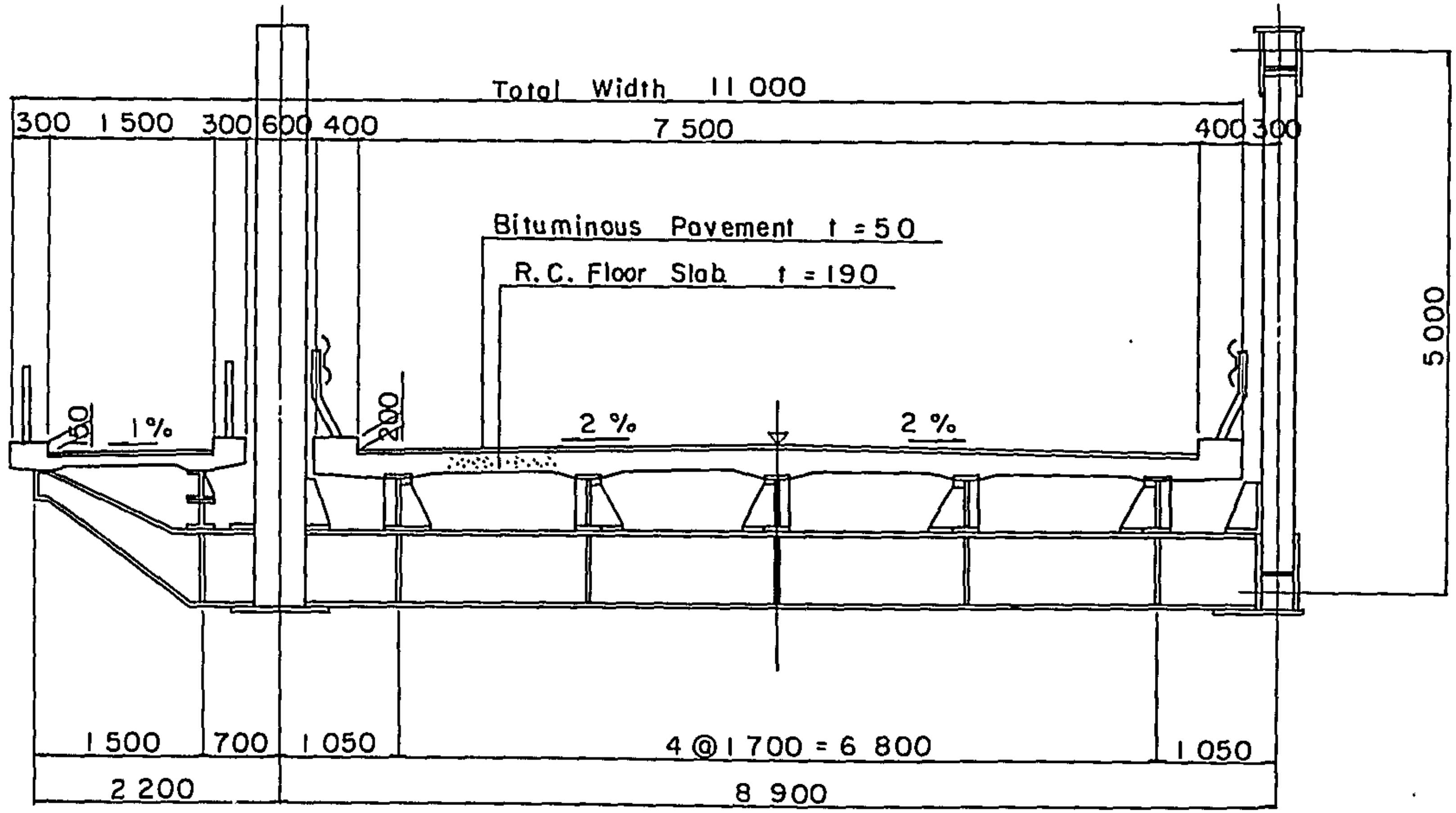
This type is planned for special bridges such as skew bridges.

b) Precast reinforced concrete bridge (P-RCT type)

The standard cross sections are shown in Figs. 4-16 and 4-17. The main girders are prefabricated at a yard, and the slabs and cross beams are cast in place.

The main girders can be fabricated even during the rainy season, if the yard is situated at an appropriate location. Since the fabricating work can be carried out intensively in the specified yard, quality control is better achieved and work efficiency is enhanced.

FIG. 4-12

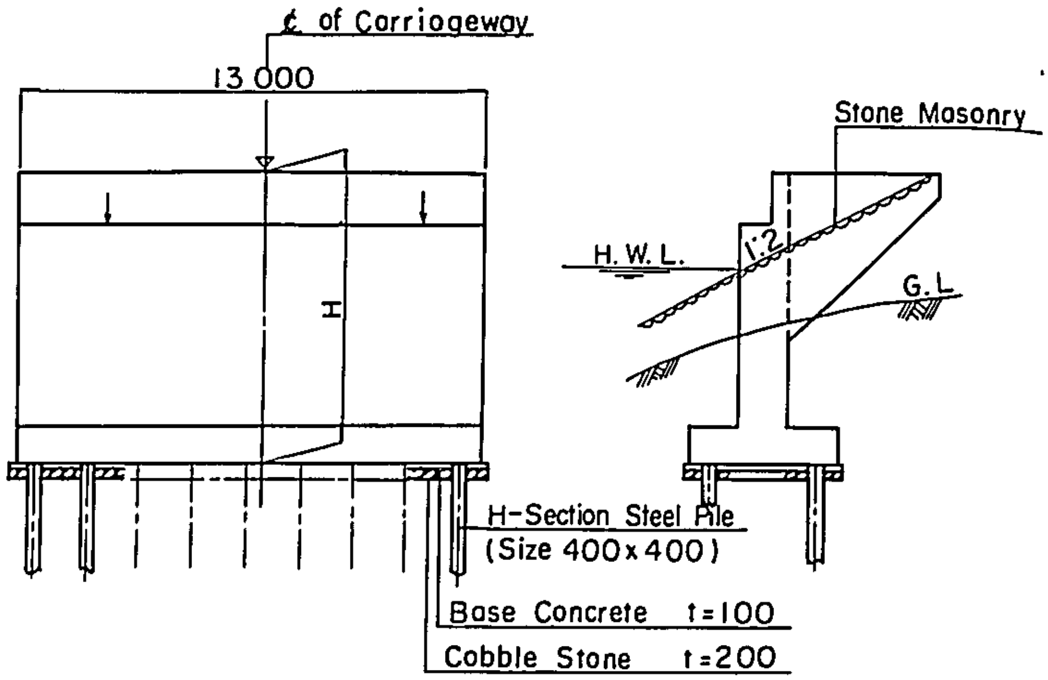


TR-40

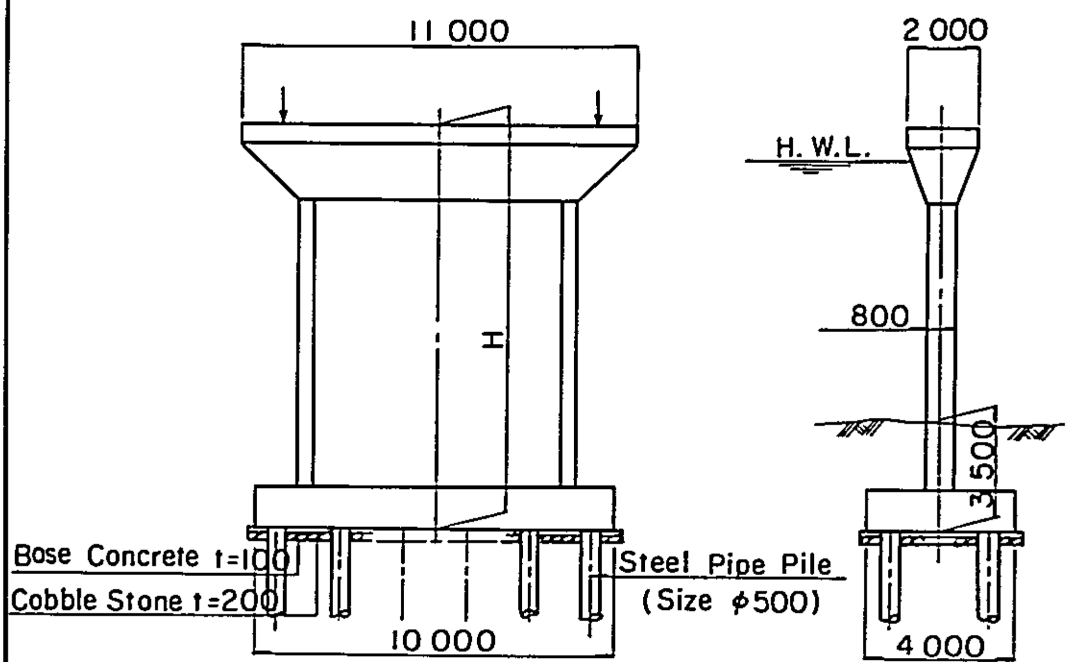
FIG. 4-12	SOUTHERN COASTAL LINK ROAD PROJECT STANDARD CROSS SECTION OF MAIN BRIDGES (PONY TRUSS TYPE)

FIG. 4-13

ABUTMENT H=4.0^{m}, 70^{m}, 80^{m}



PIER H=7.0^{m}~ 12.0^{m}



Note : Number and length of pile depends on reaction and soil condition.

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-13	STANDARD TYPE OF SUBSTRUCTURE FOR MAIN BRIDGES

Therefore, this type of bridge facilitates construction work and at the same time assures a product of high quality. In principle, this type is planned for flood-opening bridges and straight bridges over small and medium rivers.

The flood-opening bridge is planned to have a span of 13.5 m, and those of the medium to small bridges are 9.5, 11.0 or 13.5 m corresponding to the requirement of their bridge lengths.

2) Standard Types of Substructure

a) Abutment

Standard abutments are planned to cover heights from 4.0 m to 10 m at an interval of 1 m.

The structure is of the reinforced concrete wall type meeting the various requirements, including topographic conditions at site and the reaction of superstructure (see Fig. 4-18).

As a general rule, the depth of embedment of abutment is 1.5 m below the ground surface.

As described in 4.6.4, the foundation pile is to be in steel. The abutment is to be in H-section steel of 400 mm x 400 mm and its piles are driven into the bearing stratum deep enough to obtain bearing force required.

b) Piers

Since the superstructure has comparatively short spans, the volume of work for the piers becomes large.

Naturally, the type selected for the pier will largely influence the construction cost and facility of work.

In order to cope with this problem, the pile bent type in which the foundation work and main body are integrated into a simple structure and which permits easy work is planned. In the event the soil condition does not agree with the pile bent type, RC wall type is considered.

Pile bent type piers:

Piles are 500 mmϕ steel pipes. The top of the pile is connected to the reinforced concrete beam, on which the superstructure is supported. The pier type is also subclassified into four-pile and five-pile types. Whichever is appropriate to meet the reaction of the superstructure is to be adopted.

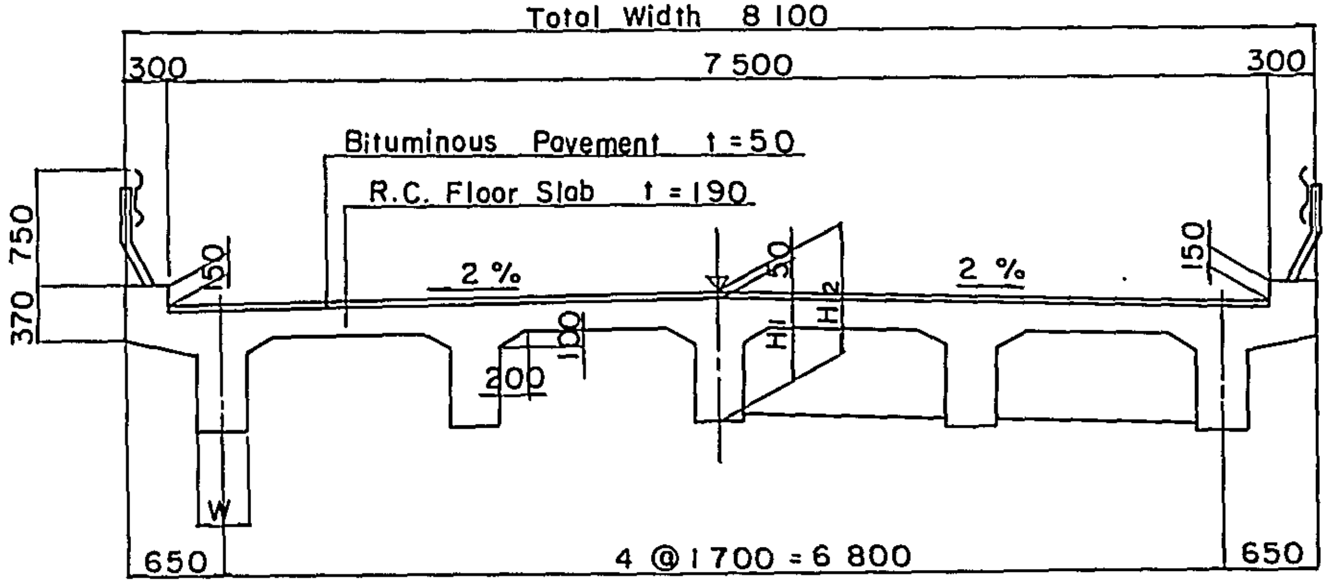
The exposed surfaces of the piles above ground must be painted or covered with Hume pipes for the purpose of preventing corrosion as shown in Fig. 4-19.

Reinforced concrete wall type piers:

This type is planned for the spread foundation and for those bridges whose bearing stratum is comparatively shallow.

Steel pipe piles of 500 mm in diameter will be used if necessary. (Fig. 4-18)

FIG. 4-14



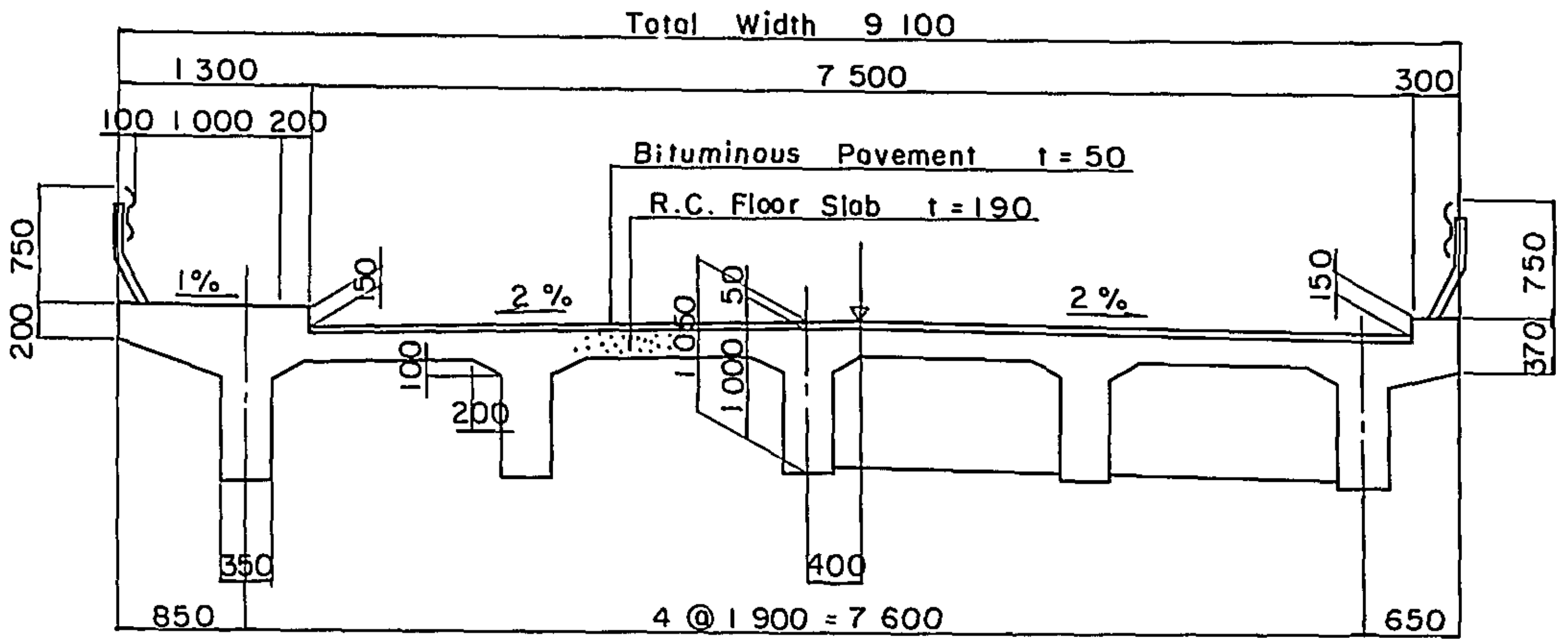
Girder Span	W	H1	H2	Type
9.5 m	350	850	900	C - RCT - 9.5 B
11.0 m	350	1 000	1 050	C - RCT - 11.0 B
13.5 m	400	1 200	1 250	C - RCT - 13.5 B

FIG. 4-14

SOUTHERN COASTAL LINK ROAD PROJECT

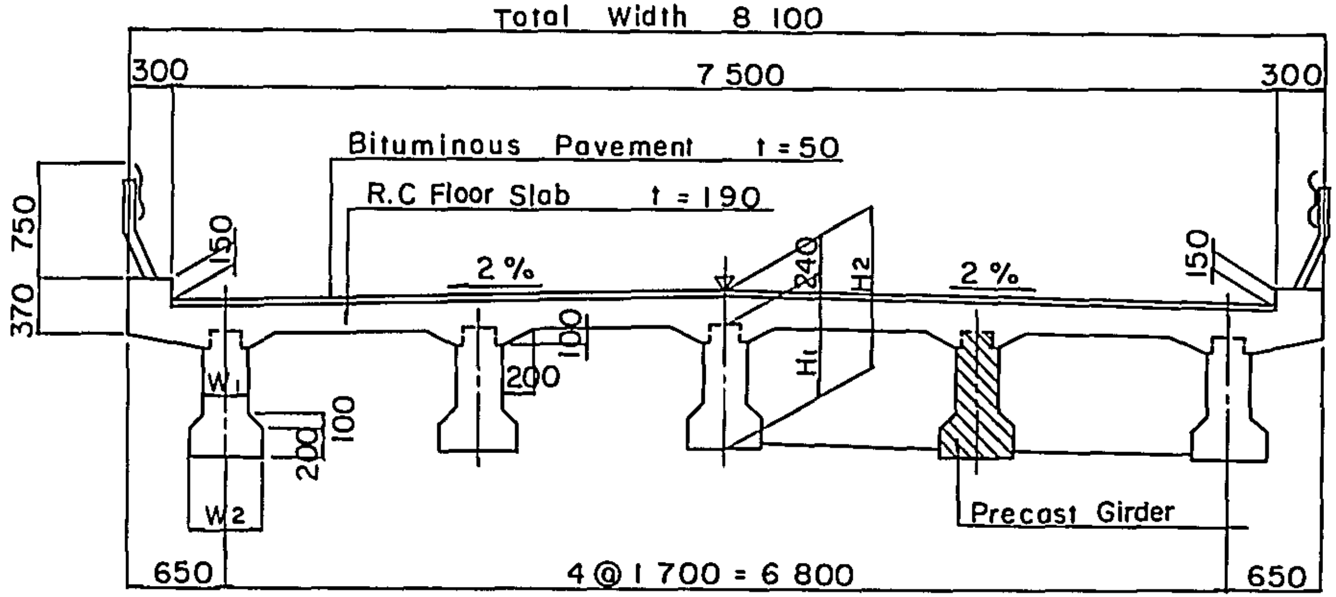
STANDARD CROSS SECTION OF SMALL TO MEDIUM BRIDGES (CAST-IN-PLACE R.C. TYPE)

FIG. 4-15



C – RCT – 11.0 A TYPE

FIG. 4-15	SOUTHERN COASTAL LINK ROAD PROJECT STANDARD CROSS SECTION OF MEDIUM BRIDGES (CAST-IN-PLACE R.C. TYPE)

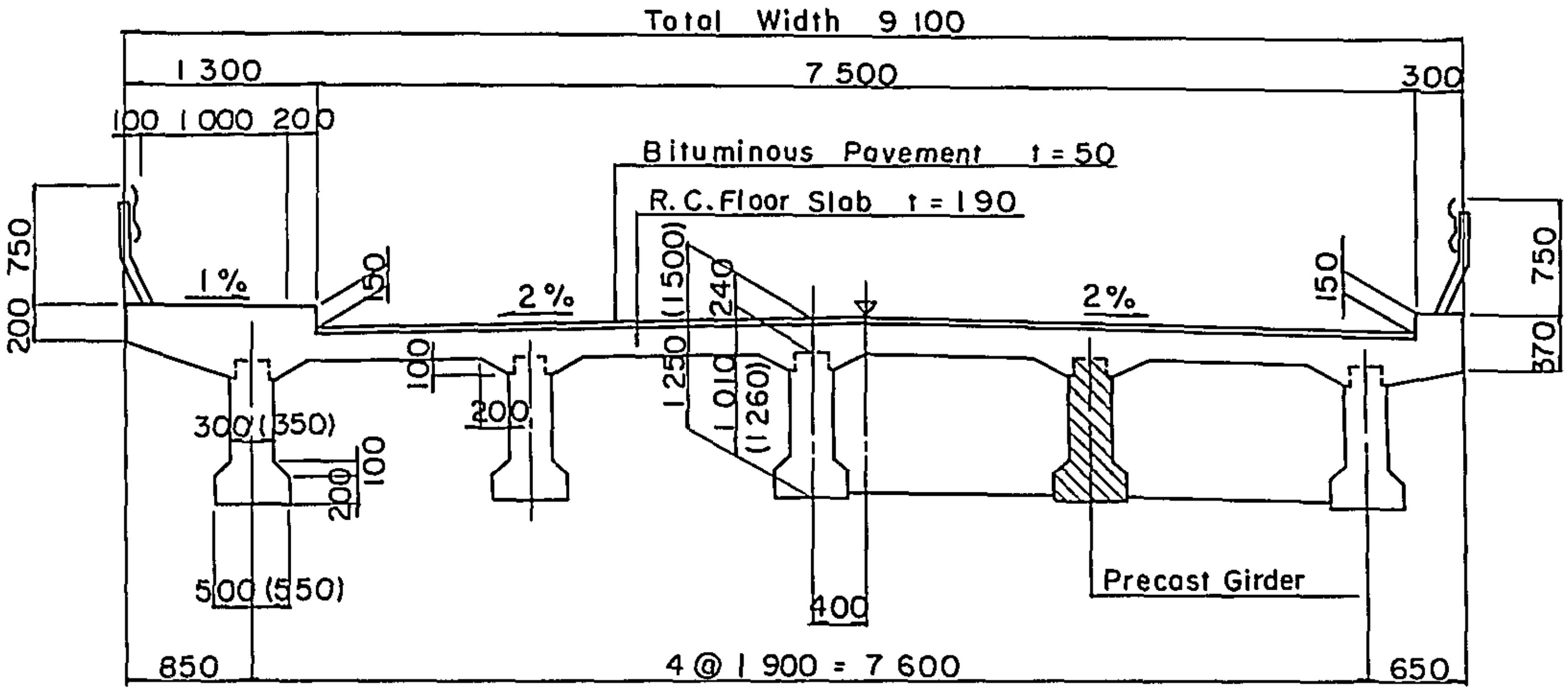


Girder Span	W1	W2	H1	H2	Type
9.5 m	300	500	860	1 100	P-RCT- 9.5 B
11.0 m	300	500	1 010	1 250	P-RCT- 11.0 B
13.5 m	350	550	1 260	1 500	P-RCT- 13.5 B

FIG. 4-16

SOUTHERN COASTAL LINK ROAD PROJECT

STANDARD CROSS SECTION OF SMALL TO MEDIUM BRIDGES (PRECAST R.C. TYPE)

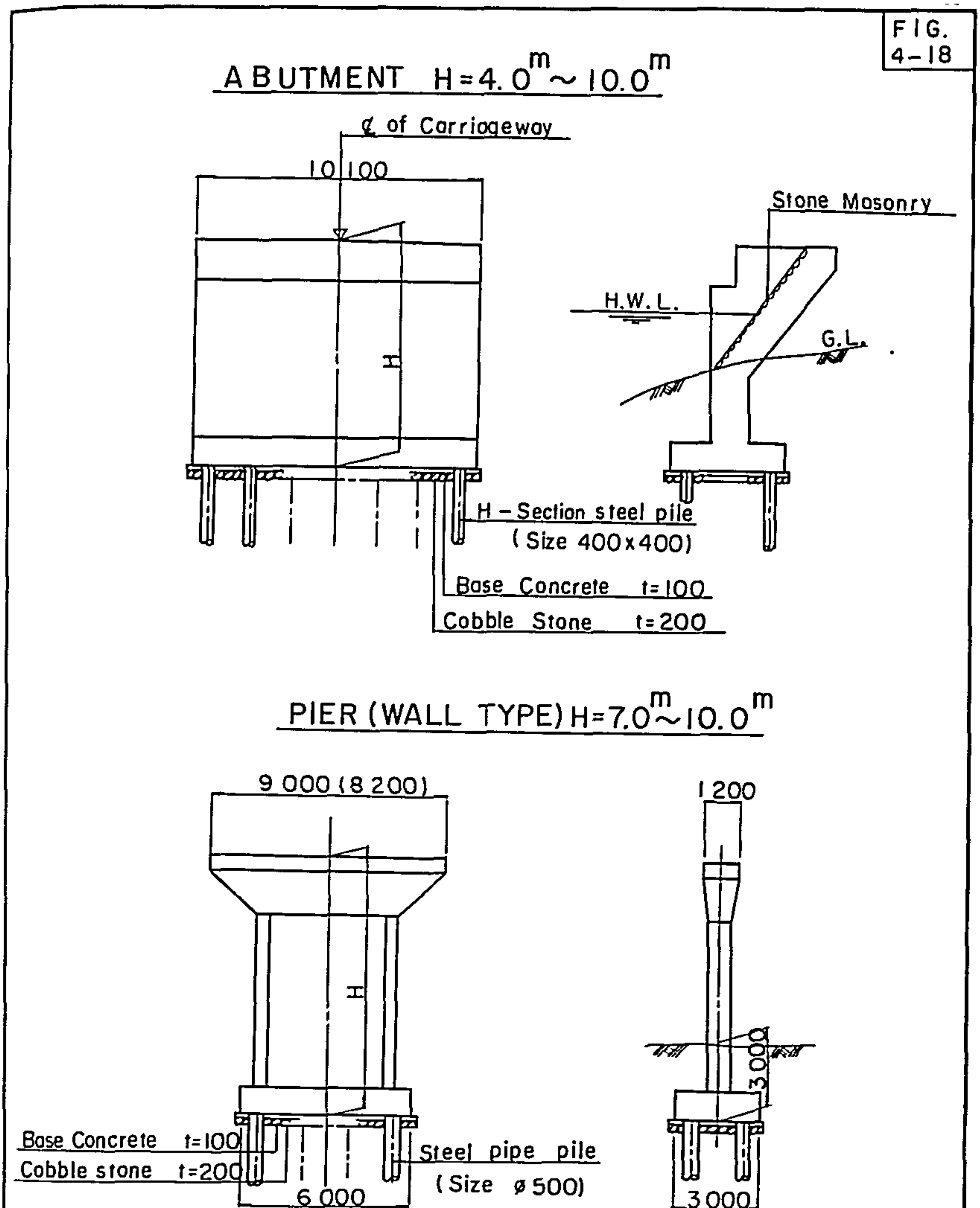


P-RCT-11.0A

P-RCT-13.5A

Notes
1. R.C. Floor Slab and Cross Beam shall be cast in place.
2. Figures in parentheses denote dimensions in case with span length of 13.5m.

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-17	STANDARD CROSS SECTION OF FLOOD-OPENING BRIDGES AND MEDIUM BRIDGES (PRECAST R.C. TYPE)



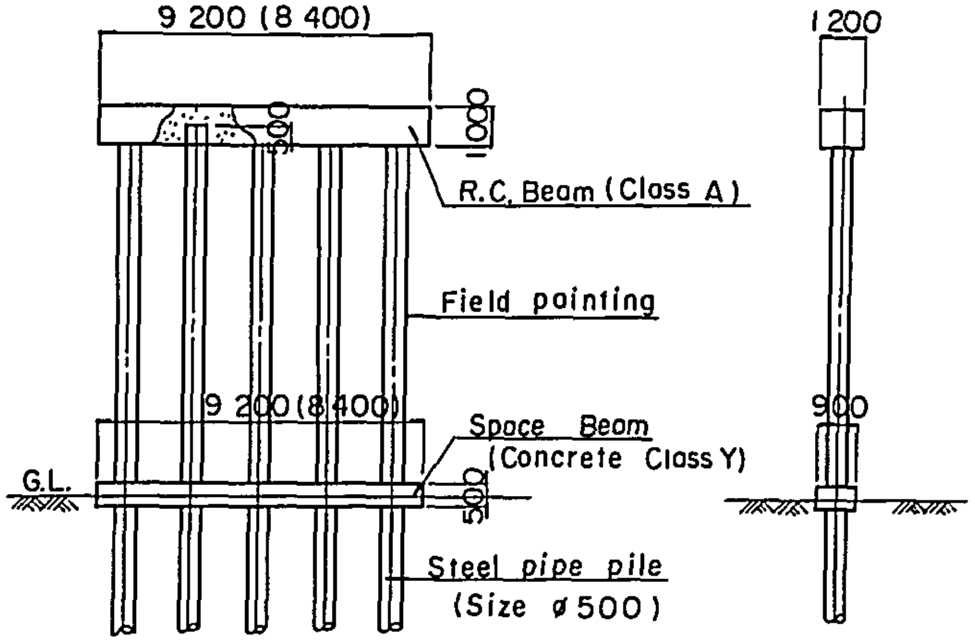
Notes. 1. Number and length of pile depend on reaction and soil condition.

2. ( ) for no-footpath Type

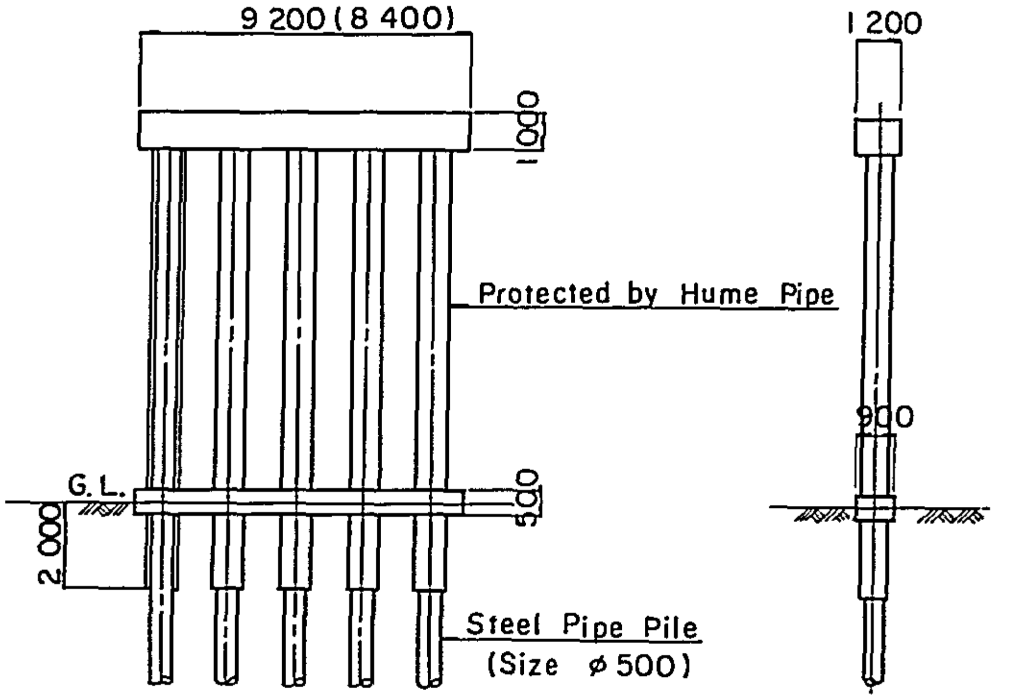
FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-18	STANDARD TYPE OF SUBSTRUCTURE FOR FLOOD-OPENING BRIDGES AND SMALL TO MEDIUM BRIDGES (I)

FIG. 4-19

PIER (PILE BENT TYPE-1)



PIER (PILE BENT TYPE-2)



Notes
1. TYPE-2 Shall be adopted where close to sea.
2. Four-pile piers are used in some cases.

FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
4-19	STANDARD TYPE OF SUBSTRUCTURE FOR FLOOD-OPENING BRIDGES AND SMALL TO MEDIUM BRIDGES(2)

4.6.4 Foundation Pile

Based on the result of soil investigation described in Paragraph 4.4, a series of comparative studies on the steel pile and reinforced concrete pile was made mainly regarding their properties as structural materials, facility of work and economic features. The studies indicate that the steel pile is to be adopted as detailed in the following.

1) Pile Design

a) Steel pile

Two types of steel piles are selected through examination of loading, soil properties and facility of work; H-section steel of 400 mm x 400 mm and steel pipe of ø500 mm with 12 mm wall thickness. The allowable vertical load per pile is calculated to be 50 t for the H-section type and 80 t for the pipe type.

b) Precast reinforced concrete pile

A non-compression and site-fabrication type. It is driven to the bearing stratum like steel piles. The allowable vertical load is to be 35 t per square pipe of 400 mm x 400 mm. The number of reinforcement bars to be incorporated per pile is determined taking account of normal and bending stress corresponding to the allowable load.

c) Cast-in-place reinforced concrete pile

Methods for cast-in-place concrete piles can be classified into the following three: driven-shell, replacing, and drilling methods.

In the driven-shell method, a steel casing pipe is driven into the bearing stratum to be filled with concrete and reinforcing bars for serving as a pile. The steel casing pile has two varieties: one is designed to have its driven end closed with a cast iron shoe while the other has an open end. The latter type is filled with concrete and bars after it is cleared of soil in the driven casing. Many of piles prepared in the driven-shell method fall in the range of diameter from ϕ350 mm to ϕ600 mm.

In the replacing method, a drilling machine is used to drill a hole down to the predetermined bearing stratum. The hole is filled with cement mortar pumped out of the drill bit, and a pile is formed therein. Piles in this method have a range of diameter similar to that of driven-shell piles.

Representative drilling methods are earth drill and reverse circulation methods. The minimum diameter of pile driven in this method is ϕ600 mm, and piles of smaller diameter cannot be processed.

Cast-in-place piles using these drilling methods may have the following problems while driven:

i) The method is likely to loosen the bearing stratum by which the pile is supported;

ii) Hole walls are likely to crumble down;

iii) Concrete will require very attentive quality control due to its often application below ground water level;

iv) Slurry tends to precipitate, and unless completely taken away causes the pile to settle reducing its bearing capacity;

v) The method generally requires highly skilled technique.

The above methods were examined in the choice of the optimum type of the cast-in-place reinforced concrete pile. As the result, the driven-shell pile was chosen for its comparatively few problems in terms of working period and application, and its adaptability to the site conditions. This type of pile was subjected to further examination and comparison with steel piles and precast reinforced concrete piles.

The cast-in-place reinforced concrete pile discussed here has the following design features. The steel casing pipe has an outside diameter of ϕ400 mm (wall thickness 3.4 mm) and is of closed-end type. It will be left as it is even after filled with concrete, but will not be regarded from the designing viewpoint as contributing to widen the effective cross section with its wall thickness due to corrosion. The allowable vertical load is 60 t per pile. The quantity of reinforcing bars per pile is calculated on the basis of resultant stress of vertical and horizontal load on the pile.

2) Structural Properties and Facility of Work

a) Steel pile

Advantages:-

i) High strength and reliability as structural material;

ii) Capable of being driven into the bearing s-ratum deep enough to obtain bearing force required;

iii) Easy to adjust the length depending on soil properties;

iv) Considerable resistance against lateral force;

v) Facility both in transportation and of work owing to light weight;

vi) Applicable as long pile using solid joints available at site.

Disadvantages:-

i) Requires anti-corrosion treatments;

ii) Makes little use of local materials and regional labour force.

b) Precast reinforced concrete pile

Advantages:-

i) Makes effective use of local materials and regional labour force;

ii) Sure application can reduce maintenance cost.

Disadvantages:-

i) Less reliability as structural material;

ii) High crack incidence during transportation and application resulting in much reduced durability;

iii) Liable to cause defects in site-prepared joints when used as long pile;

iv) Impossible to repair defects developed during being driven.

c) Cast-in-place reinforced concrete pile

Advantages:-

i) Corrosion resistance similar to that of precast concrete piles;

ii) Fewer troubles during driven than precast concrete piles;

iii) Makes more effective use of local materials and regional labor force than steel piles.

Disadvantages:-

i) Requires skilled technique and thorough construction supervision, otherwise may have defects;

ii) Earth pressure can cause buckling in steel casing pipe for a long pile and reduces pile cross-sectional area, which in turn greatly decreases the bearing capacity of pile;

iii) Requires longer construction period.

3) Economic Comparison and Evaluation

The design of pile cross-sectional area is determined based on the resultant stress of the normal and bending stresses. Cast-in-place reinforced concrete piles require longer construction period as well as more careful on-site supervision than steel piles and precast reinforced concrete piles. On the other hand, the precast reinforced concrete pile is economical in comparison with steel piles only when it is shorter than 10 m and it has a small bending stress. Piles that can be used within the range of length and bending stress represent less than 20 % of the total amount required. Further, the steel pile is comparatively easy to control its quality and to adjust its length whatever unexpected changes may be necessitated. As the conclusion, the steel pile is taken up for designing the foundation pile at this stage of preliminary design for its general economy, facility in work and better quality when completed.

It is, however, advisable to re-examine before actual construction the pile type for a particular site based on an advance detailed soil survey since there may be a site with stratum on which a reinforced concrete pile is more suitable to support the structure.

4) Corrosion of Steel Pile and Anti-Corrosion Measures

Steel pile corrosion is due to electro-chemical reaction on the pile surface with the coexistence of moisture, oxygen and difference of potential.

It is considered that such coexistence can easily occur as the proposed route runs along the coast. The structural design is, therefore, performed taking account of the rate of corrosion as well as anti-corrosion measures.

The steel pile is designed to have a thickness allowing for 2 mm of corrosion on the assumption that an underground pile has a corrosion rate of 0.02 mm/year.
The steel pile is designed to have a thickness allowing for 2 mm of corrosion on the assumption that an underground pile has a corrosion rate of 0.02 mm/year.

Overground pile bent type piers are to have the abovementioned extra thickness for corrosion and have their surfaces painted or covered with Hume pipes to provide further protection.

Pier protection using Hume pipes are planned for such bridges as follows:-

i) Bridges located quite close to the coast;

ii) Bridges over rivers having water even in dry seasons.

The pile protection Hume pipe is to be driven to a depth of 2 m from the ground level as shown in Fig. 4-19.

Anti-corrosion effect of painting is expected to last for about ten years. As for Hume pipe protection, the effect is semipermanent provided the pipe is not damaged.

4.7 Bridge Plan

4.7.1 Outline

Table 4-15 shows the number of proposed bridge sites and bridge length required for the project. The locations for the bridges along the proposed route, their lengths and types are shown in Table 4-16.

The lengths of the three main bridges, including the flood-opening bridges, are 712 m for the Matandu, 194 m for the Mavuji and 304 m for the Mbwemkuru.

The medium to small bridges are fifty-seven in all, and their aggregate length is 1,219 m. The total aggregate length of the bridges is 2,429 m.

Table 4-15 Planned Bridges for Each Construction Section

Section	Type	Number of Bridges	Length (m)	Remark
1	Medium and small bridge	2	34	
2	Main bridge	1	82	Matandu Riv.
	Flood-opening bridge	3	630	Matandu Riv.
	Medium and small bridge	22	475	
3	Main Bridge	1	82	Mavuji Riv.
	Flood-opening bridge	1	112	Mavuji Riv.
	Medium and small bridge	14	297	
4	Main bridge	1	122	Mbwemkuru Riv.
	Flood-opening bridge	2	182	Mbwemkuru Riv.
	Medium and small bridge	18	393	
5	Medium and small bridge	1	20	
	Total	66	2,429	

4.7.2 Three Major River Bridges

1) Matandu River Bridge

Hydrologically, the length of the bridge required to cross the Matandu is 680 m, including 80 m for the main bridge over the river channel, 500 m for the two flood-opening bridges on the right and 100 m for the left flood-opening bridge.

For this requirement, the main bridge is planned to be two spans of pony truss, each measuring 40 m, or about 82 m in aggregate length. For the flood-opening bridges, 13.5 m-span precast type RC girders are planned; that is, thirty-seven spans or 518 m for the right side flood-opening bridges, and eight spans or 112 m for the left flood-opening bridge. The overall length is 712 m. (See bridges Nos. (24), (25), (26) and (27) in Table 4-16.)

The abutment for the main bridge will be constructed some 10 m at the back of the slope shoulder (top margin) of the existing river channel. This is because an allowance should be provided for changes in the course of a meandering river of this kind.

The height of the main bridge abutment is 6.5 m on the right side and 7.0 m on the left. Twenty-two foundation piles will be required for each abutment, 17 m long for the right abutment and 19 m for the left one.

The depth of pier embedment is about 3.5 m from the river bed, and the pier height is 12 m. Fourteen foundation piles of 12 m long are required.

The abutments for three flood-opening bridges will range from 6.5 m to 7.0 m in height and have foundation piles from 13 m to 17 m long depending on location.

All the piers for the flood-opening bridges are of the pile bent type. Five piles will be required per pier and their overall length, including the height above ground, will vary in the range of 17 m to 21 m.

2) Mavuji River Bridge

Hydrologically, the length of the bridge required to cross the Mavuji is 180 m; namely, 80 m for the main bridge over the river channel and 100 m for the right flood-opening bridge.

For this requirement, the actual bridge is planned as follows.

Like the Matandu River Bridge, the main bridge is planned to comprise two spans of pony truss, each measuring 40 m, and the flood-opening bridge to be composed of eight blocks of 13.5-m-span precast type RC girders. For the Mavuji River, it is judged on a topographic basis that the bridge structures be arranged concentrically near the river channel. For this reason, it is planned to have the flood-opening bridge adjacent to the main bridge. The aggregate length of the bridges is about 194 m. (See bridge No. (33) in Table 4-16.)

For the main bridge, ample allowance is given with respect to the width of the river channel. This is because it is highly probable that the river course will change drastically as the river bends widely at the bridge site while the bank height is low.

The piers of the flood-opening bridge planned to adjoin the main bridge have a deep pile foundation to counter scouring at the time of flood. They are also safeguarded against high velocity expected at the time of flood. But certain measures should be taken when erosion nearly reaches the level of the existing river.

The height of the left abutment for the main bridge is 7 m, and twenty-four foundation piles of 17 m long are required.

The pier, on which the ends of both pony trusses are seated, requires fourteen foundation piles of 18 m long. The depth of pier embedment is 3.5 m from the river bed and the pier height is 11.5 m.

The piers on which the flood-opening bridge and the main bridge are joined together are designed to have a 3.5 m depth of embedment and a body height of 8.0 m. Twelve foundation piles of 21 m long are required for the pier.

All the piers for the flood-opening bridge are of the pile bent type. The number of piles required per pier is five, and their overall length, including the height above the ground level, is about 23 m.

3) Mbwemkuru River Bridge

Hydrologically, the Mbwemkuru will necessitate a bridge length of 300 m, including 120 m for the main bridge over the river channel and 180 m for two right flood-opening bridges.

For this requirement, the actual bridge is planned as follows.

The main bridge is planned to have three blocks of 40 m-span pony trusses, and the flood-opening bridges to have a total of thirteen blocks of 13.5 m-span precast RC girders, of which eight spans are joined to the main bridge as in the case of the Mavuji River.

The bridge length over the river channel, including the flood-opening bridge, is about 234 m. With the remaining flood-opening bridges of 70 m, the aggregate bridge length will be 304 m. (See bridges Nos. (46) and (47) in Table 4-16.)

The river channel of the Mbwemkuru looks comparatively stable. Considering, however, the depth of water and high velocity at the time of flood as well as the sharp bend of the river channel at the bridge site, the right bank will eventually be eroded.

The length determined for the main bridge will be ample in order to cope with expected changes of the river course. The piers of the flood-opening bridge designed to adjoin the main bridge will remain safe even when temporarily scoured by 2 to 3 m deep below. It should be noted however that the structure will be endangered if the eroded part is left uncared for over a long period of time.

The left abutment for the main bridge is planned to be supported on the footing foundation having a height of 4.0 m.

The depth of embedment of the three piers for the main bridge is planned to be 3.5 m from the existing river bed or ground. They are from left to right 10.5 m, 7.0 m and 7.0 m high, and require the foundation of ten piles 15 m deep, twelve piles 20.5 m deep and twelve piles 21.5 m deep.

All the piers for the flood-opening bridge are of the pile bent type. The number of piles required per pier is five, and their overall length, including the height above ground, is as long as about 30 m.

4.7.3 Medium to Small River Bridges

A total of fifty-seven standard type bridges ranging in length from 11.5 m to 69 m are planned. Their aggregate length is 1,219 m.

The two bridges in section No. 1, skew bridges and those bridges having a small radius of curvature are planned to be of the cast-in-place RC type (C-RCT type) as a rule.

The number of bridges coming under this category is eighteen, and their aggregate length is 287 m. These bridges are mostly planned near Kiranjerange, the border between sections No. 3 and No. 4.

The remaining thirty-nine bridges are planned to be of the precast RC type (P-RCT type). Among these, there are some bridges such as No. (62) which are to stand high on such a soft ground that it is considered inadequate to design as cast-in-place reinforced concrete bridges due to the difficulties in timbering. The wall type piers (WP type) are planned for those bridges for which a bearing stratum is available at a comparatively shallow depth to permit the application of the footing foundation, and also for those bridges for which short pile length in the ground meets their supporting requirements. Falling under this category are the bridges Nos. (15), (29), (30), (31), (38) and (39). For other bridges, the piers are planned to be of the pile bent type (BP type).

For those bridges which are located close to the seacoast and also for those bridges over rivers which carry water even in the dry season, the part of steel pipe above ground is planned to be protected with a Hume pipe. The bridges coming under this category include the bridges Nos. (9), (16), (17), (51), (54), (56), (62) and (63).

Table 4-16 Summary of Bridge Planning - 1/5

Section	Br. No.	Station	General Planning						Substructure Design Data				Remarks
			Bridge Type *1	Span	Bridge Length(m)	Width (m)	Horizontal Alignment	Skew *2 Angle(deg)	Abutment or Pier	Body Height(m)	Pile Length (m)	Number of Piles	
1	1	14+670	C-RCT-135B	1	14.0	7.5	R=1500	90	A1	6.0	15.0	14	
							A= 700		A2	6.0	15.0	14	
	2	24+665	C-RCT-9.5B	2	20.0	7.5	R=6000	L70	A1	6.0	15.0	12	
									P1	-	18.5	4	
									A2	6.5	14.5	14	
2	3	50+700	P-RCT-11A	3	34.5	7.5+1.0	R=800	90	A1	4.5	15.0	10	
									P1,P2	-	18.0 *3	4x2=8	
									A2	4.5	15.0	10	
	4	57+550	P-RCT-13.5B	2	28.0	7.5	R=1000	90	A1	4.5	15.0	12	
									P1	-	18.0	5	
									A2	4.5	15.0	12	
	5	58+600	P-RCT-13.5B	2	28.0	7.5	R=2400	90	A1	5.0	15.0	12	
									P1	-	18.0	5	
									A2	5.0	15.0	12	
	6	68+700	P-RCT-11A	3	34.5	7.5+1.0	Straight	90	A1	6.0	10.0	12	
									P1,P2	-	14.0 *3	4x2=8	
									A2	6.0	10.0	12	
	7	74+410	P-RCT-11B	2	23.0	7.5	Straight	90	A1	5.5	10.0	12	
									P1	-	14.0	4	
									A2	5.5	10.0	12	
	8	80+366	P-RCT-13.5B	1	14.0	7.5	R=3000	90	A1	6.0	10.0	14	
							R=2000		A2	6.0	10.0	14	
	9	86+920	P-RCT-9.5B	2	20.0	7.5	Straight	90	A1	7.0	10.0	14	
									P1	-	15.0	4	
									A2	7.0	10.0	14	
	10	87+700	P-RCT-9.5B	2	20.0	7.5	Straight	90	A1	7.0	5.0	14	
									P1	7.0	3.0	6	
									A2	7.0	5.0	14	
	11	98+315	P-RCT-13.5B	1	14.0	7.5	Straight	90	A1	6.0	5.0	14	
									A2	5.5	5.0	14	
	12	99+450	P-RCT-13.5B	1	14.0	7.5	R=1500	90	A1	6.0	5.0	14	
									A2	6.0	5.0	14	
	13	100+280	P-RCT-13.5B	1	14.0	7.5	R=1500	90	A1	5.5	5.0	14	
							A=500		A2	5.5	5.0	14	
	14	100+645	P-RCT-13.5B	1	14.0	7.5	R=1500	90	A1	5.5	5.0	14	
									A2	5.5	5.0	14	

* Refer to the notes at the end of this list.

Table 4-16 Summary of Bridge Planning - 2/5

Section	Br. No.	Station	General Planning						Substructure Design Data				Remarks
			Bridge Type *1	Span	Bridge Length(m)	Width (m)	Horizontal Alignment	Skew *2 Angle(deg)	Abutment or Pier	Body Height(m)	Pile Length (m)	Number of Piles	
	15	103+325	P-RCT-13.5B	2	28.0	7.5	R=3000	90	A1	6.0	5.0	14	
									P1	7.0	3.0	6	
									A2	6.0	5.0	14	
	16	106+880	P-RCT-13.5B	2	28.0	7.5	R=1500 A=1000	90	A1	6.5	10.0	16	
									P1	-	14.0	5	
									A2	6.0	10.0	14	
	17	116+945	P-RCT-13.5B	2	28.0	7.5	R=1500	90	A1	5.5	14.0	14	Ntandango Riv.
									P1	-	17.0	5	
									A2	6.0	14.0	14	
	18	117+600	P-RCT-13.5B	1	14.0	7.5	Straight	90	A1	5.0	10.0	12	
									A2	5.0	10.0	12	
	19	120+ 50	P-RCT-13.5B	1	14.0	7.5	Straight		A1	5.5	10.0	14	
									A2	5.0	10.0	12	
	20	126+350	P-RCT-13.5B	1	14.0	7.5	R=1000 A= 400	90	A1	7.0	10.0	16	
									A1	7.5	10.0	16	
	21	128+150	P-RCT-11B	2	23.0	7.5	R=1500	90	P1	-	14.0	4	
									A2	7.0	10.0	14	
	22	130+550	P-RCT-11A	3	34.5	7.5+10	R=800	90	A1	6.0	10.0	12	
									P1,P2	-	14.0 *3	4x2=8	
									A2	6.0	10.0	12	
	23	136+120	P-RCT-13.5B	1	14.0	7.5	Straight	90	A1	7.5	18.0	18	
									A2	7.5	18.0	18	
	24	137+600	P-RCT-13.5A	15	210.0	7.5+1.0	Straight	90	A1	6.5	16.0	16	Matandu Riv. (Flood-Opening Br.)
									P1~P14	-	20.0 *3	5x14=70	
									A2	6.5	16.0	16	
3	25	138+200	P-RCT-135A	22	308.0	7.5+1.0	R=1500	90	A1	7.0	17.0	16	Matandu Riv. (Flood-Opening Br.)
									P1~P10	-	21.5 *3	5x10=50	
									P11~P21	-	22.5 *3	5x11=55	
									A2	7.0	18.0	16	
	26	138+530	TR-40	2	81.7	7.5+1.5	Straight	90	A1	7.0	19.0	22	Matandu Riv. (Main Br.)
									P1	12.0	12.0	14	
									A2	6.5	17.0	22	
	27	138+800	P-RCT-13.5A	8	112.0	7.5+1.0	Straight	90	A1	6.0	13.0	14	Matandu Riv. (Flood-Opening Br.)
									P1~P4	-	17.0 *3	5x4=20	
									P5~P7	-	17.5 *3	5x3=15	
									A2	7.0	13.0	16	

* Refer to the notes at the end of this list.

Table 4-16 Summary of Bridge Planning - 3/5

Section	Br. No.	Station	General Planning						Substructure Design Data				Remarks
			Bridge Tyep *1	Span	Bridge Length(m)	Width (m)	Horizontal Alignment	Skew *2 Angle(deg)	Abutment or Pier	Body Height(m)	Pile Length (m)	Number of Piles	
3	28	144+450	P-RCT-9.5B	2	20.0	7.5	R=1000 A=500	90	A1	7.0	15.0	14	
									P1	-	18.0	4	
									A2	6.5	15.0	14	
4	29	160+805	P-RCT-11A	3	34.5	7.5+1.0	R=600 A=400		A1	5.0	4.0	10	Lingaula Riv.
									P1,P2	7.5	-	-	Footing Foundation
									A2	5.0	3.5	10	
	30	165+573	P-RCT-11B	2	23.0	7.5	Straight	90	A1	5.0	7.0	10	
									P1	7.5	5.0	66	Mbanga Riv.
									A2	5.0	7.0	10	
3	31	167+5	P-RCT-13.5B	2	28.0	7.5	R=1000	90	A1	6.5	-	-	Ukuri Riv.
									P1	9.0	-	-	Footing Foundation
									A2	7.5	-	-	
	32	169+650	P-RCT-13.5B	1	14.0	7.5	R=1000	90	A1	5.0	-	-	Namitanba Riv.
									A2	5.0	-	-	Footing Foundation
	33	179+962	TR-40	2	81.7	7.5+1.5	Straight	90	A1	8.0	17.0	24	Mavuji Riv.
									P1	11.5	18.0	14	(Main Br.)
									P2	8.0	21.0	12	
			P-RCT-13.5A	8	112.0	75+1.0	Straight	90	P3~P9	-	23.0 *3	5x7=35	(Flood-Opening Br.)
									A2	7.5	17.0	18	
	34	182+580	C-RCT-13.5B	1	14.0	7.5	Straight	90	A1	6.0	5.0	14	
									A2	6.0	5.0	14	
	35	186+400	C-RCT-9.5B	2	20.0	7.5	Straight	90	A1	5.5	5.0	12	
									P1	-	8.0	4	
									A2	5.5	5.0	12	
	36	194+610	C-RCT-11A	3	34.5	7.5+1.0	R=1200	90	A1	5.0	6.0	10	
									P1,P2	-	9.5 *3	4x2=8	
									A2	5.0	6.0	10	
	37	198+970	C-RCT-13.5B	1	14.0	7.5	R=2000	L70	A1	6.0	5.0	14	
									A2	5.5	5.0	14	
	38	217+963	P-RCT-13.5B	2	28.0	7.5	R=1500	90	A1	7.0	4.0	16	Mandawa Riv.
									P1	9.0	-	-	Footing Foundation
									A2	7.0	4.0	16	
	39	224+315	P-RCT-13.5B	2	28.0	7.5	Straight	90	A1	8.5	5.0	22	Near Mandawa
									P1	10.0	-	-	Footing Foundation
									A2	6.5	5.0	16	

* Refer to the notes at the end of this list.

Table 4-16 Summary of Bridge Planning - 4/5

Section	Br. No.	Station	General Planning: Bridge Type *1	Span	Bridge Length(m)	Width (m)	Horizontal Alignment	Skew *2 Angle(deg)	Substructure Design Data: Abutment or Pier	Body Height(m)	Pile Length (m)	Number of Piles	Remarks
3	40	225+247	C-RCT-13.5B	1	14.0	7.5	Straight	R65	A1	6.5	5.0	16	
									A2	6.0	5.0	14	
	41	225+425	C-RCT-13.5B	1	14.0	7.5	Straight	L70	A1	7.0	5.0	16	
									A2	7.0	5.0	16	
	42	231+397	P-RCT-11B	1	11.5	7.5	R=400 A=300	90	A1	5.0	5.0	10	Near Matandu
									A2	5.5	5.0	12	
	43	235+60	C-RCT-9.5B	2	20.0	7.5	R=2000 A=1000	R65	A1	6.0	5.0	12	Near
									P1	-	10.0	4	Kiranjerange
									A2	6.0	5.0	12	
4	44	238+750	C-RCT-13.5B	1	14.0	7.5	Straight	L60	A1	5.5	5.0	14	
									A2	5.0	5.0	12	
	45	239+500	P-RCT-11B	1	11.5	7.5	R=2000	90	A1	5.0	5.0	10	
									A2	5.0	5.0	10	
	46	242+706	TR-40	3	122.5	7.5+1.5	Straight	90	A1	4.0	-	-	Footing Foundation
									P1	10.5	15.0	10	Mbwemkuru Riv.
									P2	7.0	20.5	12	(Main Br.)
			P-RCT-13.5A	8	112.0	7.5+1.0	Straight	90	P3	7.0	21.5	12	
									P4~P10	-	28.5 *3	5x7=35	(Flood-Opening Br.)
									A2	6.5	27.0	16	
	47	243+700	P-RCT-13.5A	5	70.0	7.5+1.0	Straight	90	A1	5.5	28.0	14	Mbwemkuru Riv.
									P1~P4	-	31.5 *3	5x4=20	(Flood-Opening Br.)
									A2	5.0	28.5	12	
	48	253+580	P-RCT-11B	1	11.5	7.5	Straight	90	A1	8.5	10.0	22	
									A2	9.0	10.0	22	
	49	255+330	P-RCT-11B	1	11.5	7.5	R=800	90	A1	10.0	10.0	25	
									A2	9.5	10.0	25	
	50	257+85	C-RCT-11B	1	11.5	7.5	R=1200	R80	A1	8.0	10.0	16	
									A2	8.0	10.0	16	
	51	270+388	C-RCT-11A	3	34.5	7.5+1.0	R=2000	R60	A1	5.0	10.0	10	
									P1,P2	-	12.0 *3	4x2=8	
									A2	4.5	10.0	10	
	52	270+570	P-RCT-11B	1	11.5	7.5	R=2000	90	A1	5.5	10.0	12	
									A2	5.0	10.0	10	
	53	274+248	P-RCT-11B	1	11.5	7.5	R=800 A=400	90	A1	6.0	10.0	12	
									A2	6.0	10.0	12	

* Refer to the notes at the end of this list.

Table 4-16 Summary of Bridge Planning - 5/5

Section	Br. No.	Station	General Planning						Substructure Design Data				Remarks
			Bridge Type *1	Span	Bridge Length(m)	Width (m)	Horizontal Alignment	Skew *2 Angle(deg)	Abutment or Pier	Body Height(m)	Pile Length (m)	Number of Piles	
4	54	277+153	P-RCT-11A	6	69.0	7.5+1.0	R=800 A=300	90	A1	7.0	17.0	14	Nonguru Riv.
									P1~P5	-	22.5 *3	4x5=20	
									A2	7.0	17.0	14	
	55	285+23	C-RCT-11B	1	11.5	7.5	R=1500	R70	A1	6.5	10.0	14	
									A2	7.5	10.0	16	
	56	289+855	P-RCT-HA	3	34.5	7.5+1.0	R=1000 A=500	90	A1	7.0	10.0	14	Near Likonga
									P1,P2	-	17.0 *3	4x2=8	
									A2	8.5	10.0	22	
	57	292+50	P-RCT-11B	1	11.5	7.5	R=1500	90	A1	9.0	10.0	22	
									A2	9.0	10.0	22	
	58	295+995	C-RCT-11B	2	23.0	7.5	R=600	90	A1	9.0	10.0	22	Momburu Riv.
									P1	-	17.0	4	
									A2	8.5	10.0	22	
	59	298+650	C-RCT-11A	3	34.5	7.5+1.0	R=400	90	A1	5.5	11.5	12	Mbanja Riv.
									P1	-	15.5	4	
									P2	-	16.0	4	
									A2	6.5	11.5	14	
	60	302+368	C-RCT-11B	1	11.5	7.5	Straight	L45	A1	5.5	-	-	Footing Foundation
									A2	5.5	-	-	
	61	304+690	C-RCT-13.5B	2	28.0	7.5	R=1200	L60	A1	10.0	10.0	26	Mhungo Riv.
									P1	-	15.0	5	
									A2	10.0	10.0	26	
	62	306+450	P-RCT-13.5B	2	28.0	7.5	R=1200	90	A1	6.5	10.0	16	
									P1	-	14.0	5	
									A2	6.5	10.0	16	
	63	308+615	C-RCT-11B	2	23.0	7.5	R=600	90	A1	5.0	10.0	10	Likotwa Riv.
									P1	-	14.0	4	
									A2	4.5	10.0	10	
	64	13+125	P-RCT-9.5B	2	20.0	7.5	Straight	90	A1	5.5	10.0	12	
									P1	-	14.0	4	
									A2	5.0	10.0	10	

* Refer to the notes at the end of this list.

Notes

*1 Type of Superstructure

<u>C</u> - <u>RCT</u> - <u>13.5</u> <u>B</u> : (1) (2) (3) (4)	(1) Cast-in-place (2) R.C. bridge, T-beam (3) Span length (m) (4) Without footpath
<u>P</u> - <u>RCT</u> - <u>11</u> <u>A</u> : (1) (2) (3) (4)	(1) Precast (2) R.C. bridge, T-beam (3) Span length (m) (4) With footpath
<u>TR</u> - <u>40</u> : (1) (2)	(1) Truss bridge (2) Span length (m)

*2 Skew Angle

 L  R

*3 Average pile length for pier of pile bent type.

CHAPTER 5

PROJECT COST AND CONSTRUCTION PLAN

CHAPTER 5 PROJECT COST AND CONSTRUCTION PLAN

5.1 Construction Costs

Construction costs according to both Plan A (stage construction) and Plan B (non-stage construction) were estimated for the total road length of 329.8 km comprising 299.45 km between Kibiti and Linid, except 12.0 km to be covered by the Rufiji Bridge Project, and 30.35 km feeder road between Nangurukuru and Kilwa Masoko.

Total construction cost for Plan A amounts to 600,202,000 shs. which can be broken down to 302,984,000 shs. (50.5 %) in local currency and 297,218,000 shs. (49.5 %) in foreign currency. As shown in Table 5-1, the cost for the first stage amounts to 417,709,000 shs. or 70 % of the total.

On the other hand, total construction cost for Plan B amounts to 567,651,000 shs. consisting of 283,851,000 shs. (50 %) in local currency and 283,800,000 shs. in foreign currency.

Tables 5-1 and 5-2 show the total construction cost per section and Tables 5-3, 5-4 and 5-5 show the direct construction cost.

The cost was estimated on the basis of the following conditions:

1) Each cost is quoted as of October, 1975.
2) Each cost does not allow for any price fluctuation after 1975.
3) The conversion rate is set at 8.1 Tanzanian Shillings per US Dollar.
4) The costs of major materials, machinery and facilities are accounted for as follows:

   Local Currency - Aggregate; Cement; Lumber; Labour cost
   Foreign Currency - Steel materials; Construction equipment; Plant; Fuel; Oil; Asphalt; Engineering fee

5) The prime costs of construction machinery and plants are to be depreciated over the construction period so that there is no residual value at the time of completion.

6) The total construction cost comprises: direct construction costs required for earthwork, pavement, minor structures, bridge construction work; indirect cost; supervising expenses; and contingency.

7) Total construction cost is economic cost excluding tax and duties payable.

Plan A: To compelte entire route as two-lane engineered gravel road by 1983; to start pavement work ten years later, i.e. from 1993, and complete it by 1996.

Plan B: To start construction in 1978 and to make entire route paved two-lane road by 1983.

Table 5-1 Construction Cost (Plan A)

(1,000 shs.)

Item			Section 1	Section 2	Section 3	Section 4	Section 5	Total	Currency	
									Local	Foreign
First-Stage Construction	Direct Construction Cost	Preparation	534	2,804	1,817	1,935	424	7,514	6,012	1,502
		Cleaning & grubbing	454	1,992	1,466	1,332	401	5,645	1,524	4,121
		Earthwork	7,665	34,475	16,659	21,137	2,426	82,362	29,650	52,712
		Slope protection work	872	2,484	2,520	2,336	612	8,824	8,824	-
		Slope protection by block	106	1,194	626	1,163	215	3,304	1,487	1,817
		Drainage work	452	2,300	2,485	5,309	262	10,808	6,485	4,323
		Pipe culvert	802	4,748	4,281	2,999	1,481	14,311	2,862	11,449
		Box culvert	-	4,051	3,184	1,867	1,077	10,179	3,563	6,616
		Bridge	1,548	42,618	18,352	29,304	721	92,543	32,389	60,154
		Pavement	14,810	46,317	41,292	31,286	11,739	145,444	87,266	58,178
		Approach road	-	-	-	-	2,286	2,286	1,256	1,030
		Subtotal	27,243	142,983	92,682	98,668	21,644	383,220	181,318	201,902
	Contingency		1,363	7,148	4,634	4,933	1,082	19,160	6,706	12,454
	Supervise		1,090	5,719	3,707	3,947	866	15,329	7,665	7,664
	Total		29,696	155,850	101,023	107,548	23,592	417,709	195,689	222,020
Second-Stage Construction	Direct Construction Cost	Preparation	336	969	868	763	347	3,283	2,626	657
		Pavement	16,789	48,445	43,393	38,162	15,440	162,229	97,337	64,892
		Approach road	-	-	-	-	1,913	1,913	1,053	860
		Subtotal	17,125	49,414	44,261	38,925	17,700	167,425	101,016	66,409
	Contingency		856	2,471	2,213	1,946	885	8,371	2,930	5,441
	Supervise		685	1,977	1,770	1,557	708	6,697	3,349	3,348
	Total		18,666	53,862	48,244	42,428	19,293	182,493	107,295	75,198
Grand total			48,362	209,712	149,267	149,976	42,885	600,202	302,984	297,218

Table 5-2 Construction Cost (Plan B)

(1,000 shs.)

Item		Section 1	Section 2	Section 3	Section 4	Section 5	Total	Currency	
								Local	Foreign
Direct Construction Cost	Preparation	822	3,607	2,504	2,544	734	10,211	8,169	2,042
	Clearing & grubbing	454	1,992	1,466	1,332	401	5,645	1,524	4,121
	Earthwork	7,665	34,475	16,659	21,137	2,426	82,362	29,650	52,712
	Slope protection work	872	2,484	2,520	2,336	612	8,824	8,824	-
	Slope protection by block	106	1,194	626	1,163	215	3,304	1,487	1,817
	Drainage work	452	2,300	2,485	5,309	262	10,808	6,485	4,323
	Pipe culvert	802	4,748	4,281	2,999	1,481	14,311	2,862	11,449
	Box culvert	-	4,051	3,184	1,867	1,077	10,179	3,563	6,616
	Bridge	1,548	42,618	18,352	29,304	721	92,543	32,389	60,154
	Pavement	29,184	86,513	75,644	61,759	25,748	278,848	167,309	111,539
	Approach road	-	-	-	-	3,749	3,749	2,062	1,687
	Total	41,905	183,982	127,721	129,750	37,426	520,784	264,324	256,460
Contingency		2,095	9,196	6,386	6,488	1,871	26,036	9,111	16,925
Supervise		1,676	7,359	5,109	5,190	1,497	20,831	10,416	10,415
Grand total		45,676	200,537	139,216	141,428	40,794	567,651	283,851	283,800

Table 5-3 Direct Construction Cost (Plan A)

(1,000 shs.)

Stage	Group	Item	Unit	Rate (Unit=shs.)	Section 1 Quantity	Section 1 Amount	Section 2 Quantity	Section 2 Amount	Section 3 Quantity	Section 3 Amount	Section 4 Quantity	Section 4 Amount	Section 5 Quantity	Section 5 Amount	Total Quantity	Total Amount	Remarks
First Stage Construction		Preparation				534		2,804		1,817		1,935		424		7,514	
		Clearing & grubbing	m^2	1.2	378,000	454	1,660,000	1,992	1,222,000	1,466	1,110,000	1,332	334,000	401	4,704,000	5,645	
	Excavation	Road excavation	m^3	21.6	130,531	2,819	215,658	4,658	472,078	10,197	761,255	16,443	79,155	1,710	1,658,677	35,827	
		Borrow " (I)	"	16.2	138,310	2,241	657,018	10,644	-	-	-	-	-	-	795,328	12,885	
		" " (II)	"	23.5	110,844	2,605	706,359	16,599	43,535	1,023	-	-	18,205	428	878,943	20,655	
		Waste "	"	9.5	-	-	270,978	2,574	572,492	5,439	494,062	4,694	30,330	288	1,367,862	12,995	
		Total	"		379,685	7,665	1,850,013	34,475	1,088,105	16,659	1,255,317	21,137	127,690	2,426	4,700,810	82,362	
		Slope protection	m^2		218,000	872	621,000	2,484	630,000	2,520	584,000	2,336	153,000	612	2,206,000	8,824	
		Masonry work	"	176.0	600	106	6,784	1,194	3,559	626	6,609	1,163	1,222	215	18,774	3,304	
	Box Culvert	Type A(2.0x2.0-2)	m^3	1996.0	-	-	395	788	98	196	-	-	-	-	493	984	Concrete volume
		" B(2.0x2.0-3)	"	1996.0	-	-	769	1,535	713	1,423	-	-	-	-	1,482	2,958	"
		" C(2.5x2.0-3)	"	1996.0	-	-	481	960	474	946	566	1,130	385	768	1,906	3,804	"
		" D(3.0x2.5-3)	"	1996.0	-	-	385	768	310	619	369	737	155	309	1,219	2,433	"
		Total	"		-	-	2,030	4,051	1,595	3,184	935	1,867	540	1,077	5,100	10,179	"
	Pipe Culvert	Corrugated pipe	m	970.0	126	122	229	222	802	778	996	966	302	293	2,455	2,381	ø600
		"	"	1350.0	241	325	597	806	991	1,338	466	629	471	636	2,766	3,734	ø900
		"	"	2400.0	148	355	1,550	3,720	902	2,165	585	1,404	230	552	3,415	8,196	ø1200
		Total	"		515	802	2,376	4,748	2,695	4,281	2,047	2,999	1,003	1,481	8,636	14,311	
	Side Ditch	Concrete ditch	"	198.0	1,620	321	11,135	2,205	11,815	2,339	24,200	4,792	660	131	49,430	9,788	
		Corrugated pipe	"	970.0	135	131	98	95	150	146	533	517	135	131	1,051	1,020	ø600
		Total	"			452		2,300		2,485		5,309		262		10,808	
	Bridge	Main bridge	"	-	-	-	82	5,073	82	5,016	122	6,668	-	-	286	16,757	
		Flood-opening br.	"	-	-	-	630	17,632	112	3,102	182	5,853	-	-	924	26,587	
		Small bridge	"	-	34	1,548	475	19,913	297	10,234	393	16,783	20	721	1,219	49,199	
		Total	"		34	1,548	1,187	42,618	491	18,352	697	29,304	20	721	2,429	92,543	
		Approach road	"	610.0	-	-	-	-	-	-	-	-	3,750	2,286	3,750	2,286	
		Total (1)				12,433		96,666		51,390		67,382		9,905		237,776	
	Pavement	Surface	m^2	23.0	277,561	6,384	766,559	17,631	663,645	15,264	588,075	13,526	235,657	5,420	2,531,497	58,225	Soil Aggregate 10cm
		Base	"	17.3	393,755	6,812	1,086,315	18,793	936,473	16,668	822,739	14,233	333,962	5,778	3,573,244	62,284	Soil Cement 10cm
		Subbase	m^3	27.6	58,482	1,614	358,447	9,893	339,136	9,360	127,779	3,527	19,584	541	903,428	24,935	Sandy Soil
		Total (2)				14,810		46,317		41,292		31,286		11,739		145,444	
		Subtotal {(1)+(2)}				27,243		142,983		92,682		98,668		21,644		383,220	
Second Stage Construction		Preparation				336		969		868		763		347		3,283	
	Pavement	Approach road	m	510.0	-	-	-	-	-	-	-	-	3,750	1,913	3,750	1,913	
		Surface	m^2	20.3	237,820	4,828	656,599	13,329	568,495	11,540	505,574	10,263	201,618	4,093	2,170,106	44,053	
		Base: Soil cement	"	30.8	351,712	10,833	448,028	13,799	-	-	-	-	-	-	799,740	24,632	t=15cm
		Base: Soil aggregate cement	"	34.9	-	-	521,901	18,215	836,681	29,200	734,375	25,630	297,813	10,394	2,390,770	83,439	"
		Shoulder	"	10.5	107,418	1,128	295,420	3,102	252,686	2,653	216,117	2,269	90,750	953	962,391	10,105	
		Total				16,789		48,445		43,393		38,162		17,353		164,142	
		Subtotal				17,125		49,414		44,261		38,925		17,700		167,425	
Grand total						44,368		192,397		136,943		137,593		39,344		550,645	

N.B.For direct construction cost of bridges, see Tables 5-5 itemized to show each breakdown.

Table 5-4 Direct Construction Cost (Plan B)

(1,000 shs.)

Item		Unit	Rate (Unit=shs.)	Section 1 Quantity	Section 1 Amount	Section 2 Quantity	Section 2 Amount	Section 3 Quantity	Section 3 Amount	Section 4 Quantity	Section 4 Amount	Section 5 Quantity	Section 5 Amount	Total Quantity	Total Amount	Remarks
First-Stage Construction	Preparation				822		3,607		2,504		2,544		734		10,211	
	Clearing & grubbing	m^2	1.2	378,000	454	1,660,000	1,992	1,222,000	1,466	1,110,000	1,332	334,000	401	4,704,000	5,645	
Excavation	Road excavation	m^3	21.6	130,531	2,819	215,658	4,658	472,078	10,197	761,255	16,443	79,155	1,710	1,658,677	35,827	
	Borrow " (I)	"	16.2	138,310	2,241	657,018	10,644	-	-	-	-	-	-	795,328	12,885	
	" " (II)	"	23.5	110,844	2,605	706,359	16,599	43,535	1,023	-	-	18,205	428	878,943	20,655	
	Waste "	"	9.5	-	-	270,978	2,574	572,492	5,439	494,062	4,694	30,330	288	1,367,862	12,995	
	Total	"		379,685	7,665	1,850,013	34,475	1,088,105	16,659	1,255,317	21,137	127,690	2,426	4,700,810	82,362	
	Slope protection	m^2		218,000	872	621,000	2,484	630,000	2,520	584,000	2,336	153,000	612	2,206,000	8,824	
	Masonry work	"	176.0	600	106	6,784	1,194	3,559	626	6,609	1,163	1,222	215	18,774	3,304	
Box Culvert	Type A(2.0x2.0-2)	m^3	1996.0	-	-	395	788	98	196	-	-	-	-	493	984	Concrete Volume
	" B(2.0x2.0-3)	"	1996.0	-	-	769	1,535	713	1,423	-	-	-	-	1,482	2,958	"
	" C(2.5x2.0-3)	"	1996.0	-	-	481	960	474	946	566	1,130	385	768	1,906	3,804	"
	" D(3.0x2.5-3)	"	1996.0	-	-	385	768	310	619	369	737	155	309	1,219	2,433	"
	Total	"		-	-	2,030	4,051	1,595	3,184	935	1,867	540	1,077	5,100	10,179	"
Pipe Culvert	Corrugated pipe	m	970.0	126	122	229	222	802	778	996	966	302	293	2,455	2,381	ϕ600
	"	"	1350.0	241	325	597	806	991	1,338	466	629	471	636	2,766	3,734	ϕ900
	"	"	2400.0	148	355	1,550	3,720	902	2,165	585	1,404	230	552	3,415	8,196	ϕ1200
	Total	"		515	802	2,376	4,748	2,695	4,281	2,047	2,999	1,003	1,481	8,636	14,311	
Side Ditch	Concrete ditch	"	198.0	1,620	321	11,135	2,205	11,815	2,339	24,200	4,792	660	131	49,430	9,788	
	Corrugated pipe	"	970.0	135	131	98	95	150	146	533	517	135	131	1,051	1,020	ϕ600
	Total	"			452		2,300		2,485		5,309		262		10,808	
Bridge	Main bridge	"	-	-	-	82	5,073	82	5,016	122	6,668	-	-	286	16,757	
	Flood-opening br.	"	-	-	-	630	17,632	112	3,102	182	5,853	-	-	924	26,587	
	Small bridge	"	-	34	1,548	475	19,913	297	10,234	393	16,783	20	721	1,219	49,199	
	Total	"		34	1,548	1,187	42,618	491	18,352	697	29,304	20	721	2,429	92,543	
	Approach road	"	610.0	-	-	-	-	-	-	-	-	3,750	2,286	3,750	2,286	
	Subtotal (1)				12,721		97,469		52,077		67,991		10,215		240,474	
Pavement	Approach road	m	390.0	-	-	-	-	-	-	-	-	3,750	1,463	3,750	1,463	
	Surface	m^2	20.3	237,820	4,828	656,599	13,329	568,495	11,540	505,574	10,263	201,618	4,093	2,170,106	44,053	
	Base Soil cement	"	30.8	351,712	10,833	448,028	13,799	-	-	-	-	-	-	799,740	24,632	t=15cm
	Base Soil aggregate cement	"	34.9	-	-	521,901	18,215	836,681	29,200	734,375	25,630	319,742	11,159	2,412,699	84,204	"
	Upper subbase	"	26.0	367,976	9,567	1,014,785	26,384	876,114	22,778	770,014	20,020	341,154	8,870	3,370,043	87,619	Soil Cement 15cm
	Lower subbase	m^3	27.6	102,479	2,828	423,344	11,684	343,214	9,473	129,588	3,577	24,401	673	1,024,382	28,235	Sandy Soil
	Shoulder	m^2	10.5	107,418	1,128	295,420	3,102	252,686	2,653	216,117	2,269	90,750	953	962,391	10,105	
	Subtotal (2)				29,184		86,513		75,644		61,759		27,211		280,311	
Grand total {(1)+(2)}					41,905		183,982		127,721		129,750		37,426		520,785	

N.B. For direct construction cost of bridges, see Tables 5-5 itemized to show each breakdown.

Table 5-5 Direct Construction Cost for Bridges - 1/11

Section 1 Medium to Small Bridges (2 bridges, total 34.0 m)

Description			Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		551	m^3	115	63	
	Concrete	Class A	372	"	970	360	
		Class Y	21	"	635	13	
	Reinforcement		13	t	5,100	66	
	H-Steel Pile	Materials	118	"	3,750	442	
		Driving	800	m	135	108	
	Steel Pipe Pile	Materials	11	t	4,200	46	
		Driving	60	m	135	8	
		Field Painting	25	m^2	95	2	
		Hume Pipe	-	m	-	-	
	Cobblestones		32	m^3	180	6	
	Stone Masonry		250	m^2	180	45	
	Total					1,159	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	-	"	-	-	Excluding reinforcement
		Erection	-	t	-	-	
		Cast-in-Place Concrete	-	m^3	-	-	
		Reinforcement	-	t	-	-	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	123	m^3	1,410	173	
		Reinforcement	25	t	6,000	150	
			-		-	-	
	Guardrail		116	m	400	46	
	Drainage		10	ea.	315	3	
	Expansion Joint		42	m	135	6	
	Road Mark		4	ea.	435	2	
	Pavement		12	m^3	710	9	Bituminuous
	Total					389	
Grand Total						1,548	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 2/11

Section 2 Matandu River Bridge (Bridge length: 82.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		709	m^3	130	92	
	Concrete	Class A	410	"	1,000	410	
		Class Y	15	"	650	10	
	Reinforcement		15	t	5,600	84	
	H-Steel Pile	Materials	116	"	4,300	499	
		Driving	790	m	135	107	
	Steel Pipe Pile	Materials	24	t	4,700	113	
		Driving	170	m	135	23	
		Field Painting	-	m^2	-	-	
		Hume Pipe	-	m	-	-	
	Cobblestones		31	m^3	180	6	
	Stone Masonry		750	m^2	180	135	
	Total					1,479	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	210	t	9,260	1,945	
		Transportation	210	"	1,900	399	
		Erection	210	"	1,450	305	
		Field Painting	3,150	m^2	65	205	
		R.C. Floor Slab	220	m^3	2,600	572	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	-	"	-	-	Excluding reinforcement
		Erection	-	t	-	-	
		Cast-in-Place Concrete	-	m^3	-	-	
		Reinforcement	-	t	-	-	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		351	m	400	140	
	Drainage		10	ea.	315	3	
	Expansion Joint		-	m	-	-	
	Road Mark		2	ea.	435	1	
	Pavement		34	m^3	710	24	Bituminous
	Total					3,594	
Grand Total						5,073	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 3/11

Section 2 Flood-Opening Bridges (3 bridges, total 630.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		1,071	m^3	115	123	
	Concrete	Class A	1,052	"	1,050	1,105	
		Class Y	198	"	650	129	
	Reinforcement		36	t	5,600	202	
	H-Steel Pile	Materials	214	"	4,300	921	
		Driving	1,460	m	135	197	
	Steel Pipe Pile	Materials	622	t	4,700	2,923	
		Driving	3,820	m	135	516	
		Field Painting	650	m^2	95	62	
		Hume Pipe	-	m	-	-	
	Cobblestones		50	m^3	180	9	
	Stone Masonry		1,850	m^2	180	333	
	Total					6,520	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	1,544	"	1,350	2,085	Excluding reinforcement
		Erection	3,865	t	440	1,701	
		Cast-in-Place Concrete	1,661	m^3	1,500	2,492	
		Reinforcement	657	t	6,150	4,041	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		1,332	m	400	533	
	Drainage		96	ea.	315	31	
	Expansion Joint		429	m	135	58	
	Road Mark		6	ea.	435	3	
	Pavement		235	m^3	710	168	Bituminous
	Total					11,112	
Grand Total						17,632	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 4/11

Section 2 Medium to Small Bridges (22 bridges, total 475.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		6,277	m^3	153	963	
	Concrete	Class A	3,968	"	1,050	4,167	
		Class Y	230	"	650	150	
	Reinforcement		146	t	5,600	818	
	H-Steel Pile	Materials	886	"	4,300	3,810	
		Driving	6,030	m	135	814	
	Steel Pipe Pile	Materials	142	t	4,700	668	
		Driving	790	m	135	107	
		Field Painting	260	m^2	95	25	
		Hume Pipe	72	m	195	15	
	Cobblestones		342	m^3	180	62	
	Stone Masonry		3,960	m^2	180	713	
	Total					12,312	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	1,007	"	1,350	1,360	Excluding reinforcement
		Erection	2,520	t	440	1,109	
		Cast-in-Place Concrete	1,115	m^3	1,500	1,673	
		Reinforcement	426	t	6,150	2,620	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
	Guardrail		1,479	m	400	592	
	Drainage		120	ea.	315	38	
	Expansion Joint		492	m	135	67	
	Road Mark		44	ea.	435	19	
	Pavement		173	m^3	710	123	Bituminous
	Total					7,601	
Grand Total						19,913	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 5/11

Section 3 Mavuji River Bridge (Bridge length: 82.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		984	m^3	115	112	
	Concrete	Class A	393	"	1,000	393	
		Class Y	14	"	650	9	
	Reinforcement		15	t	5,600	84	
	H-Steel Pile	Materials	60	"	4,300	258	
		Driving	405	m	135	54	
	Steel Pipe Pile	Materials	73	t	4,700	342	
		Driving	500	m	135	67	
		Field Painting	-	m^2	-	-	
		Hume Pipe	-	m	-	-	
	Cobblestones		28	m^3	180	5	
	Stone Masonry		550	m^2	180	98	
	Total					1,422	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	210	t	9,260	1,945	
		Transportation	210	"	1,900	399	
		Erection	210	"	1,450	305	
		Field Painting	3,150	m^2	65	205	
		R.C. Floor Slab	220	m^3	2,600	572	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	-	"	-	-	Excluding reinforcement
		Erection	-	t	-	-	
		Cast-in-Place Concrete	-	m^3	-	-	
		Reinforcement	-	t	-	-	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		351	m	400	140	
	Drainage		10	ea.	315	3	
	Expansion Joint		-	m	-	-	
	Road Mark		1	ea.	435	1	
	Pavement		34	m^3	710	24	Bituminous
	Total					3,594	
Grand Total						5,016	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 6/11

Section 3 Flood-Opening Bridge (1 bridge, 112.0 m)

Description			Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		181	m^3	115	21	
	Concrete	Class A	188	"	1,050	197	
		Class Y	33	"	650	21	
	Reinforcement		6	t	5,600	34	
	H-Steel Pile	Materials	45	"	4,300	195	
		Driving	310	m	135	42	
	Steel Pipe Pile	Materials	116	t	4,700	546	
		Driving	700	m	135	95	
		Field Painting	160	m^2	95	15	
		Hume Pipe	-	m	-	-	
	Cobblestones		9	m^3	180	2	
	Stone Masonry		550	m^2	180	99	
	Total					1,267	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	274	"	1,200	329	Excluding reinforcement
		Erection	685	t	370	254	
		Cast-in-Place Concrete	295	m^3	1,400	413	
		Reinforcement	117	t	6,000	702	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		224	m	400	90	
	Drainage		18	ea.	315	6	
	Expansion Joint		72	m	135	10	
	Road Mark		1	ea.	435	1	
	Pavement		42	m^3	710	30	Bituminous
	Total					1,835	
Grand Total						3,102	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 7/11

Section 3 Medium to Small Bridges (14 bridges, total 297.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		4,623	m^3	165	762	
	Concrete	Class A	2,776	"	1,000	2,776	
		Class Y	139	"	650	91	
	Reinforcement		103	t	5,600	577	
	H-Steel Pile	Materials	237	"	4,300	1,020	
		Driving	1,612	m	135	219	
	Steel Pipe Pile	Materials	27	t	4,700	127	
		Driving	130	m	135	19	
		Field Painting	44	m^2	95	5	
		Hume Pipe	-	m	-	-	
	Cobblestones		237	m^3	180	43	
	Stone Masonry		2,300	m^2	180	414	
	Total					6,053	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	362	"	1,250	453	Excluding reinforcement
		Erection	905	t	400	362	
		Cast-in-Place Concrete	390	m^3	1,400	546	
		Reinforcement	152	t	6,050	920	
	R.C. Bridge (Cast-in-Place)	Concrete	499	m^3	1,540	768	
		Reinforcement	99	t	6,100	604	
			-		-	-	
	Guardrail		931	m	400	372	
	Drainage		76	ea.	315	24	
	Expansion Joint		318	m	135	43	
	Road Mark		28	ea.	435	12	
	Pavement		108	m^3	710	77	Bituminous
	Total					4,181	
Grand Total						10,234	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 8/11

Section 4 Mbwemkuru River Bridge (Bridge length: 122.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		1,347	m^3	155	209	
	Concrete	Class A	400	"	1,000	400	
		Class Y	17	"	650	11	
	Reinforcement		16	t	5,600	90	
	H-Steel Pile	Materials	-	"	-	-	
		Driving	-	m	-	-	
	Steel Pipe Pile	Materials	94	t	4,700	442	
		Driving	660	m	135	89	
		Field Painting	-	m^2	-	-	
		Hume Pipe	-	m	-	-	
	Cobblestones		34	m^3	180	6	
	Stone Masonry		150	m^2	180	27	
	Total					1,274	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	315	t	9,260	2,917	
		Transportation	315	"	1,900	599	
		Erection	315	"	1,480	466	
		Field Painting	4,760	m^2	65	307	
		R.C. Floor Slab	330	m^3	2,600	858	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	-	"	-	-	Excluding reinforcement
		Erection	-	t	-	-	
		Cast-in-Place Concrete	-	m^3	-	-	
		Reinforcement	-	t	-	-	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		514	m	400	206	
	Drainage		14	ea.	315	4	
	Expansion Joint		-	m	-	-	
	Road Mark		1	ea.	435	1	
	Pavement		51	m^3	710	36	Bituminous
	Total					5,394	
Grand Total						6,668	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 9/11

Section 4 Flood-Opening Bridges (2 bridges, total 182.0 m)

	Description		Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		456	m³	115	52	
	Concrete	Class A	356	"	1,050	373	
		Class Y	57	"	650	37	
	Reinforcement		12	t	5,600	67	
	H-Steel Pile	Materials	172	"	4,300	740	
		Driving	1,170	m	135	158	
	Steel Pipe Pile	Materials	235	t	4,700	1,105	
		Driving	1,480	m	135	200	
		Field Painting	200	m²	95	19	
		Hume Pipe	-	m	-	-	
	Cobblestones		23	m³	180	4	
	Stone Masonry		600	m²	180	108	
	Total					2,863	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m²	-	-	
		R.C. Floor Slab	-	m³	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	446	"	1,200	535	Excluding reinforcement
		Erection	1,115	t	370	413	
		Cast-in-Place Concrete	480	m³	1,400	672	
		Reinforcement	190	t	6,000	1,140	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m³	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		388	m	400	155	
	Drainage		30	ea.	315	9	
	Expansion Joint		127	m	135	17	
	Road Mark		3	ea.	435	1	
	Pavement		68	m³	710	48	Bituminous
	Total					2,990	
Grand Total						5,853	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 10/11

Section 4 Medium to Small Bridges (18 bridges, total 393.0 m)

Description			Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		5,153	m^3	125	643	
	Concrete	Class A	4,015	"	1,000	4,015	
		Class Y	220	"	650	143	
	Reinforcement		144	t	5,600	806	
	H-Steel Pile	Materials	809	"	4,300	3,479	
		Driving	5,503	m	135	743	
	Steel Pipe Pile	Materials	156	t	4,700	733	
		Driving	855	m	135	115	
		Field Painting	80	m^2	95	8	
		Hume Pipe	269	m	195	52	
	Cobblestones		308	m^3	180	55	
	Stone Masonry		4,180	m^2	180	752	
	Total					11,544	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	371	"	1,250	464	Excluding reinforcement
		Erection	927	t	400	371	
		Cast-in-Place Concrete	492	m^3	1,400	689	
		Reinforcement	174	t	6,050	1,053	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	735	m^3	1,500	1,103	
		Reinforcement	141	t	6,100	860	
			-		-	-	
	Guardrail		1,216	m	400	486	
	Drainage		112	ea.	315	35	
	Expansion Joint		448	m	135	60	
	Road Mark		36	ea.	435	16	
	Pavement		144	m^3	710	102	Bituminous
	Total					5,239	
Grand Total						16,783	

N.B. All items except truss bridge include transportation cost.

Table 5-5 Direct Construction Cost for Bridges - 11/11

Section 5 Medium to Small Bridge (1 bridge, 20.0 m)

Description			Quantity		Unit Cost(Shs.)	Amount (1,000 shs.)	Remarks
SUBSTRUCTURE	Excavation		260	m^3	115	30	
	Concrete	Class A	150	"	1,000	150	
		Class Y	11	"	650	7	
	Reinforcement		5	t	5,600	28	
	H-Steel Pile	Materials	32	"	4,300	138	
		Driving	220	m	135	30	
	Steel Pipe Pile	Materials	8	t	4,700	38	
		Driving	45	m	135	6	
		Field Painting	20	m^2	95	2	
		Hume Pipe	-	m	-	-	
	Cobblestones		14	m^3	180	3	
	Stone Masonry		150	m^2	180	27	
	Total					459	
SUPERSTRUCTURE	Truss Bridge	Truss Girder	-	t	-	-	
		Transportation	-	"	-	-	
		Erection	-	"	-	-	
		Field Painting	-	m^2	-	-	
		R.C. Floor Slab	-	m^3	-	-	Including reinforcement
	R.C. Bridge (Precast)	R.C. Girder	31	"	1,200	37	Excluding reinforcement
		Erection	80	t	440	35	
		Cast-in-Place Concrete	45	m^3	1,400	63	
		Reinforcement	15	t	6,000	90	
	R.C. Bridge (Cast-in-Place)	Concrete (Class A)	-	m^3	-	-	
		Reinforcement	-	t	-	-	
			-		-	-	
	Guardrail		64	m	400	26	
	Drainage		6	ea.	315	2	
	Expansion Joint		24	m	135	3	
	Road Mark		2	ea.	435	1	
	Pavement		7	m^3	710	5	Bituminous
	Total					262	
Grand Total						721	

N.B. All items except truss bridge include transportation cost.

5.2 Construction Plan

The construction of the Southern Coastal Link Road will be obstructed by heavy rainfalls in the rainy season and firece heat in the dry season both characteristic of the region. Work plans should therefore be established taking account of such climatic condtions.

Key site bases for constructing the road and bridges are planned to be located at Kibiti, Lindi and Kilwa Masoko for their well-developed living environment. Temporary bases are also to be located at Mohoro, Nangurukuru and Kiranjerange.

Aggregate crushing plants will be installed at Nangurukuru and Mpingo in the first stage of Plan A, and at Mpingo and Mitole in the second stage. Required amount of coarse aggregate will be 335,000 m^3 for the first stage and 320,000 m^3 for the second stage.

As shown in Table 5-6, it is planned to complete the all-weather road in five years starting in 1978. Four road construction teams and six bridge construction teams will proceed with the work in the sequence shown in Fig. 5-1 from the initial year.

In Plan A, the road is to be put into use in the form of an engineered gravel road, and ten years later completed into a paved road in a three-year second stage.

Table 5-7 shows the construction schedule of Plan A in the case that the construction work in all sections is started simultaneously.

The construction except for preparatory work is to be suspended in principle during the rainy season of about four months a year.

Table 5-6 <u>Construction Schedule</u>

	First Period															Second Period			
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Plan A	—	—	—	—	—											Pavement			
Plan B	—	—	—	—	—														

Tables 5-8 and 5-9 show capital outlay by year estimated on the basis of the above construction schedule.

FIG. 5-1

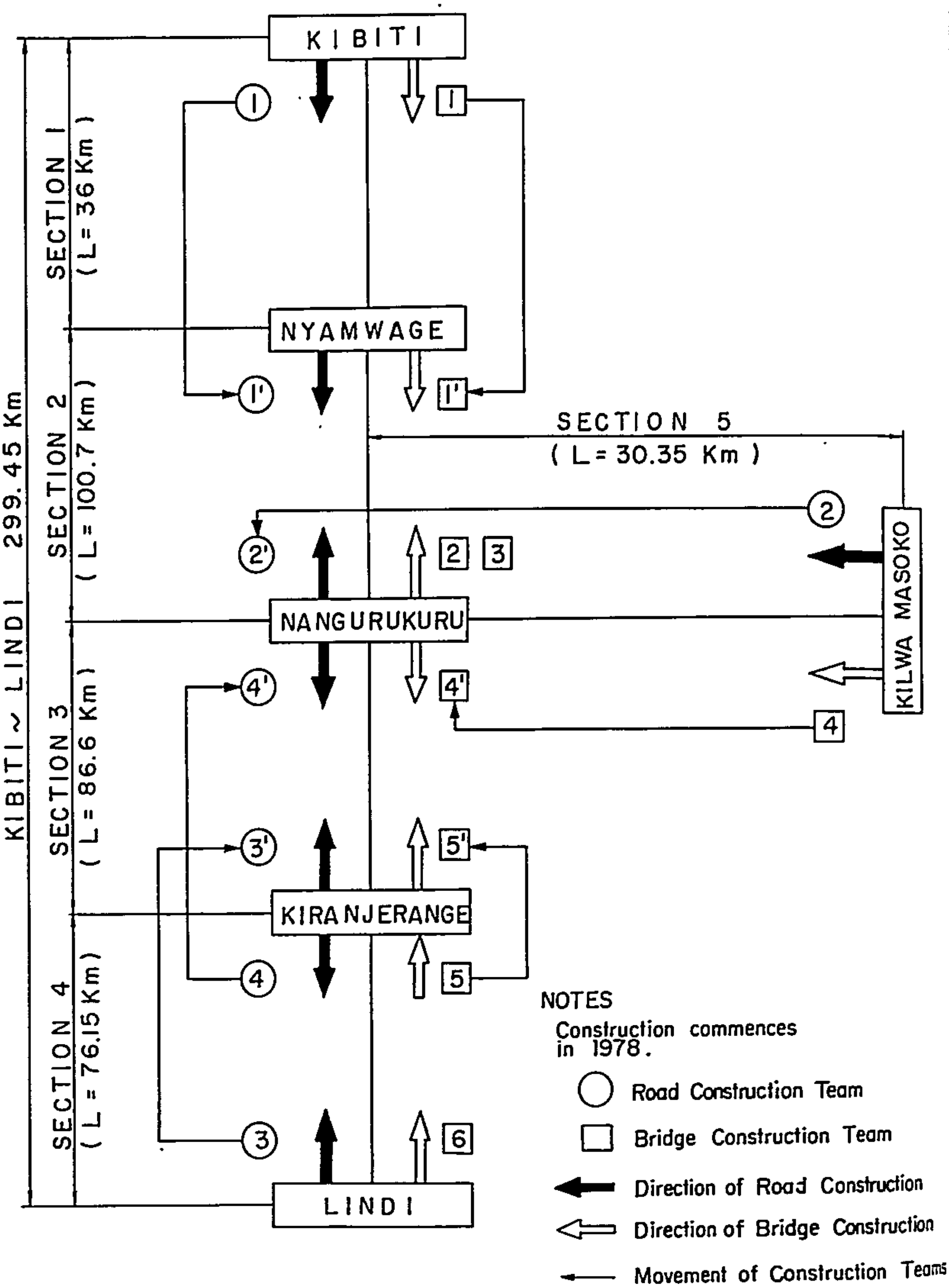


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
5-1	CONSTRUCTION SEQUENCE

W : Wet Season
D : Dry Season

Table 5-7 Work Schedule (Plan A)

Year			1977		1978		1979		1980		1981		1982		1983				1993		1994		1995	
Season			W	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D	W	D
Work site survey					■	■																		
Preparation					■	■																		
SECTION I Kibiti ∿ Nyamwage	Road	Pipe culvert				■																		
		Earthwork						■																
		Slope protection & drain								■														
		Pavement										■								■				
	Bridge	Small bridge				■		■																
SECTION II Nyamwage ∿ Nangurukuru	Road	Pipe & box culverts						■																
		Earthwork								■														
		Slope protection & drain										■												
		Pavement												■						■		■		
	Bridge	Main bridge				■		■		■														
		Flood-opening bridge				■		■		■														
		Small bridge						■		■		■		■										
SECTION III Nangurukuru ∿ Kiranjerange	Road	Pipe & box culverts						■																
		Earthwork								■				■										
		Slope protection & drain										■												
		Pavement												■										■
	Bridge	Main bridge						■		■		■												
		Flood-opening bridge								■		■		■										
		Small bridge								■		■		■										
SECTION IV Kiranjerange∿Lindi	Road	Pipe & box culverts				■																		
		Earthwork						■																
		Slope protection & drain								■				■										
		Pavement										■		■								■		■
	Bridge	Main bridge				■		■		■														
		Flood-opening bridge								■		■		■										
		Small bridge				■		■		■														
SECTION V Nangurukuru ∿ Kilwa Masoko	Road	Pipe & box culverts				■																		
		Earthwork						■																
		Slope protection & drain								■														
		Pavement										■										■		
	Bridge	Small bridge				■		■																

(1,000 shs.)

No.	Item / Section / Year	Road						Bridge						Total
		1	2	3	4	5	Total	1	2	3	4	5	Total	
1	1978	1,916	-	-	8,256	3,684	13,856	1,501	19,566	8,116	11,472	480	41,135	54,991
2	1979	8,343	13,935	11,347	23,010	2,633	59,268	220	9,226	4,503	6,504	321	20,774	80,042
3	1980	1,554	37,533	18,126	9,601	3,679	70,493	-	7,938	2,379	5,225	-	15,542	86,035
4	1981	16,162	6,516	6,138	34,101	12,795	75,712	-	6,326	3,113	5,726	-	15,165	90,877
5	1982	-	50,485	45,008	-	-	95,493	-	4,325	2,293	3,653	-	10,271	105,764
Total		27,975	108,469	80,619	74,968	22,791	314,822	1,721	47,381	20,404	32,580	801	102,887	417,709
16	1993	6,222	-	-	14,143	6,431	26,796	-	-	-	-	-	0	26,796
17	1994	12,444	17,954	16,081	28,285	12,862	87,626	-	-	-	-	-	0	87,626
18	1995	-	35,908	32,163	-	-	68,071	-	-	-	-	-	0	68,071
Total		18,666	53,862	48,244	42,428	19,293	182,493						0	182,493
Grand Total		46,641	162,331	128,863	117,396	42,084	497,315	1,721	47,381	20,404	32,580	801	102,887	600,202

Table 5-9 Construction Cost by Year (Plan B)

(1,000 shs.)

No.	Year / Item / Section	Road						Bridge						Total
		1	2	3	4	5	Total	1	2	3	4	5	Total	
1	1978	2,242	-	-	8,921	4,017	15,180	1,501	19,566	8,116	11,472	480	41,135	56,315
2	1979	8,343	14,810	12,096	23,010	2,633	60,892	220	9,226	4,503	6,504	321	20,774	81,666
3	1980	1,559	37,533	18,126	9,601	3,679	70,498	-	7,938	2,379	5,225	-	15,542	86,040
4	1981	31,811	6,516	6,138	67,316	29,664	141,445	-	6,326	3,113	5,726	-	15,165	156,610
5	1982	-	94,297	82,452	-	-	176,749	-	4,325	2,293	3,653	-	10,271	187,020
Total		43,955	153,156	118,812	108,848	39,993	464,764	1,721	47,381	20,404	32,580	801	102,887	567,651
Grand Total		43,955	153,156	118,812	108,848	39,993	464,764	1,721	47,381	20,404	32,580	801	102,887	567,651

5.3 Maintenance and Repair Costs

Periodical maintenance service is required for the completed roads starting from 1983. The required costs are calculated for the following repair and maintenance items.

Table 5-10 Maintenance and Repair Costs of Road and Bridges

(1,000 shs.)

			Item	Cost	Remarks	Total
Road	Stage		Overlay for surface	32,320	every 5 years	32,320
Road	Non-stage		Overlay for surface	48,900	every 5 years	48,900
Road	Common		Pavement maintenance	2,413	every year	3,304
Road	Common		Shoulder maintenance	162	every year	
Road	Common		Cutting grass	622	every year	
Road	Common		Ditch and culvert maintenance	107	every year	
Bridges	Common	Repain-ting	Metal bridge	970	every 10 years	1,013
Bridges	Common	Repain-ting	Pile above the earth	43	every 10 years	
Bridges	Common	Maintenance of pavement and floor slab		364	every 5 years	364
Bridges	Common	Cleaning at the end of wet season		109	every year	109

Maintenance and repair costs may vary depending on the conditions of use and on a long-term road maintenance plan to be established. However, the estimated capital outlay by year is given in Table 5-11.

Table 5-11 Maintenance and Repair Costs

(1,000 shs.)

Plan / Year	A			B		
	Road	Bridge	Total	Road	Bridge	Total
1982	1,007	-	1,007	1,007	-	1,007
1983	3,304	109	3,413	3,304	109	3,413
1984	3,304	109	3,413	3,304	109	3,413
1985	3,304	109	3,413	3,304	109	3,413
1986	3,304	109	3,413	3,304	109	3,413
1987	19,464	473	19,937	27,754	473	28,227
1988	19,464	109	19,573	27,754	109	27,863
1989	3,304	109	3,413	3,304	109	3,413
1990	3,304	109	3,413	3,304	109	3,413
1991	3,304	109	3,413	3,304	109	3,413
1992	3,304	1,486	4,790	27,754	1,486	29,240
1993	3,304	109	3,413	27,754	109	27,863
1994	3,304	109	3,413	3,304	109	3,413
1995	3,304	109	3,413	3,304	109	3,413
1996	3,304	109	3,413	3,304	109	3,413
1997	27,754	473	28,227	27,754	473	28,227
1998	27,754	109	27,863	27,754	109	27,863
1999	3,304	109	3,413	3,304	109	3,413
2000	3,304	109	3,413	3,304	109	3,413
2001	3,304	109	3,413	3,304	109	3,413
2002	27,754	1,486	29,240	27,754	1,486	29,240
2003	27,754	109	27,863	27,754	109	27,863
2004	3,304	109	3,413	3,304	109	3,413
2005	3,304	109	3,413	3,304	109	3,413
2006	3,304	109	3,413	3,304	109	3,413
2007	27,754	473	28,227	27,754	473	28,227
2008	27,754	109	27,863	27,754	109	27,863
2009	3,304	109	3,413	3,304	109	3,413
2010	3,304	109	3,413	3,304	109	3,413
2011	3,304	109	3,413	3,304	109	3,413
2012	27,754	1,486	29,240	27,754	1,486	29,240
20 Years' Total	172,757	5,662	178,419	238,237	5,662	243,899
30 Years' Total	303,597	8,493	312,090	369,077	8,493	377,570

CHAPTER 6

ECONOMIC EVALUATION

CHAPTER 6 ECONOMIC EVALUATION

6.1 Outline

In this chapter, the traffic conditions on and around the Southern Coastal Link Road are discussed, and on the basis of the existing conditions of regional traffic services, the future traffic is macroscopically analyzed with respect to normal traffic, generated traffic and the diverted traffic.

In paragraph 6.4, the running cost is calculated according to the prices as of October 1975, of fuels, lubricants, tires and vehicles, etc.

Also with the running cost by type of vehicle and the future traffic volume by type of vehicle taken as a basis, the running benefits resulting from improvement and new construction of roads are estimated.

In addition, the benefits of shortcut funneling of the hitherto roundabout traffic via Songea and Iringa between the South and Dar es Salaam thanks to the construction of all-weather road and the benefits of diversion of some traffic from the Coastal Shipping Line to the Southern Coastal Link Road are estimated, and the total benefits and costs are compared as to various plans in order to calculate the cost-benefit ratio, internal rate of return and net present value for the purpose of evaluating the present project from an economic point of view.

6.2 Existing Conditions of Regional Traffic

6.2.1 Existing Conditions of the Southern Costal Link Road

The existing conditions of the coastal road between Dar es Salaam and Mtwara is shown in Table 6-1.

Table 6-1 Existing Conditions of Southern Coastal Link Road

(km)

Section / Road surface	Dar es Salaam - Kibiti	Kibiti - Nangurukuru	Nangurukuru - Lindi	Lindi - Mtwara	Nangurukuru - Kilwa Masoko
Bitumen	135.0	-	3.5	40.0	-
Engineered gravel	-	-	-	66.0	-
Improved earth	-	31.9	86.8	-	17.8
Earth	-	124.3	78.0	-	18.9
Total	135.0	156.2	168.3	106.0	36.7

Table 6-1 shows that an aggregate 565.5 km length of the two-lane road between Dar es Salaam and Mtwara comprises 178.5 km of bitumen (32 % to the total), 66 km of engineered gravel (12 %), 118.7 km of improved earth (21 %) and 202.3 km of earth (35 %), and tells of the fact that there is much to be desired.

Because of littoral topography, the road is comparatively flat; the ratio of mountain path to the length is as small as about 20 %, and the ratios of the paths running on the downs and the plains are 13 % and 67 %, respectively.

6.2.2 Traffic Volume

The traffic volume in the past in Tanzania showed no particular pattern of secular change, and the growth rate of the traffic volume varied with year and site.

Like this, the past traffic volume on the Southern Coastal Link Road gave no distinctive pattern of change.

As is clear from Table 6-28, the traffic volume on the Southern Coastal Link Road is ten to one hundred vehicles a day, though dependent on the site.

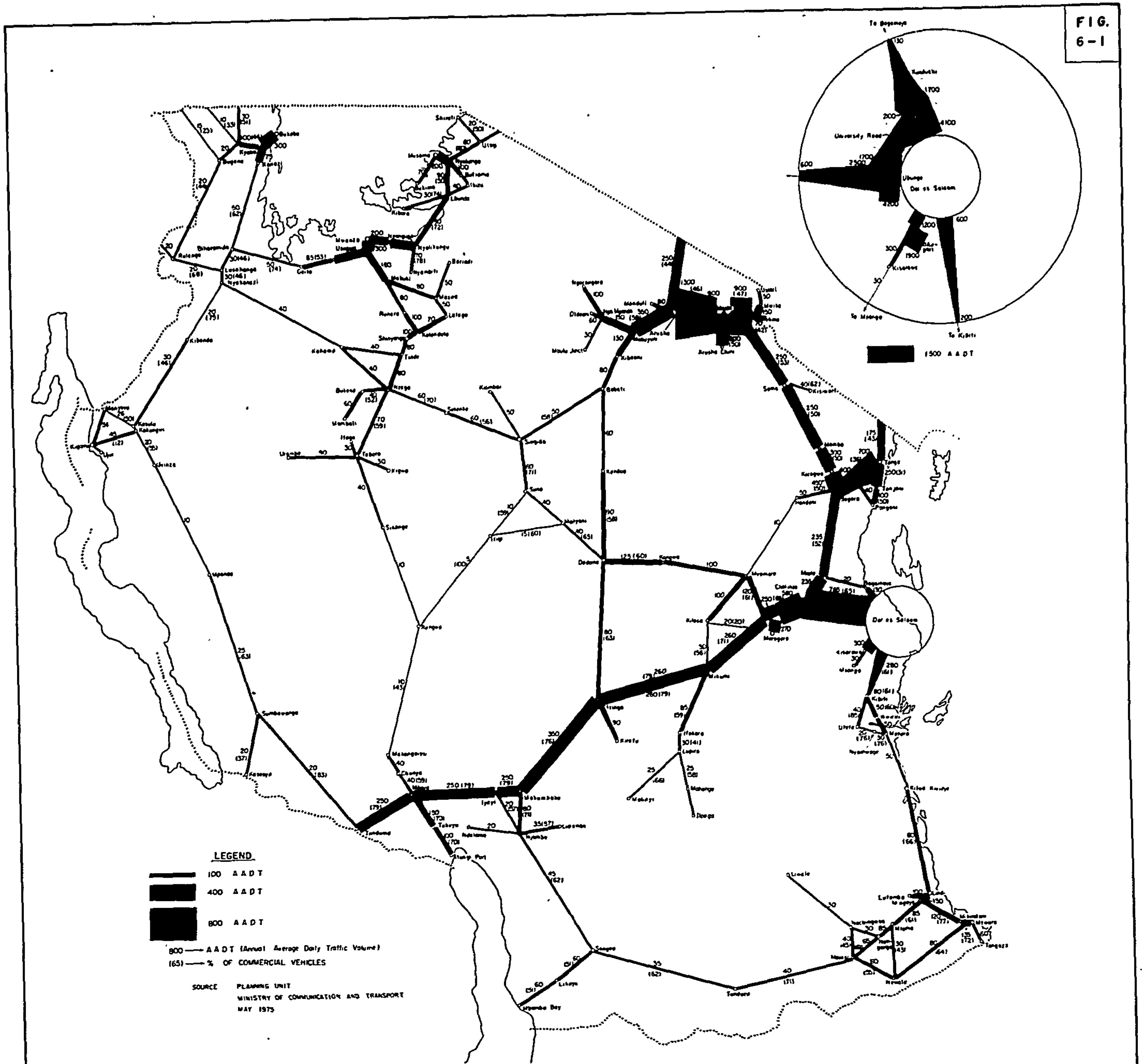
According to Fig. 6-1 which gives annual average daily traffic volume in Tanzania in 1974, the paved Dar es Salaam-Kibiti section showed the largest traffic volume of two hundred and eighty to eighty vehicles a day, and the traffic crossing the Rufiji was also a sizable value of ninety vehicles a day. The Mohoro-Lindi section showed fifty to sixty vehicles a day, the lowest among others.

The O-D distribution results observed in September 1968 by Comworks at census point No. 055 near Nangurukuru are graphically represented in Fig. 6-2.

As is clear from Fig. 6-2, the Southern Coastal Link Road has served as an artery between Dar es Salaam and major local cities, including Lindi and Mtwara, but the interzonal trips within the confines of Dar es Salaam and Mtwara have been comparatively rare.

Table 6-2 is an OD table of goods by type of article observed in November 1969 at Mkwanga; it is found that the movements of goods between Dar es Salaam on the one hand and Kisarawe Region and Rufiji District on the other are large. By type of article, building materials and agricultural products are transported from Kisarawe and Rufiji to Dar es Salaam, and sundry goods are sent from Dar es Salaam to Rufiji, Lindi and Mtwara.

It is worthy of note that most of cargo freighters from Dar es Salaam to Kisarawe and Rufiji run empty; namely, that after hauling building materials and agricultural produces to Dar es Salaam, they return unloaded or with a little amount of sundry goods for local needs.



SOUTHERN COASTAL LINK ROAD PROJECT

FIG. 6-1 ROAD TRAFFIC VOLUMES IN 1974

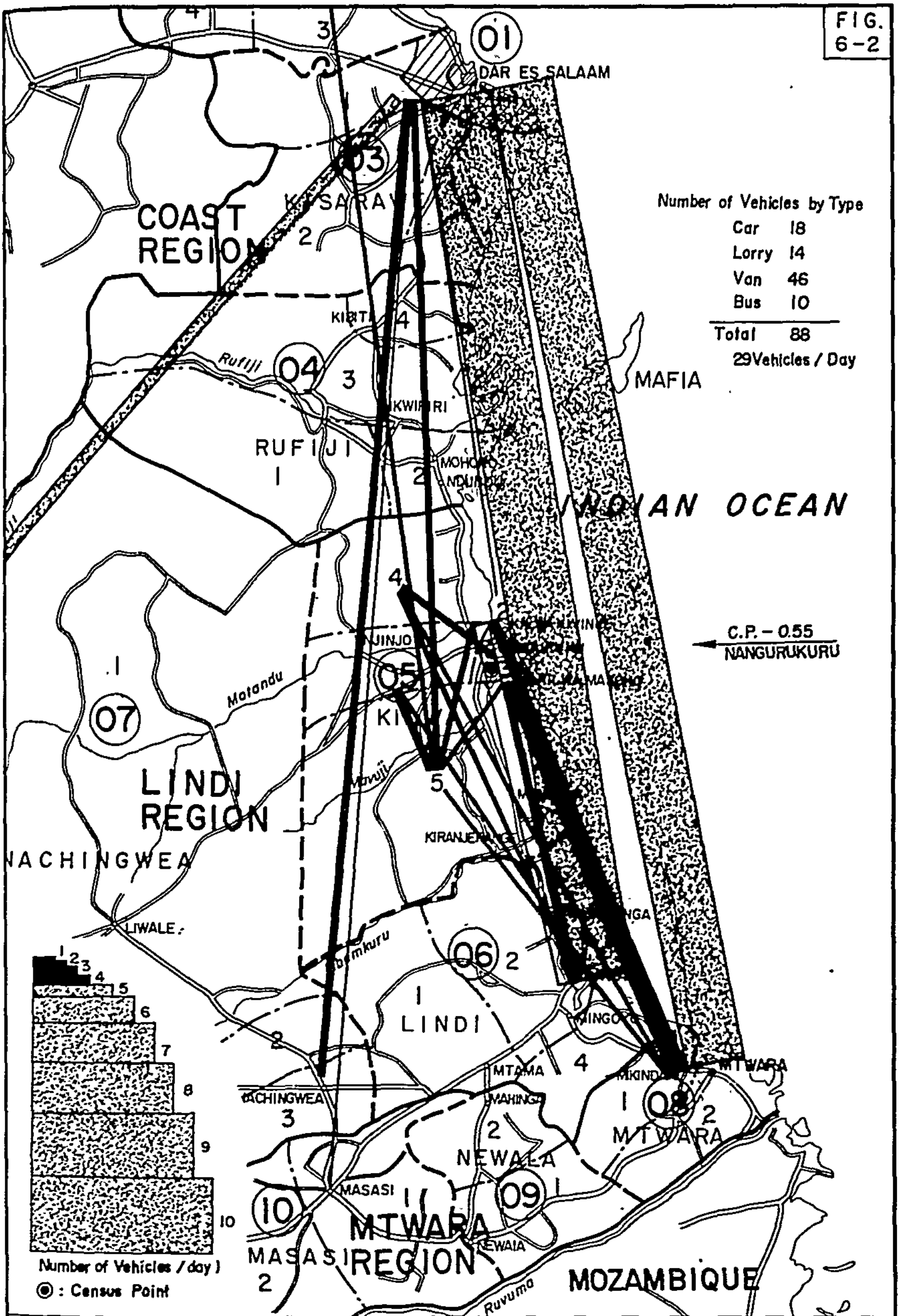


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
6-2	TRAFFIC DISTRIBUTION AT THE CENSUS POINT Sept., 1968 – 0.55 (NANGURUKURU)

Table 6-2 OD Table of Goods by Type of Article
(Census point: Mkwanga, Time of census: November, 1969)

(Ton)

O \ D	01	02	03	04	05	06	07	08	09	10	11	12	19	Total
01			(01)-267 (03)-12 (09)-7	(01)-213 (02)-28 (03)-20 (05)-7 (07)-6 (09)-46	(09)-7	(03)-5 (06)-5 (09)-16		(07)-8 (09)-44				(01)-5		(01)-485 (02)-28 (03)-37 (05)-7 (06)-5 (07)-14 (09)-120
03	(01)-19 (03)-53 (05)-165 (09)-14 (15)-17													(01)-19 (03)-53 (05)-165 (09)-14 (15)-7
04	(01)-70 (03)-171 (05)-55 (09)-6 (15)-8													(01)-70 (03)-171 (05)-55 (09)-6 (15)-8
05	(03)-7 (05)-7													(03)-7 (05)-7
06	(01)-18 (02)-7													(01)-18 (02)-7
08	(01)-16													(01)-16
19						(06)-6								(06)÷6
Total	(01)-123 (02)-7 (03)-231 (05)-227 (09)-20 (15)-15		(01)-267 (03)-12 (09)-7	(01)-213 (02)-28 (03)-20 (05)-7 (07)-6 (09)-46	(09)-7	(03)-5 (06)-11 (09)-16		(07)-8 (09)-44				(01)-5		(01)-608 (02)-35 (03)-268 (05)-234 (06)-11 (07)-14 (09)-140 (15)-15

Notes: 1) Types of goods
(01): Empty (02): Manufactured Goods (03): Building Materials
(04): Livestock (05): Agri. Products (06): Fish
(07): Fuel oil (08): Copper (09): Miscellaneous
(10): Fertilizers (11): Tea (12): Coffee
(13): Tobacco (14): Cotton (15): Sisal

6.2.3 Bus Traffic on the Southern Costal Link Road

The public transport between Dar es Salaam and Mtwara is the buses operated on the routes shown in Fig. 6-3.

In fact, the buses are playing an important role in communication between the South and Dar es Salaam.

However, the basic shortage of the buses is seen, and passengers are sometimes carried on the back of trucks. It is generally seen that vans, pickups and land rovers are used as if they were omnibuses.

The bus routes are formed to interlink Dar es Salaam and local cities such as Kilwa Masoko, Lindi, Mtwara, Liwale, Nachingwea and Masasi.

The bus routes are each operated by one bus company or more. For example, the bus companies operating on the Dar es Salaam-Lindi route are shown in Table 6-3.

Table 6-3 Bus Companies Operating between Dar es Salaam and Lindi

Name of company	Direction	Departure
1. Mswahili Bus Service	Lindi → DSM.	Sun., Tues., Fri.
	DSM. → Lindi	Mon., Wed., Sat.
2. Mnolela Bus Service	Lindi → DSM.	Mon., Wed., Fri.
	DSM. → Lindi	Tues., Thur., Sat.
3. Teeteeko	Lindi → DSM.	Everyday
	DSM. → Lindi	Everyday
4. NATCO		unknown
5. Manyara Bus Service	Lindi → DSM.	Tues., Thur., Sat.
	DSM. → Lindi	Mon., Wed., Fri.

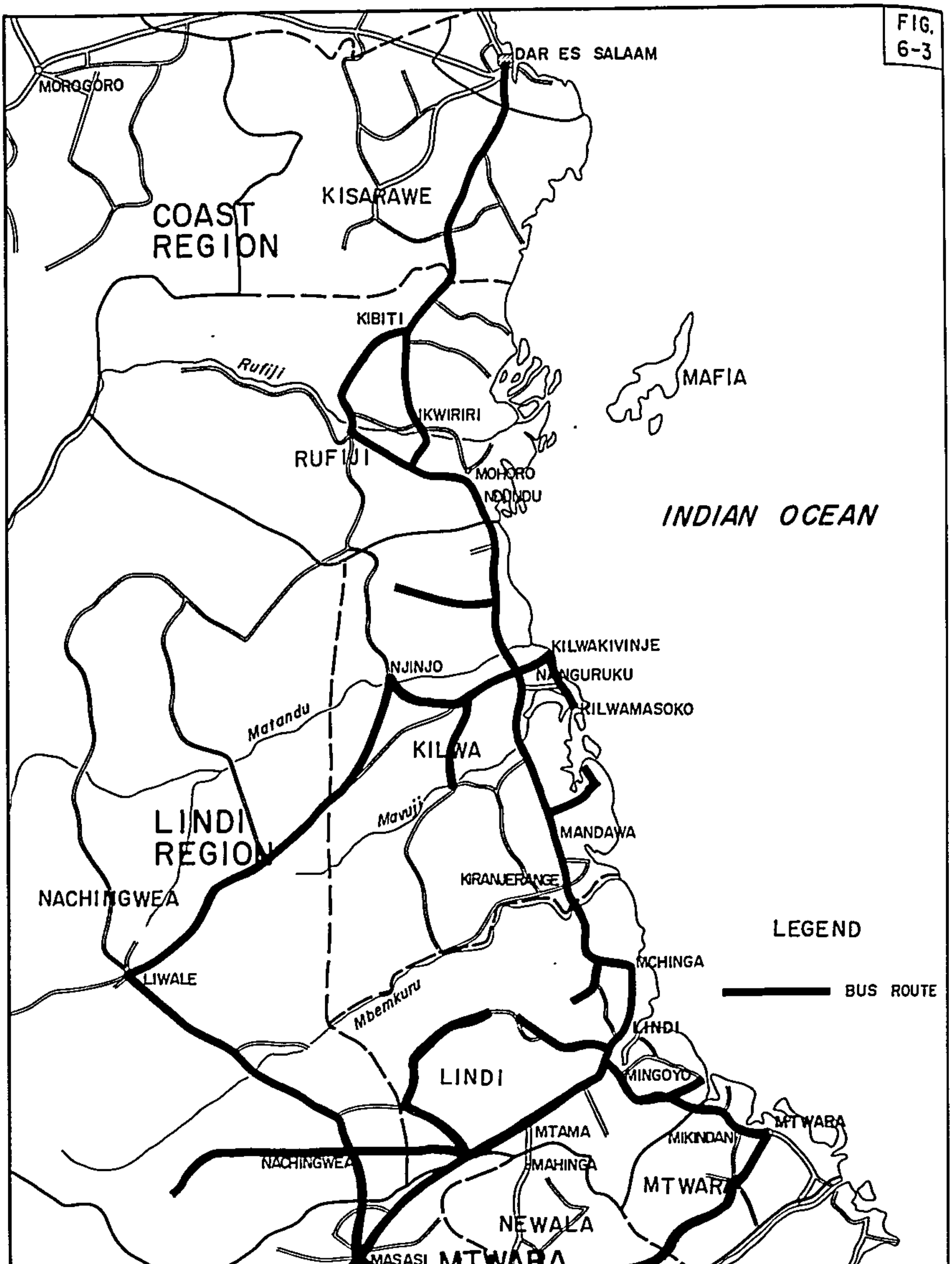


FIG. 6-3	SOUTHERN COASTAL LINK ROAD PROJECT
	BUS ROUTE NETWORK AROUND THE COASTAL AREA IN 1974

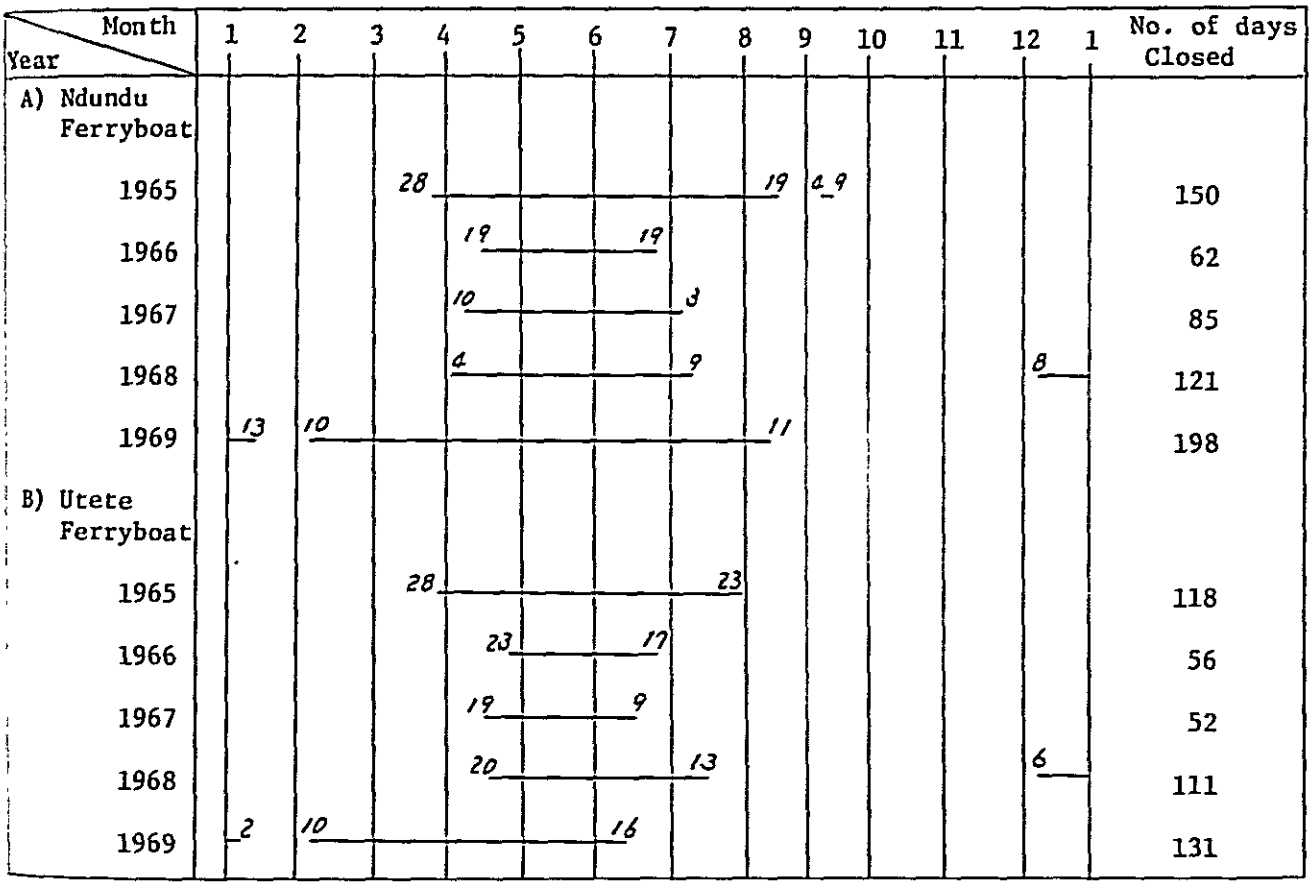
6.2.4 Ferry Across the Rufiji

The Rufiji, the largest of all rivers in Tanzania, has two ferries at Ndundu and Utete which are operated all the year round except in case of flood in the rainy season. The number of days closed, the times of closure and resumption are dependent on the severity of rainfall and how the riverbanks are affected by floods.

More often than not, the quays are relocated every year for easy operation.

By way of reference, the times of closure at Ndundu and Utete in the period from 1965 to 1969 are shown schematically in Fig. 6-4.

Fig. 6-4 Times of Closure at Ndundu and Utete Ferries



Average number of days closed: Ndundu Ferry: 123 days, Utete Ferry: 94 days

Source: Office of Regional Engineer Coast

The period and the times of closure of ferry operation vary from year to year, though the closure is mostly in April to August, and the average number of days closed is 123 for Ndundu ferry and 94 for Utete ferry.

The seasonal change in traffic volume across the Rufiji is large as shown in Table 6-4 as it is governed by the service interruption of ferries by inundation, delivery seasons of agricultural crops, and passableness between the Southern Coastal Link Road and feeder roads, etc. Interview surveys were made with the drivers of the vehicles using the ferryboats at Ndundu and Utete in regard to origin and destination. Typical OD taken on the average of three days of survey is shown in Tables 6-5 and 6-6.

According to Table 6-5, the traffic between Dar es Salaam and the major local cities such as Kilwa Masoko, Lindi and Mtwara is noticeable, and the traffic pattern bears a close resemblance to that of OD results obtained in 1969 to 1970 by the Ministry of Communication and Transport.

In Table 6-6 in which OD distribution at Utete ferry is shown, it is found that the tie between Dar es Salaam and Utete and between Kilwa Masoko and Lindi is strong.

The daily change in traffic volume obtained from OD traffic data at Rufiji ferry is shown in Table 6-7 for reference.

Table 6-4 Monthly Traffic Volume across the Rufiji at Utete and Ndundu Ferries

Year	Month	Vehicles		Persons	
		Vehicles/Month	Vehicles/Day	Persons/Month	Persons/Day
1969	1	260	9	18,100	603
	2	80	3	20,000	667
	3	120	4	21,300	710
	4	40	1	13,700	457
	5	60	2	7,000	233
	6	180	6	6,000	200
	7	1,120	37	35,000	1,167
	8	1,920	64	36,000	1,200
	9	2,000	67	24,000	800
	10	1,860	62	95,000 (meeting of TAUN,etc.)	3,167
	11	1,600	53	24,000	800
	12	560	19	13,000	433
1970	1	240	8	18,000	600
	2	40	1	10,000	33
	3	15	1	19,000	633
	4	-	-	6,000	200
	5	-	-	12,000	400
	6	345	12	85,000	2,833
	7	Date unavailable			
	8	1,700	57	31,000	1,033
	9	1,400	47	27,000	900
	10	1,760	59	23,000	767

Notes: Monthly traffic volume is converted into the daily traffic volume with one month taken as 30 days.

Source:Regional Engineer Coast.

Table 6-5 Typical OD Distribution at Ndundu Ferry

(Vehicle/Day)

Origin \ Destination	Dar es Salaam	Kibiti	Ikiwiriri	Nyamwage	Mohoro	Kilwa Masoko	Njinjo	Lindi	Mtwara	Masasi	Mtumbi	Total
1. Dar es Salaam				1	3	5	1	9	4	1	1	25
2. Kibiti				1								1
3. Ikiwiriri				4								4
4. Nyamwage	1		3									4
5. Mohoro	2											2
6. Kilwa Masoko	3											3
7. Njinjo	1											1
8. Lindi	5											5
9. Mtwara	2											2
10. Masasi	0											0
11. Mtumbi	1											1
Total	15		3	6	3	5	1	9	4	1	1	48

Notes: 1) The average of typical OD distribution measured for 3 days in October 1975 is converted into the one-day OD distribution above.

2) The average daily traffic volume corresponding to the above table is 57 vehicles.

3) The OD table above represents 84 % of the total OD.

Table 6-6 Typical OD Distribution of Utete Ferry

(Vehicles/Day)

Origin \ Destination	Dar es Salaam	Kifiti	Utete	Kilwa Masoko	Lindi	Mikindani	Mtwara	Total
1. Dar es Salaam			3	3	6		1	13
2 Kibiti			2					2
3 Utete	7	1		0		2		10
4 Kilwa Masoko	2		1					3
5 Lindi	9							9
6 Mikindani			2					2
7 Mtwara	0							0
Total	18	1	8	3	6	2	1	39

Note: 1) The typical OD distribution measured for 3 days, one day each in July, August and September in 1975 is reduced by averaging to the one-day OD distribution above.
2) The average daily traffic volume corresponding to the above OD table is 47 vehicles.
3) The above OD table represents 83 % of the total OD.

Table 6-7 Daily Change in Traffic Volume at Rufiji Ferries

Ferry	Month/Year	Max. daily Traffic Volume	Min. daily Traffic Volume	Aveage Daily Traffic Volume
Ndundu	Jul. 1973	41	2	20
	Aug.	73	30	52
	Sep.	70	16	53
	Oct.	74	25	49
	Nov.	86	35	57
	Dec.	72	5	25
	Sep., 1974	75	8	49
	Oct.	84	24	51
	Nov.	98	13	48
	Dec.	56	11	41
	Jul., 1975	47	9	30
	Aug.	84	29	58
	Sep.	131	13	57
	Oct.	68	32	49
Utete	Jul., 1975	64	5	32
	Aug.	23	4	15
	Sep.	59	6	26
	Oct.	32	4	21

Source: Regional Office of Ndundu and Utete Ferry Boat Service.

As is clear from Table 6-7, the daily traffic volume changes largely, and one of the two ferries shoulders the traffic of the other when the latter fails due to flood or others. In Table 6-7, there are months for which data are not available. This is due to lack of data in the Regional Office or due to floods that had checked crossing the river. The ferryboat is 8 Tons, and can only carry one bus, two small vehicles and some one hundred passengers per service.

It is towed by a motorboat of some 5 m long for shuttling. The average trip time of the Rufiji ferry is 15 to 20 min., inclusive of some 10 min. of loading and unloading.

If one misses a service, he is forced to wait 20 min. to 30 min. for the next chance. The quay on the right bank is connected to a steep access road of about 30 m, and if a truck loaded with timber stalls on the slope, the ferry service is totally stopped or limited to transporting passengers alone, until the truck is repaired. Even in the dry season, the ferry service is interrupted one day or so owing to the failure of truck or ferryboat.

The riverbanks at Ndundu are comparatively stable, and the quay sites do not change year by year. However, the riverbanks at Utete experience changes and the quay sites are forced to be relocated for ease of maneuver from year to year.

The ferryboat service is available from about 7:30 a.m. to 6:30 p.m., but takes a rest by night.

Until two years ago, the tolls were 10 Cents per passenger, 50 Cents per motorcycle or bicycle, 2 Shs. per passenger car or van, 5 Shs. per lorry, truck or bus, and there was no need for the passengers to pay so far as they paid for the vehicle they were aboard. Now, the services are available free of charge.

6.2.5 Coastal Shipping Services

Two vessels - MS Mtwara (700 tons) and MV Lindi (500 tons) are currently in service between Dar es Salaam and the littoral cities, Mafia, Kilwa Masoko, Lindi and Mtwara. MS Mtwara shuttles back and forth twice every week between Dar es Salaam and Mtwara, and MV

Lindi makes one and a half round trip on the same route. One way from Dar es Salaam to Mtwara requires 18 hrs. if run straight without stopping on the way. If Mafia, Kilwa Masoko and Lindi are called at on the way, it will be 48 hrs.

The distance from Dar es Salaam to the ports is as follows.

Dar es Salaam to Mafia	80 sea miles
Dar es Salaam to Kilwa Masoko	130 sea miles
Dar es Salaam to Lindi	200 sea miles
Dar es Salaam to Mtwara	400 sea miles

The toll varies with the leg and class.

- The fare for the cabin class is twice that for the tourist class, as shown in Table 6-8 below.

Table 6-8 Passenger Fares

(Shs.)

Tourist \ Cabin	DSM.	Mafia	Kilwa Masoko	Lindi	Mtwara
DSM.		30	46	66	72
Mafia	15		24	44	50
Kilwa Masoko	23	12		22	32
Lindi	33	22	11		-
Mtwara	36	25	16		

Source: Tanzania Coastal Shipping Line Ltd. Oct., 1975

The flat-rate freightage system is applied to any distance between ports except for the Dar es Salaam-Zanzibar section.

Food and bags are 140 Shs. per ton, and sundry goods 160 Shs. per ton. The freight rate for a haul between Dar es Salaam and Zanzibar is 130 Shs. per ton for all goods.

The annual total of traffic of passengers and cargoes is as follows. The corresponding OD distribution of passengers and cargoes in 1974 is shown in Tables 6-9 and 6-10.

Number of passengers: (persons)	1973	15,799
	1974	21,029
Weight of cargoes : (tons)	1973	78,249
	1974	121,735

Table 6-9 shows a heavy passenger traffic between Dar es Salaam on the one hand and Mafia, Kilwa Masoko, Lindi and Mtwara on the other, particularly between Dar es Salaam and Mtwara which accounts for 47 % of the total passenger traffic.
As regards freights, the traffic volume between Dar es Salaam on the one hand and Mtwara, Lindi, Mafia, Kilwa Masoko and Zanzibar on the other and between Zanzibar and Pemba is heavy. The freights transported in 1974 between Dar es Salaam and Mtwara were 90,000 tons or 74 % of the total shiploadings.

In addition to these large vessels (MS Mtwara and MV Lindi) currently in operation, schooners and dhows are also operated along the coast for carrying freights.

Lindi Port receives five schooners a day on the average, and the journey from there to Dar es Salaam takes 3 days.

Tanzania Coastal Shipping Line Ltd. operates, in addition to MS Mtware and MV Lindi, schooners of 100 to 250 tons chartered from private owners for the purpose of marine transportation.
Most of them, however, are getting worn out.

6.2.6 Lindi Port and Kilwa Masoko Port

Lindi Port and Kilwa Masoko Port are used for trade with the rest of domestic ports and also with Kenya.

The foreign trade with Lindi Region is carried on mainly through Mtwara Port.

In the rainy season, the traffic by the Southern Coastal Link Road

Table 6-9 Number of Passengers Transported by Coastal Shipping Line (1974)

(Persons)

Origin \ Destination	Dar es Salaam	Mafia	Kilwa	Lindi	Mtwara	Total
Dar es Salaam	-	2,069	756	1,867	5,036	9,728
Mafia	2,158	-	496	110	303	3,067
Kilwa	704	260	-	117	146	1,227
Lindi	1,633	87	264	-	1	1,985
Mtwara	4,766	157	99	-	-	5,022
Total	9,261	2,573	1,615	2,094	5,486	21,029

Source: Tanzania Coastal Shipping Line Ltd.

Table 6-10 Volume of Cargoes Transported by Coastal Shipping Line (1974)

(Tons)

Destination / Origin	Dar es Salaam	Mtwara	Lindi	Mafia	Kilwa	Zanzibar	Pemba	Tanga	Pangani	Mombasa	Total
Dar es Salaam	-	58,797	7,280	1,832	2,132	5,119	1,799	-	-	-	76,959
Mtwara	30,783	-	-	-	-	-	-	971	-	-	31,754
Lindi	1,478	-	-	-	-	-	-	-	-	-	1,478
Mafia	2,064	-	-	-	-	-	-	-	377	143	2,584
Kilwa	596	796	-	-	-	-	-	-	-	-	1,392
Zanzibar	1,736	-	-	-	-	-	2,037	-	-	-	3,773
Pemba	-	-	-	-	-	-	-	-	-	-	-
Tanga	-	1,232	175	-	-	-	-	-	-	-	1,407
Pangani	-	-	-	-	-	-	-	-	-	-	-
Mombasa	1,094	-	454	-	-	-	840	-	-	-	2,388
Total	37,751	60,825	7,909	1,832	2,132	5,119	4,676	971	377	143	121,735

Source: Tanzania Coastal Shipping Line Ltd.

is interrupted, and the coastal shipping plays an important role. But, the ports are suitable only for small schooners, and their service standard is low.

The improvement of Lindi Port and Kilwa Masoko is of great necessity in meeting the current demand for coastal transportation.

The shiploadings and the numbers of passengers handled at Lindi Port and Kilwa Masoko Port are given in Tables 6-11 and 6-12. The most important cargoes handled there are also enumerated in Tables 6-13 and 6-14.

Table 6-11 Shiploadings and Passengers at Lindi Port

Year	Number of arrivals	Freights (Tons)		Passengers (Persons)	
		Imports	Exports	Getting off	Getting on
1971	195	22,194	3,295	464	415
1972	169	26,950	5,606	319	925
1973	140	21,868	3,595	80	242
1974	83	16,029	2,213	1,941	1,711

Table 6-12 Shiploadings and Passengers at Kilwa Masoko Port

Year	Number of arrivals	Freights (Tons)		Passengers (Persons)	
		Imports	Exports	Getting off	Getting on
1971	-	2,458	6,994	0	0
1972	-	2,218	6,847	0	0
1973	149	-	923	0	0
1974	106	2,230	4,843	1,027	1,020

Table 6-13 Principal Cargoes Handled at Lindi Port

(Tons)

	Principal Cargoes	1972	1973
Export	Sisal	177	1,050
	Lumber	117	-
	Grand nuts	276	-
	Copra	80	-
	Rolling stock	-	14
Import	Rice	1,036	2,465
	Sugar	2,122	1,275
	Maize	2,401	2,420

Table 6-14 Principal Cargoes Handled at Kilwa Masoko Port

(Tons)

	Principal Cargoes	1972	1973
Export	Cashew nuts	4,365	315
	Copra	1,059	55
	Lumber	342	48
	Sesame and other oil materials	998	-
Import	Food	1,700	1,043
	Building Materials	43	265
	Fuels	90	52
	Livestock	5	70

6.2.7 Mtwara Port

Mtwara Port is well sited and equipped, and has contributed much toward the growth of industry and economy in Mtwara and Ruvuma Regions. In fact, Mtwara Port serves as the distribution center for Mtwara Region.

As port facilities, it has a deep wharf of some 380 m long and four warehouses (with floor spaces of 1,189 m^2, 3,122 m^2, 3,122 m^2 and 9,290 m^2, respectively).

For loading and unloading operations, there are eight mobile cranes of which two are rated at 11 tons, three at 7 tons and the remaining three at 5 tons.

The cargo handling capacity of Mtwara Port is about 370,000 tons a year, and the operating efficiency of the berth is 70 %.

The volume of freight handled over past five years at Mtwara Port was comparatively stable. The total amount of domestic and foreign imports and exports was 165,740 tons in 1971 and 194,509 tons in 1972 or only half the capacity of the Port.

The amount of freight handled at Mtwara Port is shown in Table 6-15 below.

Table 6-15 Amount of Freight Handled at Mtwara Port

(Tons)

Goods	1971 Export	1971 Import	1972 Export	1972 Import
Dry General cargo	96,532	23,830	129,366	35,551
Dry bulk	-	11,100	-	9,400
Bulk oil	-	22,760	-	19,006
Total	96,532	59,700	129,366	63,957

As shown above, the exports accounted for 60 to 70 % of the total cargoes. The principal exports from Mtwara are as shown in Table 6-16 below.

Table 6-16 Principal Exports from Mtwara Port

(Tons)

Goods	1971	1972	1973
Cashew nuts	71,614	90,258	82,897
Cassabas	1,690	16,299	2,400
Sisal	6,679	14,435	7,800
Sesame	4,171	7,312	3,100
Lumber	1,782	1,723	1,300
Total	85,936	130,027	97,497

As shown in Table 6-16, cashew nuts account for about 70% of the total exports.

It is believed that Mtwara Port, which is well sited and equipped, will soon be used to its advantage, dwarfing Dar es Salaam which has already been congested heavily. With the improvement of the road leading to the hinterland of Mtwara Port, the efficiency of Mtwara Port will be heightened more and more.

6.2.8 Civil Aviation in the Southern Coastal Region

East African Airways is operating on the routes between Dar es Salaam on the one hand and Songea, Nachingwea, Mtwara, Lindi, Kilwa and Mafia on the other.

Dealt with here are Mtwara Airport, Lindi Airport, Kilwa Airport and Nachingwea Airport which are directly concerned with the present project.

The facilities of Mtwara Airport are enough to answer the current needs of air traffic.

Mtwara Airport has two runways, one measuring 30 m wide by about 2,240 m long and tarmac-finished and the other 30 m wide by 1,160 m long and gravel-finished. However, warehousing and cargo handling facilities are yet to be improved.

Four services a week are available between Dar es Salaam and Mtwara via Lindi Airport. Fokker Friendship F27 of East African Airways is flying on this route.

Lindi Airport has three runways of 1,380 to 1,840 m long. The 1,610 m one running east to west is gravel-finished, while the other two are of the grass surface. This airport is in want of electric facilities and lighting facilities, and the landing and taking-off are not possible at night.

Kilwa, Nachingwea and Lindi airports are all operated by East African Airways with three flight services a week.

Kilwa Airport and Nachingwea Airport have unpaved runways, and Douglas DC-3 is suitable.

Table 6-17 shows the flights and fares between Dar es Salaam and the cities along the Southern Coastal Link Road.

Table 6-17 Flight Fares (as of March 3, 1975)

(Shs.)

Flight	Single fare	Double fare
Dar es Salaam-Kilwa	195	-
Dar es Salaam-Lindi	285	399
Dar es Salaam-Mafia	135	-
Dar es Salaam-Mtwara	340	476
Dar es Salaam-Songea	550	-
Dar es Salaam-Zanzibar	75	105

Source: East African Airways

Tables 6-18 and 6-19 show the OD distribution of inter-airport passeng in the littoral regions in 1973 and 1974.
As is clear from these tables, the number of passengers conveyed between Dar es Salaam and Zanzibar is by far the largest among these

airports, followed by Dar es Salaam-Mtwara and Dar es Salaam-Mafia routes. Most of passengers fly to and from Dar es Salaam, and there are few flyings between local airports.

Table 6-18 Air Passenger OD in 1973

(Persons)

Destination / Origin	Dar es Salaam	Kilwa	Lindi	Mtwara	Nachingwea	Mafia	Zanzibar	Total
Dar es Salaam		459	1,694	4,592	700	3,391	19,148	29,984
Kilwa	444		0	-	-	10	-	454
Lindi	2,351	0		-	-	-	-	2,351
Mtwara	3,935	-	-		-	-	-	3,935
Nachingwea	793	-	-	-		-	-	793
Mafia	3,528	15	-	-	-		-	3,543
Zanzibar	19,186	-	-	-	-	-		19,186
Total	30,237	474	1,694	4,592	700	3,401	19,148	60,246

Table 6-19 Air Passenger OD in 1974

(Persons)

Origin \ Destination	Dar es Salaam	Kilwa	Lindi	Mtwara	Nachingwea	Mafia	Zanzibar	Total
Dar es Salaam		543	2,661	4,381	1,391	3,397	24,032	36,405
Kilwa	516		1	-	-	45	-	562
Lindi	2,795	0		-	-	-	-	2,795
Mtwara	4,330	-	-		-	-	-	4,330
Nadingwea	1,324	-	-	-		-	-	1,324
Mafia	3,604	30	-	-	-		-	3,634
Zanzibar	24,538	-	-	-	-	-		24,538
Total	37,107	573	2,662	4,381	1,391	3,442	24,032	73,588

6.3 Forecast of Future Traffic Volume

6.3.1 Normal Traffic

There are various methods of forecasting traffic volume.

To our regret, however, almost every developing nation is destitute of precise data worth applying the most advanced stochastic procedure using exact model equations.

1) On the occasion of the site survey, the survey team visited the government authorities concerned, such as Ministry of Works, Ministry of Communications and Transport and Regional Development Office, and collected information and data on traffic. But, there were no data available for clearly depicting the OD pattern and past trend of traffic.

2) In Tanzania, the various agencies have conducted traffic surveys at various census points, though not systematically. Accordingly, it is difficult to explore the past trend of traffic out of the data thus obtained.

3) As is seen in Fig. 6-5, the traffic change in Tanzania is more noticeable in the seasonal pattern, that is, depending on whether it is in the dry season or rainy season, or whether the agricultural crops are ready to deliver or not, rather than in the yearly pattern; namely, it is not enough to supply data for the survey team to analyze the past trend of traffic at specific points.

4) For the same reason, the other consultants who conducted economic or engineering survey of the road projects in Tanzania gave up trend analysis in their reports, as represented by the Economic and Engineering Study of Tanzania Highway prepared by Lyon Associates, Inc. and the Economic Feasibility of Two International Road Links in Tanzania prepared by the United Research Company.

Also, the present and future over, say, twenty to thirty years ahead, of the agricultural and forestry production plans, tourism development plan, and demand-supply balance of agriculture and forestry have not yet been figured out clearly, and it is hard to estimate the traffic twenty to thirty years ahead quantitatively as classified into agriculture, forestry and tourism, etc.

Considering that the basic data falls short of the needs and lacks accuracy and reliability, it is preferred to apply a macroscopic analysis method with the control total reduced to a sizable value from a wide perspective point of view rather than to go for dissecting and forecasting the traffic concerning agriculture, forestry and tourism to get at dubious traffic volume.

For the purpose of macroscopic analysis, the following method is considered, and the future trend is imagined after digging into the stochastic results from various angles.

The methodology of the future traffic estimation and its results are dealt with in detail hereunder.

18,240 simple correlation coefficients are calculated with respect to 192 indices of principal industries and economics and are rendered into a simple correlation matrix.

Major industrial and economic indices are enumerated below.

> Population; number of employees by industry; finance (revenues and expenditures by account)/ GDP by component; per capita GDP; values of exports by article; amount of exports by article; number of vehicles registered by type; volume of transport of goods and passengers by railway; volume of cargoes, passengers, imports and exports handled by shipping; volume of cargoes and passengers handled by air; agricultural production by crop; livestock production; number of manufacturing employees; industrial output by article; cement consumption; mining production and value; oil production; consumption of gasoline and heavy oil; production and consumption of electric power; etc.

Of the industrial and economic indices, those which are considered most closely tied up with the number of vehicles in use by type are shown in the form of a simple correlation matrix in Table 6-20.

According to Table 6-20, the number of vehicles in use and GDP hold a strong correlativity, and also the correlations between GDP on the one hand and the volume of transport by rail, sea and air of goods and passengers on the other are also high.

It is therefore surmised that the road traffic may be forecasted from the correlation between the number of vehicles in use and GDP.

Table 6-20 Simple Correlation Matrix

Item	Year	GDP at Factor Cost	Gasoline Consumption	Diesel
Population	0.9971	0.9905		
Total Recurrent and Development Expenditure	0.9337	0.9165		
GDP at Factor Cost	0.9929	1.0000		
GDP per Capita	0.9442	0.9736		
Exports (Total)	0.9003	0.9134		
Imports (Total)	0.8784	0.7422		
Passenger Cars	0.9916	0.9937	0.9928	
Vans	0.9787	0.9668	0.9748	
Lorries	0.9916	0.9892		0.9904
Buses	0.9665	0.9528		0.9588
Total	0.9926	0.9862		
Holding Rate (Vehicles/Person)	0.9724	0.9770		
Railway, Goods Traffic	0.9250	0.9436		
Railway, Passengers	0.6981	0.6928		
Shipping, Total Goods Handled	0.9841	0.9870		
Airway, Passengers Carried	0.9756	0.9645		
Cargo, ton-km	0.8322	0.8142		
Consumption, Gasoline	0.9962	0.9933		
Diesel	0.9867	0.9919		
Electricity Production	0.9984	0.9930		
Local Sales	0.9991	0.9922		

The growth rates in the past of population, GDP, number of vehicles in use, and gasoline consumption are determined in Table 6-21.

Table 6-21 Annual Average Growth Rates of Population, GDP and Number of Vehicles in Use

(Percent/Year)

	1960-65	1965-69	1970-74	1965-74	Projection
Population	2.5	2.6	2.7	2.6	
GDP	5.7	5.9	4.1	5.1	5.0
Passenger cars	4.6	2.3	2.0	2.0	2.5
Vans	0.3	5.4	5.3	5.3	5.0
Lorries	0.7	6.9	7.4	7.4	5.0
Buses	2.2	6.7	13.7	11.1	6.0
Vehicles, all types	-	4.2	4.8	4.5	-
Gasoline	-	3.8	2.6	3.2	-
Diesel	-	10.3	8.3	9.0	-
Gasoline and diesel	-	6.9	5.7	6.2	-

The vehicular traffic is considered to be a function of the number of vehicles operated and the fuel consumption, and its growth rate is inferred to lie between the growth rate of fuel consumption and that of the number of vehicles. On the other hand, a high correlativity exists between the traffic volume and GDP, and since the growth rate of GDP intervenes between the growth rates of fuel consumption and the number of vehicles in operation, the growth rate of GDP is taken for that of the future traffic volume.
Namely, the growth rate of traffic volume in future will be equal to the same value of 5 % as GDP's.

As shown in Table 6-22, the growth rate of GDP in the African countries (incl. Tanzania) down the Sahara forecast by FAO (Food and Agricultural Organization) is 5.2 % a year, and will be enough to justify the 5 % growth rate of GDP in future Tanzania.

Table 6-22 Growth Rates of GDP in Future

(Percent/Year)

Area	1962-85	1970-75	1975-85
1) Latin America	5.6	n.a.	6.1
2) South America	5.0	4.9	5.7
3) Asia and Far East	5.9	n.a.	6.6
4) South Africa down the Sahara	4.9	n.a.	5.2
5) Southwestern Africa and Middle and Near East	5.7	n.a.	5.7

The future traffic growth in Tanzania forecast in the East Africa Transport Study is: 8 % for light vehicles (cars and vans) and 6 % for heavy vehicles (trucks and buses) or 7 % on the average.

When compared with this value, the 5 % value set as the future traffic growth rate will not be too much.

The value which is the total of the traffic for all types of vehicles calculated from the future traffic for each type based on the growth rate of its own is much the same as the value forecast for all types of vehicles from the outset. For this reason, the future traffic is determined using the future GDP growth rate. With this then, the future traffic by type of vehicle is projected according to the correlations between the traffic volume and its composition by type of vehicle.

If a bridge crosses the Ruvuma that borders on Mozambique, the Southern Coastal Link Road becomes an international trunk road and will have to face a rapid increase in the traffic volume.

However, there is nothing known about the traffic in Mozambique, and it is also difficult to set out the road influence area to be created by the construction of the Ruvuma River bridge. If the road influence area may be established, it is almost impossible to depict the origination and concentration of traffic from the influence area on the part of Mozambique. At the same time, the Southern Coastal Link Road, as an international trunk road it must assume when the bridge is constructed over the Ruvuma, and its traffic will be governed more strongly by the policy towards the adjacent nation than the economic and industrial conditions of the influence area.

Aside from this precarious international traffic, it is preferred here to apply the future traffic growth rate projected for Tanzam Highway in the nature of an international trunk road to the case where the Ruvuma River bridge will be constructed.

The traffic growth rate forecast for Tanzam Highway is as shown in Table 6-23, and the traffic growth rate expected when the Ruvuma River bridge is constructed is set at 7 % for estimating the future traffic volume. The results are to be put to a sensitivity analysis.

It should be noted however that the rate 7 % is simply an assumption; namely that it is not so sensitive or accurate as to govern the growth rate with change in the site or the number of sites of the Ruvuma River bridges. Even if a bridge is constructed between Masunguru and Negomana, it is practically impossible to forecast the traffic volume over twenty to thirty years which will flow in from Mozambique, because nothing is known about the traffic conditions in Mozambique and also because the supply-demand balance of goods between Tanzania and Mozambique is not pictured clearly on a long-term basis.

For these reasons, the economic assessment is made with the traffic growth rate set at 7 % regardless of the location and number of bridges.

FIG. 6 - 5

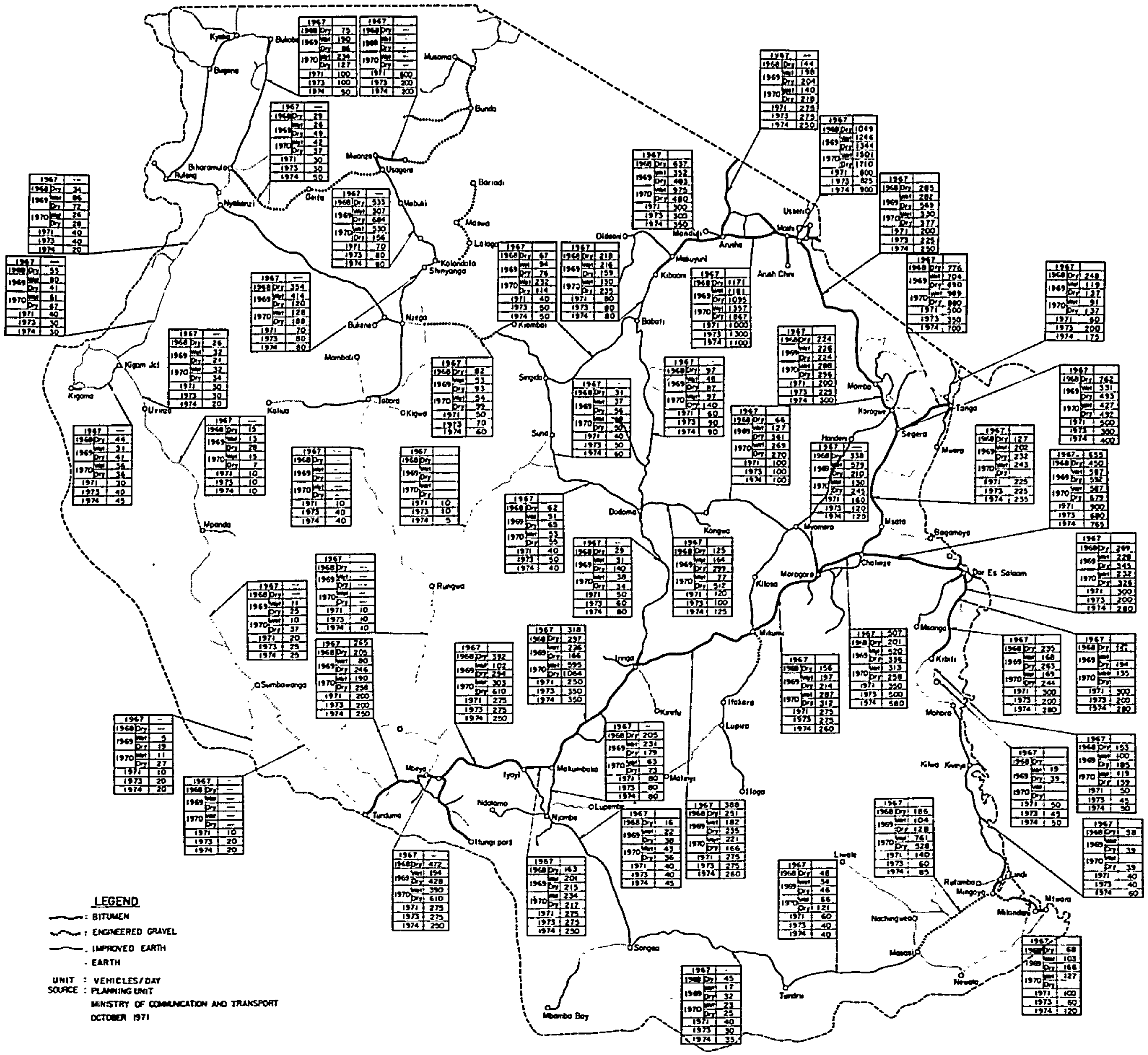


FIG 6 - 5

SOUTHERN COASTAL LINK ROAD PROJECT

DAILY TRAFFIC VOLUME (1967-1974)

Table 6-23 Estimated Average Annual Rate of Traffic Growth along the Tanzam Highway

(Percent/Year)

Road section	Improved road	
	1967-69	1970-80
1) Dar es Salaam - Morogoro	7	7
2) Morogoro - Mbeya	6	7
3) Mtwara - Mbeya	6	7
4) Kapiri Mposhi - Mpika	8	10

Source: Development Potential of Tanzam Highway

A few problems are encountered here in establishing the values of initial traffic volume that furnish the basis for estimating normal traffic volume. Figure 6-1 gives the average daily traffic in 1974 while Tables 6-31 through 6-34 included later in this chapter to show estimated traffic volume give the values in 1973. The discrepancy comes from unsatisfactory accuracy of the results of the traffic surveys. The data obtained from Planning Unit, Ministry of Communication and Transport (former name of Ministry of Works) gives the traffic volume by section of the Southern Coastal Link Road as shown in Table 6-24 below.

Table 6-24 Traffic Volume along Southern Coastal Link Road

(Vehicles/Day)

Section / Year	Kibiti -Utete	Kibiti -Mohoro	Mohoro -Kilwa Kivinje	Kilwa Kivinje -Lindi
1968	-	-	19	30 - 58
1969	-	19 - 39	-	39
1970	-	-	-	39
1971	130	50	50	40
1972	-	-	-	-
1973	130	45	50	40
1974	40	50	50	60

The above table gives different traffic volume from year to year and section to section with no systematic pattern of its secular change. It is quite difficult to grasp past trend from the data.

Table 6-24 also shows a yearly average traffic volume of 130 for Kibiti-Utete section both in 1971 and 1973, and 45 to 50 for Kibiti-Mohoro section. The value of 130 leaves room for doubt since a survey of ferry traffic made at the Rufiji crossing clearly indicates that Kibiti-Mohoro route has more traffic than Kibiti-Utete route.

As seen in the above, the traffic volume varied widely from survey to survey conducted at different points, in different seasons and years, even the data themselves lacking reliability. This leads to a conclusion that it is inadequate to adopt a traffic volume in a certain year as the initial value. The volume for 1973 shown in Tables 6-31 through 34 was thus estimated taking all the available past data into consideration.

When the Rufiji River Bridge is completed, almost all the traffic of both Utete and Mohoro routes will concentrate on it. On the basis of this assumption, the initial traffic volume in Section 1 was set at the total of the volumes of the two routes.

6.3.2 Generated Traffic

Considering the range and accuracy of the data currently available about the traffic and transportation, the projection of the generated traffic which will come forth anew owing to the reduction of transportation cost is hard.

As a method of forecast, there is one in which a demand curve is determined after analysis of the correlation between the transportation cost and the amount transported and then from that curve the increased traffic volume resulting from the reduction of transportation cost due to road improvement is calculated. As for the present project, this method is hardly applicable. The situation is that even major international financial institutions have yet to establish the method of projecting the generated traffic.

Such being the circumstances, there will be nothing but the following method, though it may be somewhat irrational.

The pattern of traffic in all Tanzania shows no particular yearly change; it is rather represented by seasonal change that the traffic volume is larger in the dry season than in the rainy season.

In the rainy season, the roads, particularly unpaved ones, are bogged or become softened and slippery, seriously degrading the trafficability. As often as not, the passage is totally checked.

In the dry season, however, even such poor roads are set fast and improved amazingly.

The difference in trafficability between the rainy and dry seasons is, as it were, the difference between the uncared-for state and the improved state of the Southern Coastal Link Road. The rainy season and the dry season take place alternately in a year. Assuming that the industrial and economic milieus in the areas along the Road will not change in a year, then the rise of traffic volume in the dry season over the rainy season is considered to have more significant reference to the increase in the roadability (or reduction of transportation cost) than to the climatic conditions. In short, the differential in traffic volume between the dry season and rainy season includes a component of induced traffic. The difference in traffic volume between the two seasons is due not merely to the difference in road conditions, but to the fact that in the rainy season the ferries on the Rufiji are forced to suspend however temporary they may be, that the traffic which ought to take shape is turned into dormancy as an announcement of ferry service interruption is fast circulated among the inhabitants, and that part of overland transportation is diverted to sea in the rainy season.

On the other hand, the delivery season of agricultural crops varied with respective harvesting seasons.

The cashew nuts which account for some 70 % of total exports from Mtwara Port are delivered most from November to January in the rainy season, and least from June to October in the dry season.

As stated above, the various factors are intertwined to make a difference in traffic volume between the dry and rainy seasons.

It is almost impossible to analyze these factors, and there is no proper way of projecting the generated traffic. It is therefore assumed that the difference in traffic volume between the rainy and dry seasons is solely dependent on the road conditions, that is, the difference in transportation cost, and that the increment of traffic volume in the dry season over the rainy season is the induced traffic. The traffic volume in the dry season as against the rainy season is stochastically determined according to the following method, and the most probalbe value is applied to the forecast of the generated traffic.

The change in per cent of the dry season traffic over the rainy season is schematically rendered in Fig. 6-6 by making use of data obtained at about three hundred and seventy points in Tanzania. The most probable value of the dry season traffic over the rainy season in all Tanzania is +10 %. However, the lowest value for the Southern Costal Link Road is +20 %, and this value is taken as the ratio of the generated traffic to the normal one when the unpaved road is transformed into a paved one.

The reason why this lowest value, 20 %, is taken is that the traffic volume in the rainy season is reduced not only by the degradation of road surfaces, but by the suspension of the Rufiji ferries and diversion of overland transportation to shipping.

In other words, the degradation of the road surfaces in the rainy season, that is, the resultant increase in the transporation cost, is considered attributable to the reduction of traffic volume. Then, it is found that the ratio of the traffic in the dry season to that in the rainy season will become smaller than that appearing in Fig. 6-6. It is now evident that in order to make the degraded road conditions alone responsible for the reduction in traffic volume in the rainy season, it is rational to take the lowest value, 20 %.

For the above reasons, the generated traffic is considered to be 20 % of the normal traffic, and the generated traffic expected to be developed in the stages of modification from earth to gravel road and from gravel to paved road is calculated by rationing the 20 %

FIG. 6-6

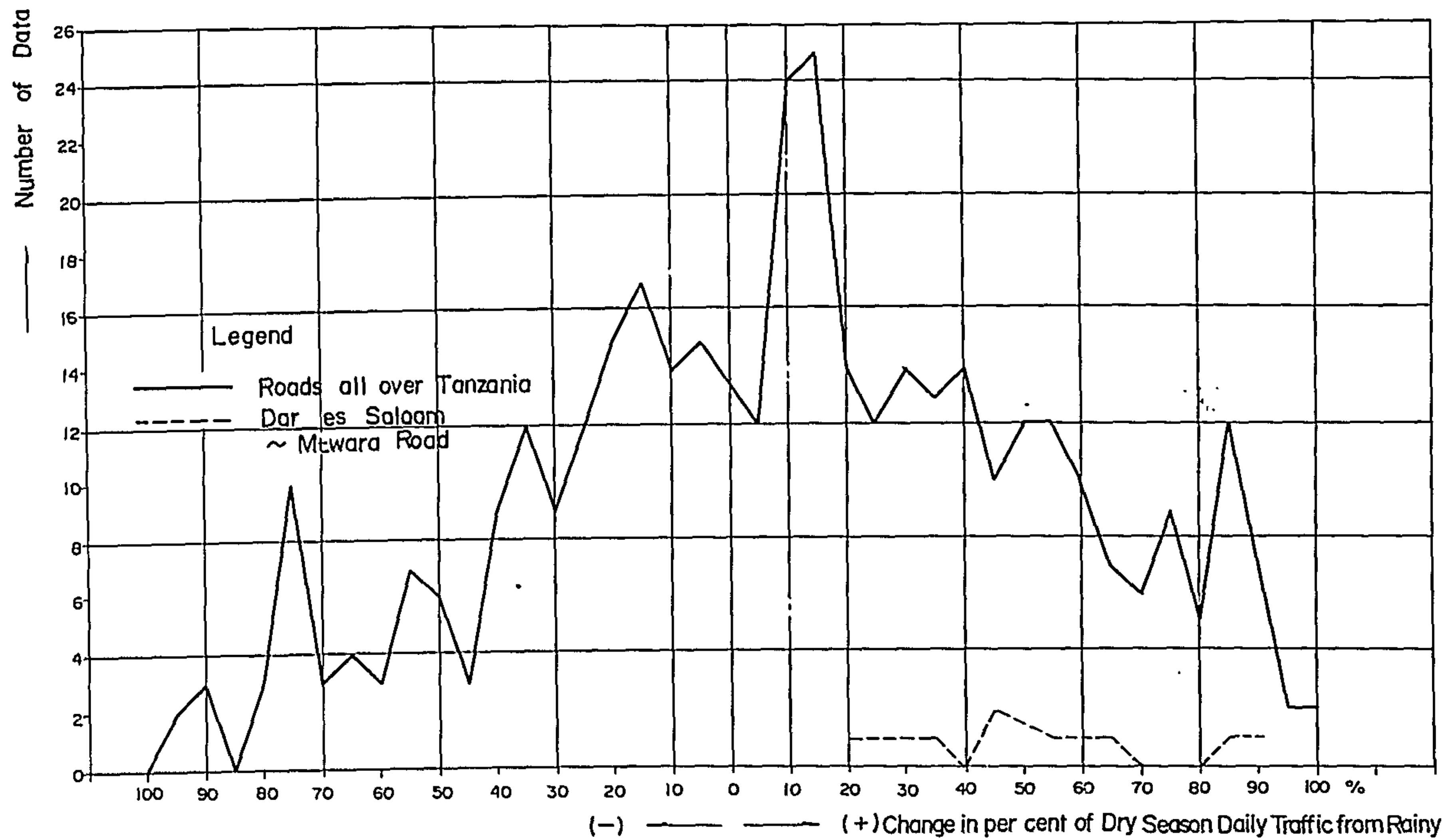


FIG 6 - 6	SOUTHERN COASTAL LINK ROAD PROJECT
	FREQUENCY DISTRIBUTION AT FIXED CENSUS POINTS OF DRY AS AGAINST RAINY SEASON TRAFFIC

increase rate according to the ratio of the benefits per vehicle expected to be brought about in respective stages.

6.3.3 Diverted Traffic

When the Southern Coastal Link Road is completed, the flow of traffic will undergo a complete change.

From the rest of roads and from sea, the traffic will gravitate toward it, forming new vigorous stream between Dar es Salaam and the South. The following discusses how the traffic will be diverted by the Southern Coastal Link Road.

1) Diverted Traffic from Coastal Shipping Lines

The diversion of traffic from the coastal shipping lines by the completion of the Southern Coastal Link Road is forecast according to the flow chart illustrated in Fig. 6-7.

At present, there are two competing transport systems operating between Dar es Salaam and the South.

They are the coastal road and the coastal shipping lines serving on three routes (DSM. - Kilwa Masoko, DSM. - Lindi, and DSM. - Mtwara).

Fig. 6-8 shows the contribution rate curve of the costal road as a function of freight share, cost and transport time in relation to the coastal shipping lines.

Namely, it shows that the vehicle utilization rate will increase with the improvement of the coastal road.

Hence, the difference in vehicle utilization rate between improvement and non-improvement of the existing coastal road may well be regarded as the rate of traffic diversion from the shipping lines (Table 6-25).

The diverted traffic volume from the shipping lines is calculated on the assumption that all the diverted cargo (Table 6-26) will be handled by 4-ton lorries.

2) Diverted Traffic from Detour Route

So far as inland transportation is concerned, the Tunduru-Dar es Salaam section will benefit most from the traffic diversion by reason of its long travel time, much operating cost and OD distribution.

First, the demand of traffic between Tunduru and Dar es Salaam is determined. Then, the prospective diverted traffic is estimated from the ratio of the traffic cost on the existing coastal road to that on this detour route in order to exclude the effect of the future traffic demand already estimated by the GDP growth rate method.

Finally, the diverted traffic volume is determined by applying the ratio of deour route cost to the improved coastal road cost to the traffic determined above.

Namely, it is determined according to the flow chart in Fig. 6-9 on the assumption that the ratio of the running costs will be a paramount determinant.

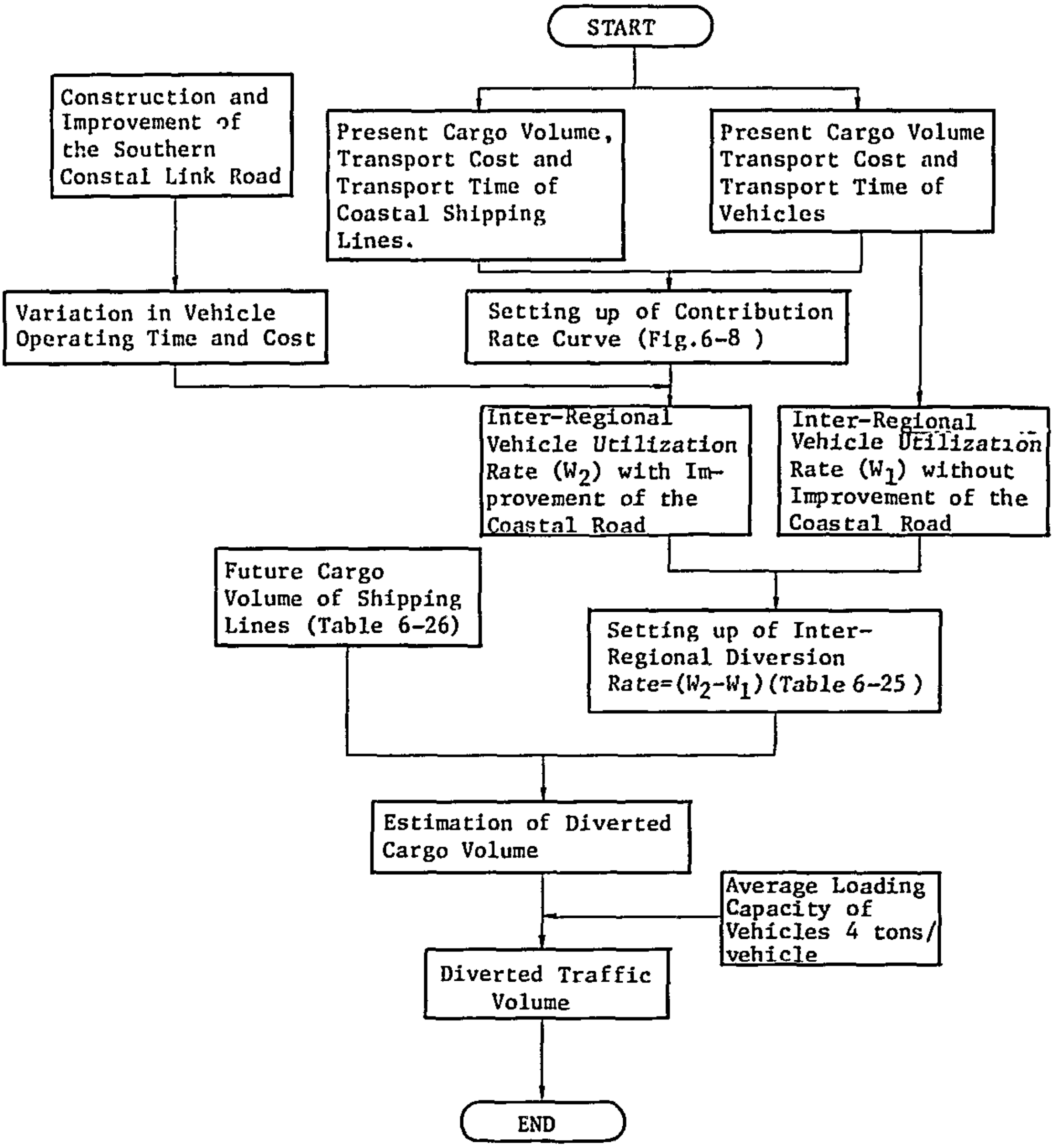


Fig. 6-7 Flow Chart for Forecast of Traffic Diversion from Shipping Lines to Southern Coastal Road

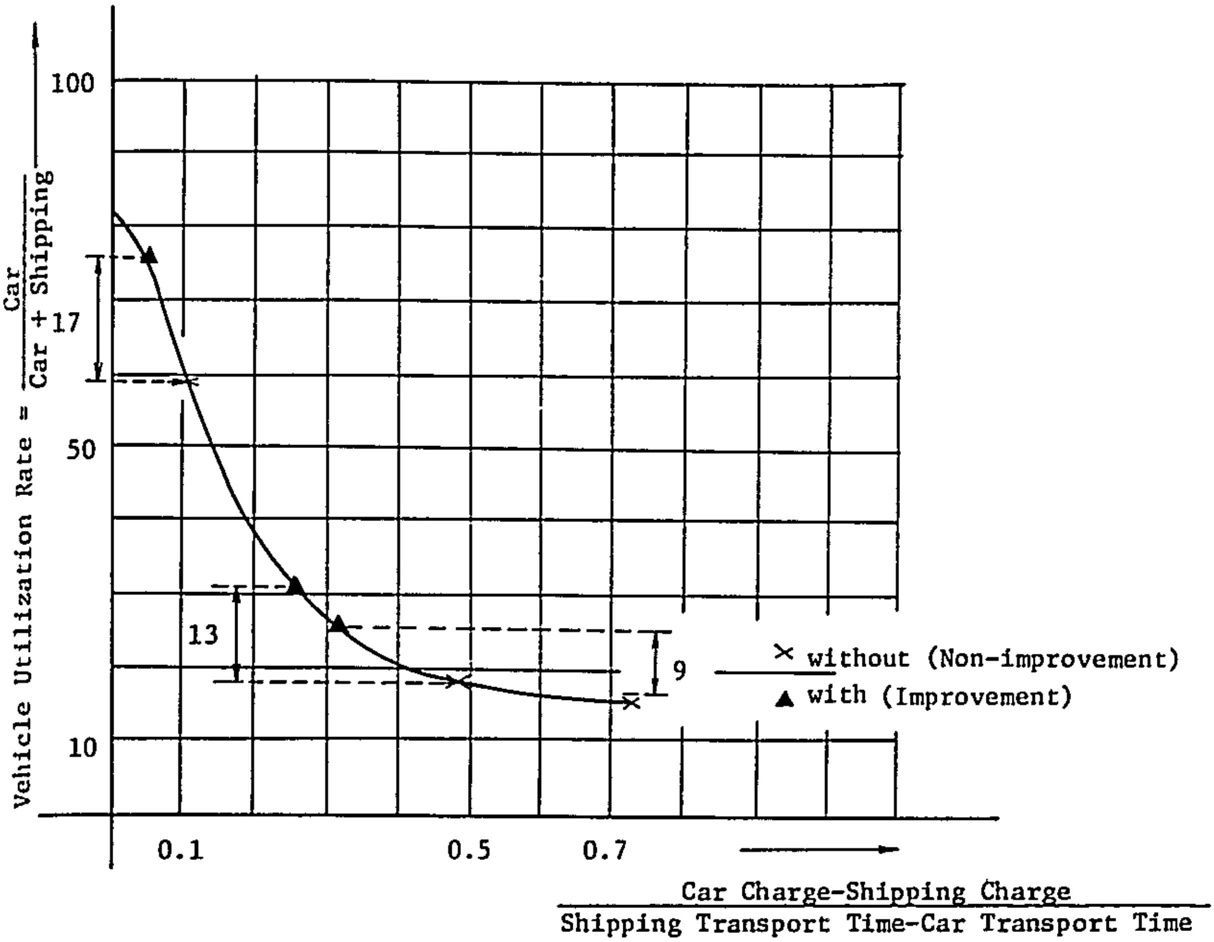


Fig. 6-8 Contribution Rate Curve for Determination of Traffic Volume Diversion Rate

Table 6-25 Diversion Rate

	DSM ∿Kilwa Masako	DSM ∿ Lindi	DSM ∿ Mtwara
Diversion Rate (%)	17	13	9

Table 6-26 Commodity Movement within Traffic Diversion Area (ton/year)

	1974	1982	1992	2002	2011
DSM ∿ Kilwa	2728	3183	3996	4832	5575
DSM ∿ Lindi	8758	10240	12856	15547	17939
DSM ∿ Mtwara	89580	124955	156878	189713	218900
Total	101066	138378	173730	210092	242414
Ratio, Target year/1974	1.00	1.37	1.72	2.08	2.40

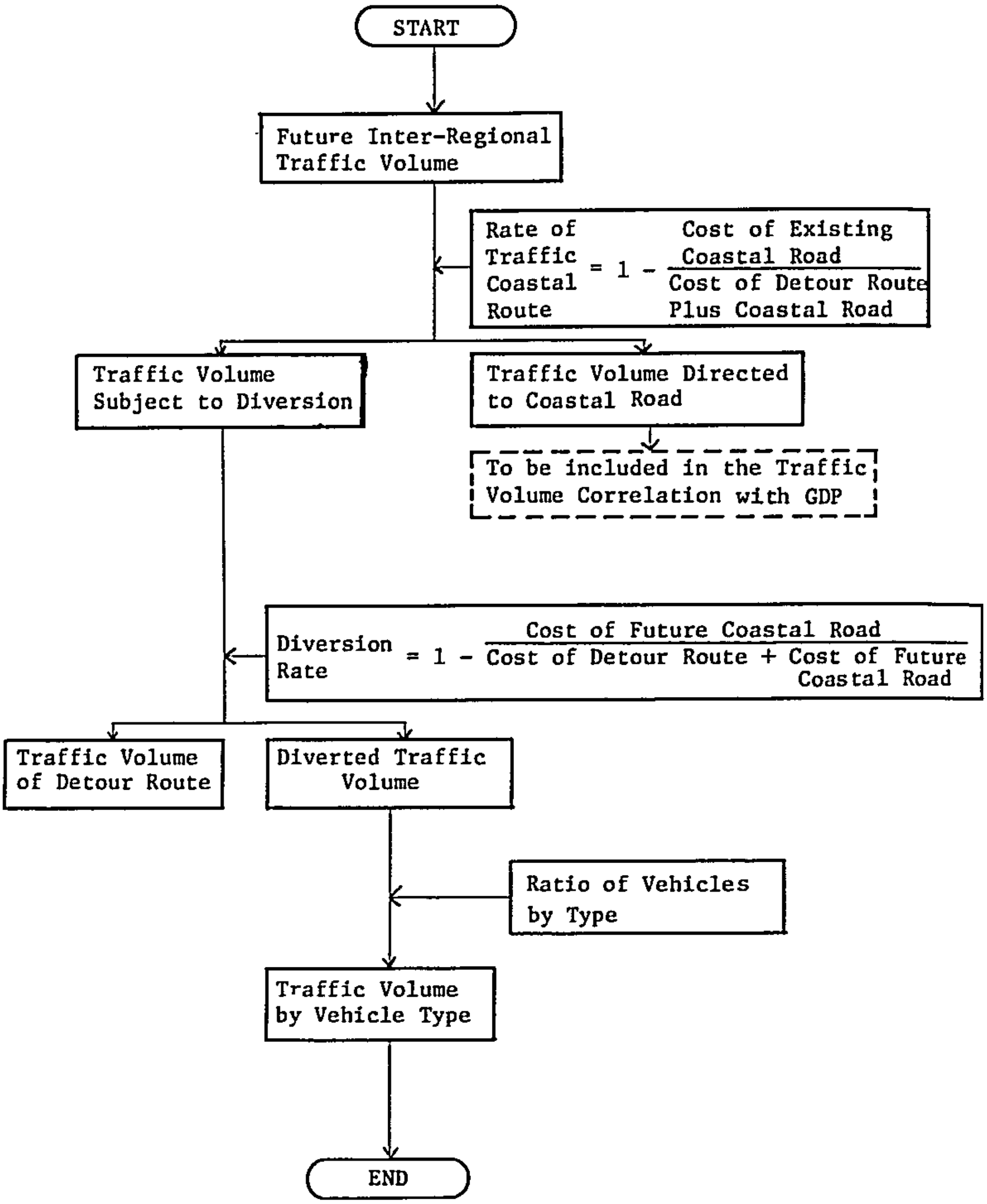


Fig. 6-9 Flow Chart for Forecast of Diverted Traffic Volume from Detour Route to Coastal Road

6.3.4 Composition of Types of Vehicles Running on the Southern Coastal Link Road

The composition of the types of vehicles running on the existing road changes from place to place, reflecting the local traits as signified by income level, degree of urbanization, road conditions, and industrial and economic conditions. In and around the cities, a number of passenger cars are used for the purpose of business, commutation, going to school and tourism. The farther from the cities we go, the lower becomes the utilization of the passenger cars, and the larger becomes the use of vans, pickups and lorries for cargo transportation, partly because of poor road conditions.

The composition of vehicle types is considered a function of traffic volume; generally, the ratio of passenger cars to the total becomes higher as the traffic volume goes up. The type-wise vehicular traffic data obtained in the past on the Southern Coastal Link Road also attests to this phenomenon, though it shows a dispersion. As regards the vans, lorries and buses, however, the data are too much dispersed to present a definite pattern.

The films taken by Lyon Associates, Inc. are used to grasp the close correlation between the types of vehicles and traffic volume in Tanzania, and their analytical results are compared with the analytical results of the traffic survey data obtained by COMWORKS and other organs. It is found that the correlation between the types of vehicles and the traffic volume is justfiable.

The correlation thus obtained is given in Table 6-27.
By dint of this table, Lyon Associates, Inc. was able to estimate the composition of vehicle types on the major arteries and local roads all over Tanzania.

Table 6-27 Classification of Vehicle Types by Traffic Volume

Daily Traffic Volume	Composition of types of vehicles, %			
	Cars	Vans	Lorries	Buses
0 - 100	16	35	31	18
101 - 200	20	35	29	16
201 - 400	25	34	27	14
401 - 700	30	34	24	12
701 - 1,000	34	34	22	10
1,001 - 1,500	38	32	22	8
1,501 - 2,000	42	30	22	6
2,001 - 3,000	44	30	20	6
3,001 - 4,000	48	28	19	5
over 4,000	50	26	16	8

Source: Economic and Engineering Study
Tanzania Highway, Lyon Associates, Inc.

Judging from the composition of the vehicle types on the Southern Coastal Link Road estimated using past traffic data, it is unreasonable to directly apply the values on Table 6-27 to the Road. The composition of the types of vehicles running on the Southern Coastal Link Road is studied here, accordingly.

The composition of the types of vehicles observed on the Southern Coastal Link Road in the past is shown in Table 6-28 below.

Table 6-28 Composition of the Types of Vehicles on the Southern Coastal Link Road

Census point	Date	Composition, %				Daily traffic (vehicles/day)
		Cars	Vans	Lorries	Buses	
Kibiti-Ikwiriri (south of Kibiti)	Sept., '74	6.9	12.9	56.2	24.0	72
Kibiti-Utete (west of Kibiti)	-ditto-	0.8	16.8	67.2	15.2	42
Utete-Nyamwage (south of Utete)	-ditto-	3.4	41.4	55.2	0	10
Nyamwage-Mohoro (south of Nyamwage)	Oct., '74	3.9	16.9	54.5	24.7	39
Kilwa-Lindi (south of Kilwa)	July,'73	0	17.2	65.6	17.2	32
Lindi-Kilwa (north of Lindi)	-ditto-	1.7	24.3	49.7	24.3	38
Lindi-Mtwara (south of Lindi)	-ditto-	8.6	26.1	54.3	11.0	97
Average, %		5.1	20.6	56.8	17.5	

The composition at the census points around the Southern Coastal Link Road other than the above is as shown in Table 6-29 below.

Table 6-29 Composition of the Types of Vehicles on the Peripheral Roads around the Southern Coastal Link Road

Census point	Date	Composition, %				Daily traffic (vehicles/day)
		Cars	Vans	Lorries	Buses	
Kibiti- Dar es Salaam (north of Kibiti)	Sept.,'74	5.7	21.7	41.5	31.1	71
Lindi- Masasi (west of Lindi)	July,'73	6.4	36.5	34.6	22.5	93
Mtwara-Newara (west of Mtwara)	-ditto-	1.0	32.0	49.8	17.2	68
Newara-Mtwara (east of Newara)	-ditto-	1.4	38.7	32.0	27.9	49
Masasi- Nanganga (east of Masasi)	Apr.,'75	3.1	32.8	38.1	26.0	44
Mingoyo- Mtwara (south of Mingoyo)	-ditto-	5.2	20.8	58.4	15.6	58
Mingoyo Mtwara (west of Mingoyo)	-ditto-	0.5	25.5	49.0	25.0	69
Average, %		3.5	29.7	43.3	23.5	

The census points shown in Table 6-29 lie in the vicinity of the local cities, such as Mtwara, Lindi, Masasi and Kibiti, and the road conditions are comparatively well. In addition, there are many bus routes, and the ratio of buses in the composition is high, naturally.

The ratio of the passenger cars on and around the Southern Coastal Link Road is very small compared with the all-Tanzania average. For this, the following two reasons are considered.

1) The Southern Coastal Link Road, for the most part, is left bare and unpaved and is not so good as to permit the running of passenger cars. The passenger cars, let them force their way, will be damaged seriously to their great cost. Once stalled on their way, their repairs will be hard.

2) The local income level is not so high as to permit the use of passenger cars. The bus is more economical instead.

From Tables 6-27 through 6-29, and with account taken of the local characteristics of the Southern Coastal Link Road and the compositional patterns of the types of vehicles in Tanzania, the composition of the types of vehicles on the Southern Coastal Link Road is projected in Table 6-30.
This table is modified a little and shown in Fig.6-10.

Table 6-30 Composition of the Types of Vehicles on the Southern Coastal Link Road

Daily Traffic (vehicles/day)	Cars	Vans	Lorries	Buses	Total
0 - 100	5	20	57	18	100
101 - 200	10	20	54	16	100
201 - 400	17	19	50	14	100
401 - 700	25	19	44	12	100
701 - 1,000	31	19	40	10	100
1,001 - 1,500	34	18	40	8	100
1,501 - 2,000	37	17	40	6	100

The traffic volume by type in future is determined by applying the ratios specified in Table 6-30 and Fig. 6-10 after forecasting of the total traffic volume.

FIG.
6 - 10

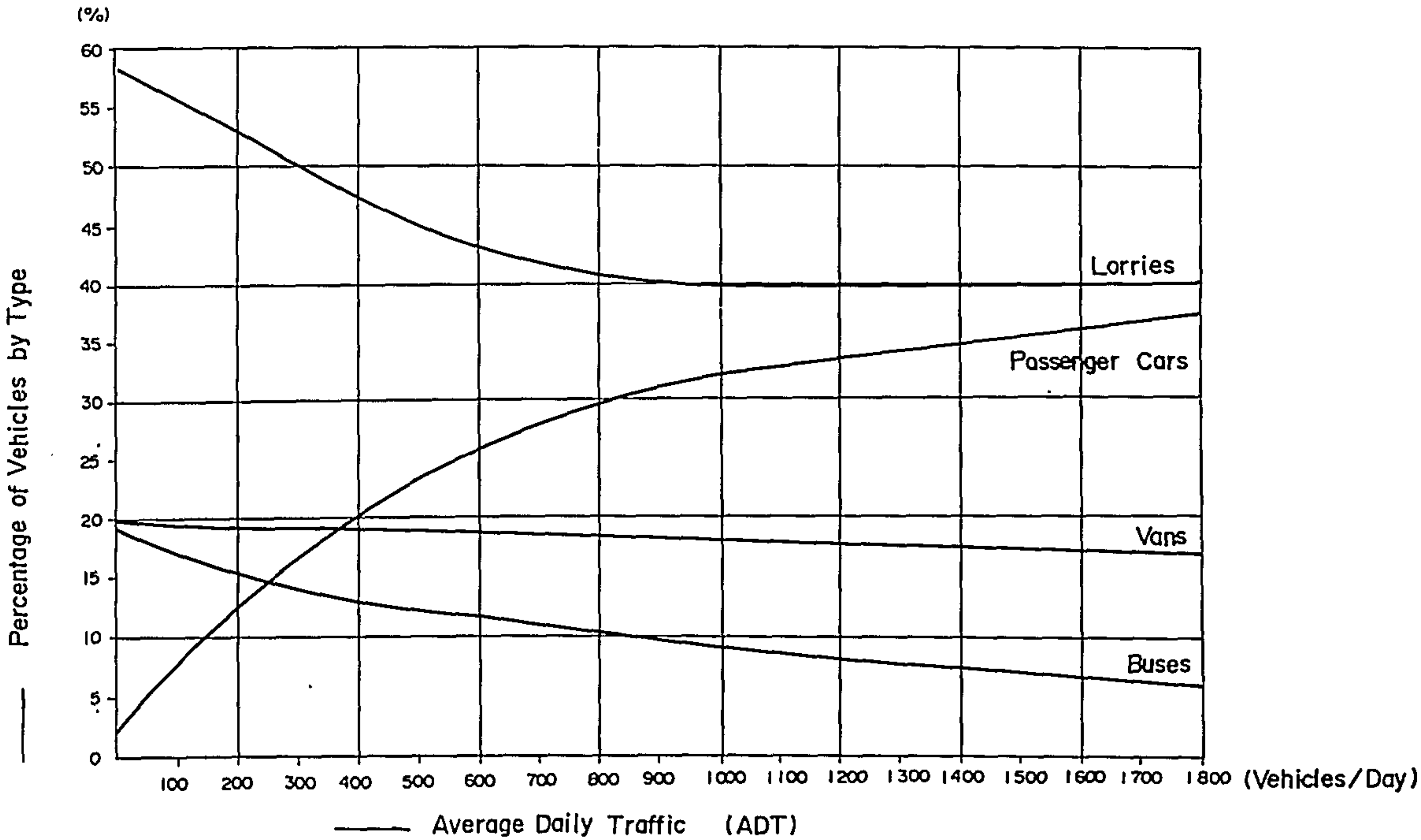


FIG. 6-10	SOUTHERN COASTAL LINK ROAD PROJECT
	RELATIONSHIP BETWEEN TRAFFIC VOLUME AND VEHICLE CLASSIFICATION

6.3.5 Results of Future Traffic Forecast

1) Plan Subjected to the Forecast of Future Traffic Volume

With due consideration given to the findings and results of the interim reports and also to the results of discussions made thereafter, the design speed, route, cross section of the road, pavement structure, lane arrangement and other various factors are scanned mainly from a technical point of view, and two plans A (basic plan) and B are taken up for appraisal. For each plan and for each work section, two cases - (1) one with a bridge over the Ruvuma and (2) the other without - are studied for the forecast of traffic volume and the economic appraisal.

1. Plan A (basic plan)

   The entire route is completed with a two-lane engineered gravel road by 1983. In 1993, ten years later, when the traffic volume will be beginning to increase, the paving work will be started to be completed in 1996 for the entire route.

2. Plan B

   The consturction work is started in 1978, and the pavement of the entire route will be completed in 1983.

In the stage of the interim report, the traffic projection and economic evaluation were carried out for each work section and for each of the following four plans.

In this final report, however, the plans are screened to the above two after a series of studies and discussions.

Plans taken as Subjects of Evaluation in the Interim Report

No. 1 plan (basic plan): A plan in which the entire route is paved into a two-lane type from the beginning.

No. 2 plan: A plan in which the Kibiti-Nyamwage section which has a larger traffic compared with other sections is completed with a two-lane structure with the other sections (No. 2 through No. 5 section) in a single lane type, and then in keeping with the traffic increase the entire route is transformed into the type of the basic plan.

No. 3 plan: Almost the same as No. 2 plan, but different in that the shouldering for the work sections, No. 2 through 5, is not carried out in the first stage.

No. 4 plan: A plan in which the entire route is completed with an engineered gravel road at first and then modified into the type of the basic plan.

2) Results of the Future Traffic Forecast

The future traffic volumes forecast by plan, by case, by section, by type of vehicle and by year are given in Tables 6-31 through 6-34, respectively.

Table 6-31 Daily Traffic Volume by Plan by Case

Plan A (Basic Plan) Case 1

(Vehicles/Day)

Road Section	Type of Traffic	1973	1983	1993	1996	2003	2012
1 Kibiti ∿ Nyamwage	Normal Traffic	95	155	252	292	411	637
	Generated Traffic	-	26	28	33	33	33
	Diverted Traffic	-	11	12	15	19	24
	Total	95	192	292	340	463	694
2 Nyamwage ∿ Nangurukuru	Normal Traffic	50	81	133	154	216	335
	Generated Traffic	-	15	17	18	18	18
	Diverted Traffic	-	11	12	15	19	24
	Total	50	107	162	187	253	377
3 Nangurukuru ∿ Kiranjerange	Normal Traffic	40	65	106	123	173	268
	Generated Traffic	-	11	13	15	15	15
	Diverted Traffic	-	10	11	14	18	23
	Total	40	86	130	152	206	306
4 Kiranjerange ∿ Lindi	Normal Traffic	40	65	106	123	173	268
	Generated Traffic	-	11	13	15	15	15
	Diverted Traffic	-	10	11	14	18	23
	Total	40	86	130	152	206	306
5 Nangurukuru ∿ Kilwa Masoko	Normal Traffic	30	49	80	92	130	201
	Generated Traffic	-	9	10	11	11	11
	Diverted Traffic	-	1	1	1	1	1
	Total	30	59	91	104	142	213

Table 6-32 Daily Traffic Volume by Plan by Case

Plan A (Basic Plan) Case 2

(Vehicles/Day)

Road Section	Type of Traffic	1973	1983	1993	1996	2003	2012
1 Kibiti ∿ Nyamwage	Normal Traffic	95	170	334	409	658	1209
	Generated Traffic	-	29	31	37	37	37
	Diverted Traffic	-	11	12	15	19	24
	Total	95	210	377	461	714	1270
2 Nyamwage ∿ Nangurukuru	Normal Traffic	50	90	177	217	348	640
	Generated Traffic	-	17	20	21	21	21
	Diverted Traffic	-	11	12	15	19	24
	Total	50	118	209	253	388	685
3 Nangurukuru ∿ Kiranjerange	Normal Traffic	40	72	142	174	279	512
	Generated Traffic	-	12	14	17	17	17
	Diverted Traffic	-	10	11	14	18	23
	Total	40	94	167	205	314	552
4 Kiranjerange ∿ Lindi	Normal Traffic	40	72	142	174	279	512
	Generated Traffic	-	12	14	17	17	17
	Diverted Traffic	-	10	11	14	18	23
	Total	40	94	167	205	314	552
5 Nangurukuru ∿ Kilwa Masoko	Normal Traffic	30	54	106	130	209	384
	Generated Traffic	-	10	11	12	12	12
	Diverted Traffic	-	1	1	1	1	1
	Total	30	65	118	143	222	397

Table 6-33 Daily Traffic Volume by Plan by Case

Plan B Case 1

(Vehicles/Day)

Road Section	Type of Traffic	1973	1983	1993	2003	2012
1 Kibiti ∿ Nyamwage	Normal Traffic	95	155	252	411	637
	Generated Traffic	-	31	33	33	33
	Diverted Traffic	-	11	12	19	24
	Total	95	197	297	463	694
2 Nyamwage ∿ Nangurukuru	Normal Traffic	50	81	133	216	335
	Generated Traffic	-	16	18	18	18
	Diverted Traffic	-	11	12	19	24
	Total	50	108	163	253	377
3 Nangurukuru ∿ Kiranjerange	Normal Traffic	40	65	106	173	268
	Generated Traffic	-	13	15	15	15
	Diverted Traffic	-	10	11	18	23
	Total	40	88	132	206	306
4 Kiranjerange ∿ Lindi	Normal Traffic	40	65	106	173	268
	Generated Traffic	-	13	15	15	15
	Diverted Traffic	-	10	11	18	23
	Total	40	88	132	206	306
5 Nangurukuru ∿ Kilwa Masoko	Normal Traffic	30	49	80	130	201
	Generated Traffic	-	10	11	11	11
	Diverted Traffic	-	1	1	1	1
	Total	30	60	92	142	213

Table 6-34 Daily Traffic Volume by Plan by Case

Plan B Case 2

(Vehicles/Day)

Road Section	Type of Traffic	1973	1983	1993	2003	2012
1 Kibiti ∿ Nyamwage	Normal Traffic	95	170	334	658	1209
	Generated Traffic	-	34	37	37	37
	Diverted Traffic	-	11	12	19	24
	Total	95	215	383	714	1270
2 Nyamwage ∿ Nangurukuru	Normal Traffic	50	90	177	348	640
	Generated Traffic	-	18	21	21	21
	Diverted Traffic	-	11	12	19	24
	Total	50	119	210	388	685
3 Nangurukuru ∿ Kiranjerange	Normal Traffic	40	72	142	279	512
	Generated Traffic	-	15	17	17	17
	Diverted Traffic	-	10	11	18	23
	Total	40	97	170	314	552
4 Kiranjerange ∿ Lindi	Normal Traffic	40	72	142	279	512
	Generated Traffic	-	15	17	17	17
	Diverted Traffic	-	10	11	18	23
	Total	40	97	170	314	552
5 Nangurukuru ∿ Kilwa Masoko	Normal Traffic	30	54	106	209	384
	Generated Traffic	-	11	12	12	12
	Diverted Traffic	-	1	1	1	1
	Total	30	66	119	222	397

6.4 Vehicle Operating Cost

The vehicle operating cost is calculated according to the references 1)* and 2)* and following the processes explained below.

1) The values of the fuel, lubricants, tires and brand-new car as of October, 1975, are dissected into respective retail prices, sales taxes, duties and profits in order to calculate the net prices of fuel, lubricants and tire and the car by type.

2) Then, these net prices are applied to calculate the fuel cost, lubricant cost and tire cost by type of vehicle (car, pickup, 9-ton truck and 50-passenger bus), by topography (flat to rolling, rolling to hilly and hilly to mountainous) and by road condition (bitumen, gravel and earth).

   The cost calculation is carried out by type of vehicle, by topography and by road condition.

3) The maintenance labour cost and the cost of maintenance parts are calculated using respectively the labour cost and average value of vehicle.

4) The wage is calculated using the driver's wage and mean working time.

5) The depreciation cost, interest and insurance are calculated.

6) The costs calculated in steps 1) through 5) are summed up.

The vehicle operating cost by type of vehicle, topography and by road condition are shown in Tables 6-35 through 6-37.

Notes: * Jan de Weille, "Quantification of Road User Savings" (International Bank for Reconstruction and Development)

** Lyon Associates, Inc., "Economic and Engineering Study, Tanzania Highway"

In Tables 6-35 through 6-37, the vehicle operating costs on the engineered gravel, improved earth and earth roads in the hilly and mountainous areas are high for the trucks than for buses.

The reasons are as follows.

According to Jan de Weille's method, the fuel consumption by truck is 2.2 times as much as by bus in the hilly and mountainous areas. By the oil shock we have been experiencing since 1973, the fuel cost has been sent up high; the net prices of gasoline and diesel oil as of October 1975 were 3 times and 4.1 times higher than those in 1971.

The poorer the topography and the road condition are, the larger the difference in fuel consumption between truck and bus will become to the disadvantage of truck.

Table 6-35 Summary of Vehicle Operating Costs on Varying Quality of Surface - Flat to Rolling Terrain

(Tanzanian Cents per Vehicle-Kilometer)

Type and Quality of Surface	Cars	Pickups	Trucks	Buses
A. Bitumen				
1) Good	59.32	67.47	171.75	185.57
2) Poor	74.15	84.34	214.69	231.96
3) Bad	100.84	114.70	291.98	315.47
B. Engineered Gravel				
1) Good	69.13	79.14	222.46	243.13
2) Poor	89.87	102.88	289.20	316.07
3) Bad	120.98	138.50	389.31	425.48
C. Improved Earth				
1) Good	73.82	84.79	240.69	271.03
2) Poor	95.97	110.23	312.90	352.34
3) Bad	129.19	148.38	421.21	474.30
D. Earth				
1) Good	98.25	119.91	420.20	432.59
2) Poor	117.90	143.89	504.24	519.11
3) Bad	157.20	191.86	672.32	692.14

Table 6-36 Summary of Vehicle Operating Costs on Varying Quality of Surface - Rolling to Hilly

(Tanzanian Cents per Vehicle-Kilometer)

Type and Quality of Surface	Cars	Pickups	Trucks	Buses
A. Bitumen				
1) Good	61.49	69.34	174.28	188.22
2) Poor	76.86	86.68	217.85	235.28
3) Bad	104.53	117.88	296.28	319.97
B. Engineered Gravel				
1) Good	71.00	81.24	238.46	247.08
2) Poor	92.30	105.61	310.00	321.20
3) Bad	124.25	142.17	417.31	432.39
C. Improved Earth				
1) Good	75.26	86.96	267.82	275.80
2) Poor	97.84	113.05	348.17	358.54
3) Bad	131.71	152.18	468.69	482.65
D. Earth				
1) Good	100.54	123.15	449.92	446.71
2) Poor	120.65	147.78	539.90	536.05
3) Bad	160.86	197.04	719.87	714.74

Table 6-37 Summary of Vehicle Operating Costs on Varying Quality of Surface - Hilly to Mountainous Terrain

(Tanzanian Cents per Vehicle-Kilometer)

Type and Quality of Surface	Cars	Pickups	Trucks	Buses
A. Bitumen				
1) Good	63.75	76.12	193.97	205.37
2) Poor	79.69	95.15	242.46	256.71
3) Bad	109.38	129.40	329.75	349.13
B. Engineered Gravel				
1) Good	74.18	88.87	270.31	266.87
2) Poor	96.43	115.53	351.40	346.93
3) Bad	129.82	155.52	473.04	467.02
C. Improved Earth				
1) Good	79.12	94.85	307.18	295.81
2) Poor	102.86	123.31	399.33	384.55
3) Bad	138.46	165.99	537.57	517.67
D. Earth				
1) Good	111.23	140.17	525.08	480.62
2) Poor	133.48	168.20	630.10	576.74
3) Bad	177.97	224.27	840.13	768.99

6.5 Economic Evaluation

6.5.1 Costs

The costs with which to appraise the project are tax-free construction costs (preparation costs, direct construction costs, indirect costs and supervising expenses) and the maintenance costs determined for each plan and for each section. (Taxes and duties are neglected from the costs.)

The yearly investment allocations of these costs vary depending on plan and section, and are determined according to an investment plan meeting the work schedule during the project life.

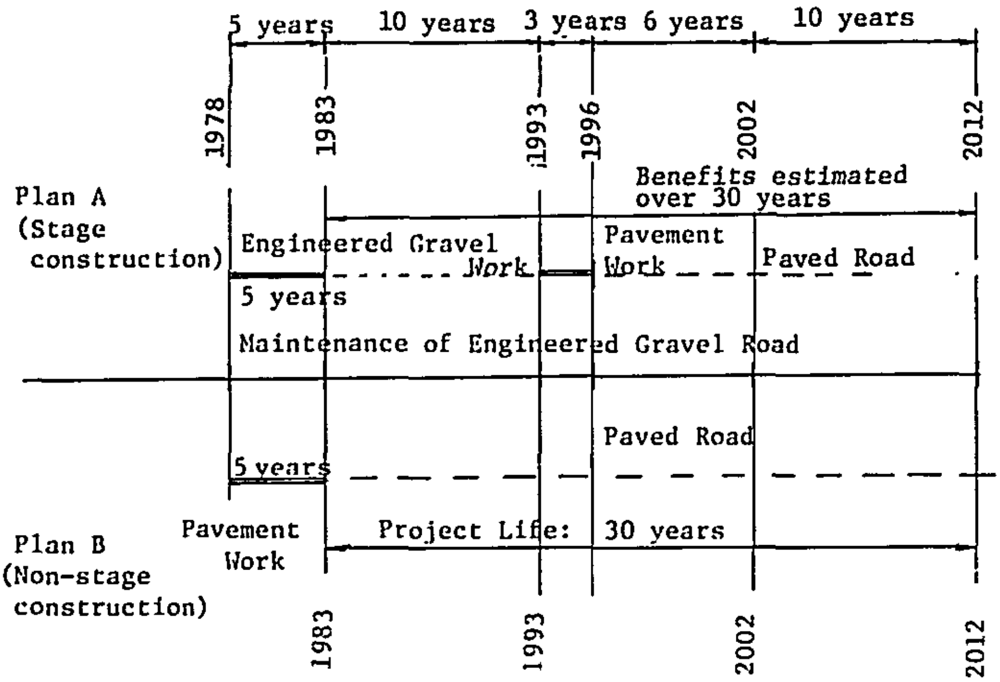
The investment plan is discussed in some detail in the following.

As shown in the work schedule in Fig. 6.11, if the implementation of the project is started in 1978 and completed in five years, the Sourhtern Coastal Link Road will be available to the public from 1983.

In Plan A (stage construction), the Road starts with engineered gravel and is improved ten years later to be a paved one; namely, the benefits are calculated on the assumption that it will serve as an engineered gravel road from 1983 to 1996 and then as a paved road from 1996 on.

In Plan B (non-stage construction), the construction work is scheduled to start in 1978 and end in 1983 when the paved road will be available to the public.

Fig.6-11 Work Schedule by Plan



The reference year for the computation of present worth value is set at 1978 when the implementation work will be started.
For computation, 1 Tanzanian shilling is set at ¥37.
The construction costs calculated are based on the prices as of October, 1975.

Periodic maintenance costs for repairs of road overlay and bridge repainting and yearly standing maintenance costs for each year and for each plan are summed up to calculate the total maintenance costs.

In the economic evaluation, "With and Without Comparison Method" is applied; namely, it is considered that after improvement of the earth road, the maintenance costs for the existing road can be dispensed with, and that the difference in maintenance cost between the new road and the existing road over the project life is reckoned as an economic cost.

6.5.2 Benefits

The direct benefits taken up in the economic evaluation are the following three.

1) Running benefits due to improvement or new construction of road.

2) Benefits resulting from cutting short the roundabout way between Dar es Salaam and the South via Iringa and Morongoro because of the improvement of the Southern Coastal Link Road.

3) Benefits resulting from partial diversion of cargo flow from coastal shipping lines to the Southern Costal Link Road.

The running benefits are calculated based on the road inventory of the existing and improved roads, future traffic volume by type of vehicle, and operating costs by type of vehicle.

The reduction of vehicle operating costs due to the improvement of road varies depending on type of vehicle; it is 50 to 60 % for cars and vans and 60 to 70 % for lorries and buses.

The benefits are also discussed in item 1) of 6.3.5 where the two plans (Plan A: stage construction; Plan B: non-stage construction) and two cases (Case 1: 5 % traffic volume increase; Case 2: 7 % traffic volume increase when the Southern Coastal Link Road assumes an international arterial role as a result of the construction of a bridge over the Ruvuma bordering on Mozambique) are discussed for future traffic projection and economic evaluation.

6.5.3 Appraisal of the Project

1) In the economic evaluation, yearly economic costs and benefits, internal rate of return and cost-benefit ratio are calculated for each of the two plans with twenty- and thirty-year project life, ±30 % of change in cost and benefit, and 5 % (Case 1) and 7 % (Case 2) of traffic volume increase as parameters.

A sensitivity analysis is made as to how the internal rate of return changes with change in costs and benefits. In this case, computation is made with either cost or benefit fixed.

Further, the internal rate of return was calculated also for a case in which only Section 1 is paved according to Plan A and the other sections are opened for traffic after finished with the first stage, i.e. as engineered gravel road, to serve throughout project life.

2) Yearly economic costs and benefits calculated as above are shown in Tables 6-38 and 6-39 as to both Plans A and B.

3) The internal rates of return and cost-benefit ratio are shown in Tables 6-40 and 6-41 as to each plan, each case and project life of twenty and thirty years.

According to Table 6-40, the internal rates of return for thirty- and twenty-year project life are in the range of 6.32 to 9.55 % and 3.23 to 6.32 %, respectively. Namely, the internal rate of return for a project life of twenty years is lower than that for a project life of thirty years. This is because the traffic volume increase is in geometric progression, and suggests that the benefits will increase with year and therefore that it is advantageous from an economic point of view to evaluate the project on a long-term basis.

According to Tables 6-40 and 6-41, Plan A is more advantageous than Plan B in terms of economy. In other words, it means that it is more preferable to construct a gravel road at a low cost when the traffic volume remains low and then improve it into a paved one with increase in the traffic volume than to construct a paved road on a wholesale scale from the beginning. On the other hand, the internal rate of return by section shows that No. 1 section with a great deal of traffic is most significant from the economic viewpoint. The internal rate of return for No. 1 section lies in the range of 9.91 % to 15.84 % for each of plans, cases and project life.

After No. 1 section, follow Nos. 2, 5, 3 and 4 sections, with only a small difference between the last two in the internal rate of return. It is accordingly more practical to work on No. 4 section prior to No. 3 section judging from the course of work.

4) The relationships between discount rate, cost, benefit and cost-benefit ratio for Plans A and B are given in Figs. 6-12 and 6-13. From Figs. 6-12 and 6-13, it is found that Plan B in Fig. 6-13 shows larger cost and benefit while Plan A in Fig. 6-12 shows larger B/C. Namely, Plan A is still advantageous over Plan B.

   The results of sensitivity analysis are shown in Figs. 6-14 and 6-15. It is found that, for the same plan, the decline of the internal rate of return is developed more noticeably by the reduction of benefits than by the increase of costs. To put it another way, the reduction of internal rate of return is more sensitive to the reduction of benefits than the increase of internal rate of return is to the increase of benefits.

   Also, the reduction of the internal rate of return is less sensitive to the increase of costs, and the increase of internal rate of return is sensitive to the reduction of costs.

5) Table 6-40 shows the internal rate of return for a case in which only Section 1 is paved according to Plan A leaving the other sections as finished with the first stage of the plan, i.e. as engineered gravel road, to serve throughout project life.
   As can be seen, the internal rate of return for a thirty-year project life is within the range from 6.21 to 13.45 % and from 8.81 to 15.84 % at the traffic increase rates in Case 1 and Case 2 respectively, a slight increase over the values for Plan A.

6) The foregoing has discussed from every point the results of economic evaluation. But the Southern Coastal Link Road will have very powerful social effects as a major land transportation line linking together Metropolitan Dar es Salaam and the southern regions.

These effects can be broadly classified into direct effects such as utilization of the road and the increase in general demand accompanying the construction, and indirect effects both enumerated in Fig. 6-16. The diagram gives the idea of correlations and influence of such effects spreading from one to others.

Some of the direct effects that are given in the diagram have already been discussed as economic benefits in terms of economic values.

On the other hand, the Road will have immeasurable indirect effects in increasing the administrative efficiency between the capital and the south and improving the welfare and cultural level of the regional inhabitants as well as in expediting the development of industries, national market, production and distribution of commodities, and effective use of land and labour force.

Table 6-38 Yearly Economic Costs and Benefits (Plan A)

(1,000 shs.)

Year		Economic Costs			Benefits	
		Construction Costs	Maintenance and Repair Costs	Total	Case 1	Case 2
1	1978	54,991		54,991		
2	1979	80,042		80,042		
3	1980	86,035		86,035		
4	1981	90,877		90,877		
5	1982	105,764	1,007	106,771		
6	1983		3,413	3,413	29,931	32,781
7	1984		3,413	3,413	31,408	35,269
8	1985		3,413	3,413	32,885	37,756
9	1986		3,413	3,413	34,362	40,244
10	1987		19,937	19,937	35,839	42,732
11	1988		19,573	19,573	37,315	45,219
12	1989		3,413	3,413	38,792	47,707
13	1990		3,413	3,413	40,269	50,195
14	1991		3,413	3,413	41,746	52,683
15	1992		4,790	4,790	43,223	55,170
16	1993	26,796	3,413	30,209	44,700	57,658
17	1994	87,626	3,413	91,039	47,527	61,909
18	1995	68,071	3,413	71,484	50,355	66,159
19	1996		3,413	3,413	61,429	81,321
20	1997		28,227	28,227	64,609	87,197
21	1998		27,863	27,863	67,790	93,073
22	1999		3,413	3,413	70,970	98,949
23	2000		3,413	3,413	74,150	104,825
24	2001		3,413	3,413	77,330	110,701
25	2002		29,240	29,240	80,511	116,577
26	2003		27,863	27,863	83,690	122,453
27	2004		3,413	3,413	88,113	131,514
28	2005		3,413	3,413	92,535	140,574
29	2006		3,413	3,413	96,958	149,634
30	2007		28,227	28,227	101,380	158,694
31	2008		27,863	27,863	105,803	167,754
32	2009		3,413	3,413	110,225	176,814
33	2010		3,413	3,413	114,648	185,874
34	2011		3,413	3,413	119,070	194,934
35	2012		29,240	29,240	123,493	203,994
Total	Project Life: 20 Yrs.	600,202	178,419	778,621	1,005,141	1,318,125
	Project Life: 30 Yrs.	600,202	312,090	912,292	2,041,056	2,950,364

Table 6-39 Yearly Economic Costs and Benefits (Plan B)

(1,000 shs.)

Year		Economic Costs			Benefits	
		Construction Costs	Maintenance and Repair Costs	Total	Case 1	Case 2
1	1978	56,318		56,318		
2	1979	81,666		81,666		
3	1980	86,040		86,040		
4	1981	156,610		156,610		
5	1982	187,022	1,007	188,029		
6	1983		3,413	3,413	34,933	38,364
7	1984		3,413	3,413	36,716	41,242
8	1985		3,413	3,413	38,500	44,120
9	1986		3,413	3,413	40,283	47,000
10	1987		28,227	28,227	42,066	49,877
11	1988		27,863	27,863	43,849	52,755
12	1989		3,413	3,413	45,633	55,633
13	1990		3,413	3,413	47,416	58,511
14	1991		3,413	3,413	49,199	61,390
15	1992		29,240	29,240	50,983	64,268
16	1993		27,863	27,863	52,766	67,146
17	1994		3,413	3,413	55,856	72,674
18	1995		3,413	3,413	58,945	78,202
19	1996		3,413	3,413	62,035	83,730
20	1997		28,227	28,227	65,124	89,258
21	1998		27,863	27,863	68,214	94,785
22	1999		3,413	3,413	71,304	100,313
23	2000		3,413	3,413	74,393	105,841
24	2001		3,413	3,413	77,483	111,369
25	2002		29,240	29,240	80,572	116,897
26	2003		27,863	27,863	83,662	122,424
27	2004		3,413	3,413	88,164	131,595
28	2005		3,413	3,413	92,666	140,765
29	2006		3,413	3,413	97,168	149,935
30	2007		28,227	28,227	101,671	159,105
31	2008		27,863	27,863	106,173	168,276
32	2009		3,413	3,413	110,675	177,446
33	2010		3,413	3,413	115,178	186,616
34	2011		3,413	3,413	119,680	195,786
35	2012		29,240	29,240	124,183	204,957
Total	Project Life: 20 Yrs.	567,656	243,899	811,555	1,096,270	1,433,375
	Project Life: 30 Yrs.	567,656	377,570	945,226	2,135,490	3,070,280

Table 6-40 Internal Rate of Return by Plan, Case and Section

(%)

Plan \ IRR	IRR (20 Years)		IRR (30 Years)	
	Case 1	Case 2	Case 1	Case 2
Plan A: -				
No.1 Section	11.59	14.15	13.45	15.84
No.2 Section	5.46	8.31	8.40	10.98
No.3 Section	-	3.12	4.69	7.47
No.4 Section	-	2.72	4.37	6.85
No.5 Section	1.21	5.37	5.97	9.23
Total	3.30	6.32	6.99	9.55
Plan B: -				
No.1 Section	9.91	12.39	11.72	14.05
No.2 Section	5.03	7.61	7.69	10.11
No.3 Section	0.41	3.29	4.41	6.90
No.4 Section	0.35	2.93	4.11	6.37
No.5 Section	1.04	3.99	4.66	7.37
Total	3.23	5.82	6.32	8.71

Table 6-41 Cost-Benefit Ratio by Plan, Section and Case

Plan	Section \ Discount Rate (%) \ Case	B/C (20 Years)										B/C (30 Years)									
		Case 1					Case 2					Case 1					Case 2				
		6	8	10	12	14	6	8	10	12	14	6	8	10	12	14	6	8	10	12	14
Plan A (Basic Plan)	No.1 Section	2.17	1.74	1.41	1.16	0.97	2.93	2.30	1.83	1.47	1.20	2.50	1.93	1.51	1.21	0.99	3.52	2.62	2.00	1.56	1.25
	No.2 Section	1.40	1.09	0.87	0.70	0.58	1.95	1.49	1.16	0.92	0.74	1.62	1.21	0.93	0.73	0.59	2.34	1.70	1.27	0.97	0.77
	No.3 Section	0.92	0.73	0.59	0.48	0.40	1.29	1.00	0.78	0.63	0.51	1.07	0.81	0.63	0.50	0.41	1.55	1.14	0.86	0.67	0.53
	No.4 Section	0.87	0.67	0.53	0.42	0.34	1.21	0.91	0.70	0.55	0.44	1.03	0.75	0.57	0.44	0.35	1.47	1.05	0.77	0.58	0.46
	No.5 Section	1.06	0.86	0.70	0.59	0.49	1.52	1.20	0.96	0.78	0.64	1.22	0.95	0.75	0.61	0.51	1.83	1.37	1.05	0.83	0.67
	Average	1.19	0.93	0.74	0.60	0.50	1.65	1.27	0.99	0.79	0.64	1.38	1.04	0.80	0.63	0.51	1.99	1.45	1.08	0.84	0.66
Plan B	No.1 Section	1.39	1.17	0.99	0.85	0.73	1.72	1.44	1.21	1.03	0.88	1.84	1.47	1.19	0.97	0.81	2.44	1.91	1.51	1.22	1.00
	No.2 Section	0.91	0.76	0.64	0.55	0.47	1.16	0.96	0.80	0.68	0.58	1.22	0.96	0.77	0.63	0.52	1.67	1.29	1.01	1.81	0.66
	No.3 Section	0.61	0.51	0.44	0.38	0.33	0.78	0.65	0.55	0.47	0.40	0.82	0.66	0.53	0.44	0.36	1.12	0.87	0.69	0.56	0.46
	No.4 Section	0.57	0.47	0.39	0.33	0.28	0.73	0.60	0.49	0.41	0.35	0.78	0.60	0.48	0.39	0.32	1.05	0.80	0.63	0.50	0.40
	No.5 Section	0.64	0.54	0.46	0.39	0.34	0.83	0.69	0.58	0.49	0.42	0.85	0.68	0.55	0.45	0.37	1.19	0.93	0.73	0.59	0.48
	Average	0.77	0.65	0.55	0.46	0.40	0.98	0.81	0.68	0.58	0.49	1.04	0.82	0.66	0.54	0.44	1.41	1.09	0.86	0.69	0.56

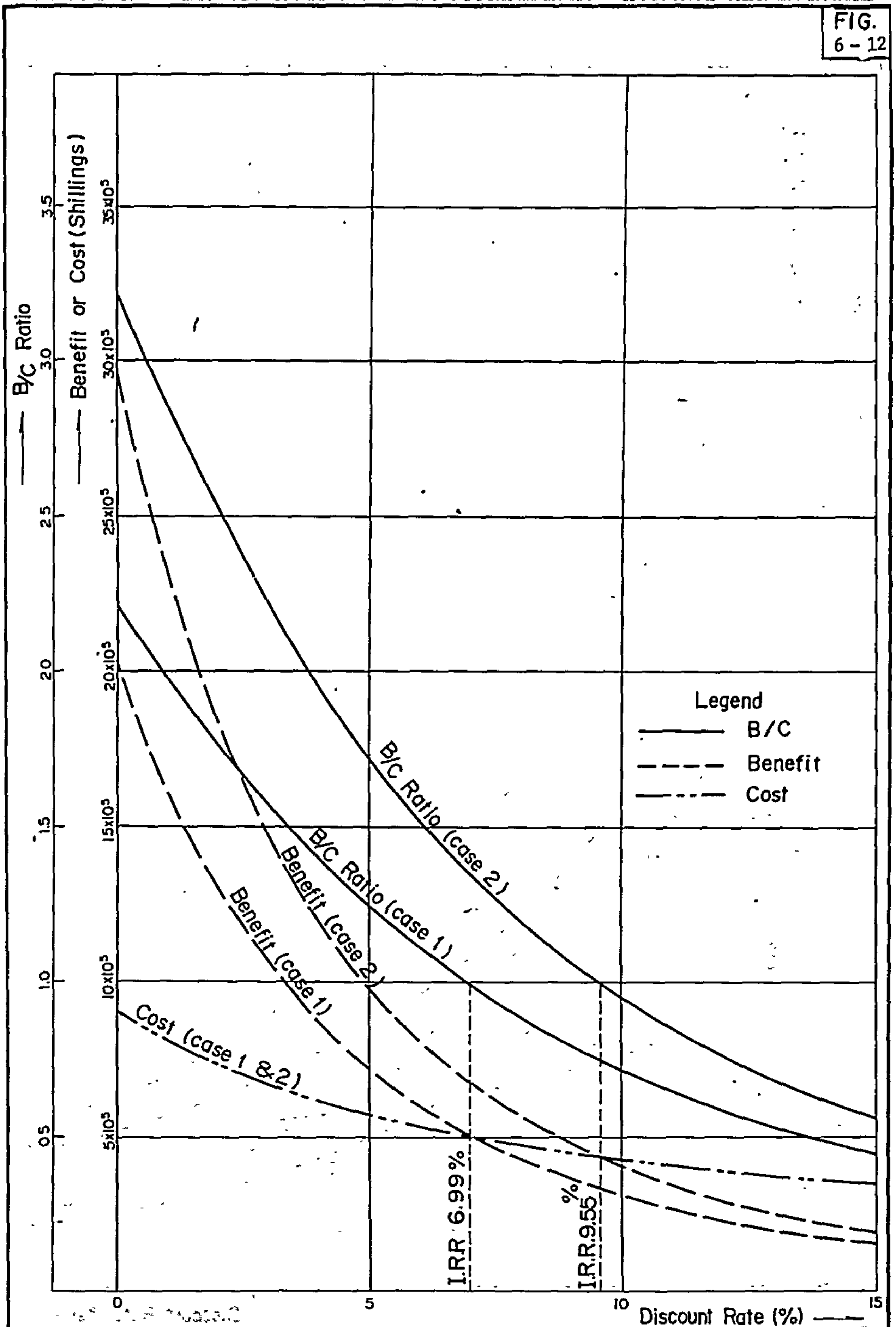


FIG. 6 - 12

SOUTHERN COASTAL LINK ROAD PROJECT

RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN A (Project Life : 30 Years)

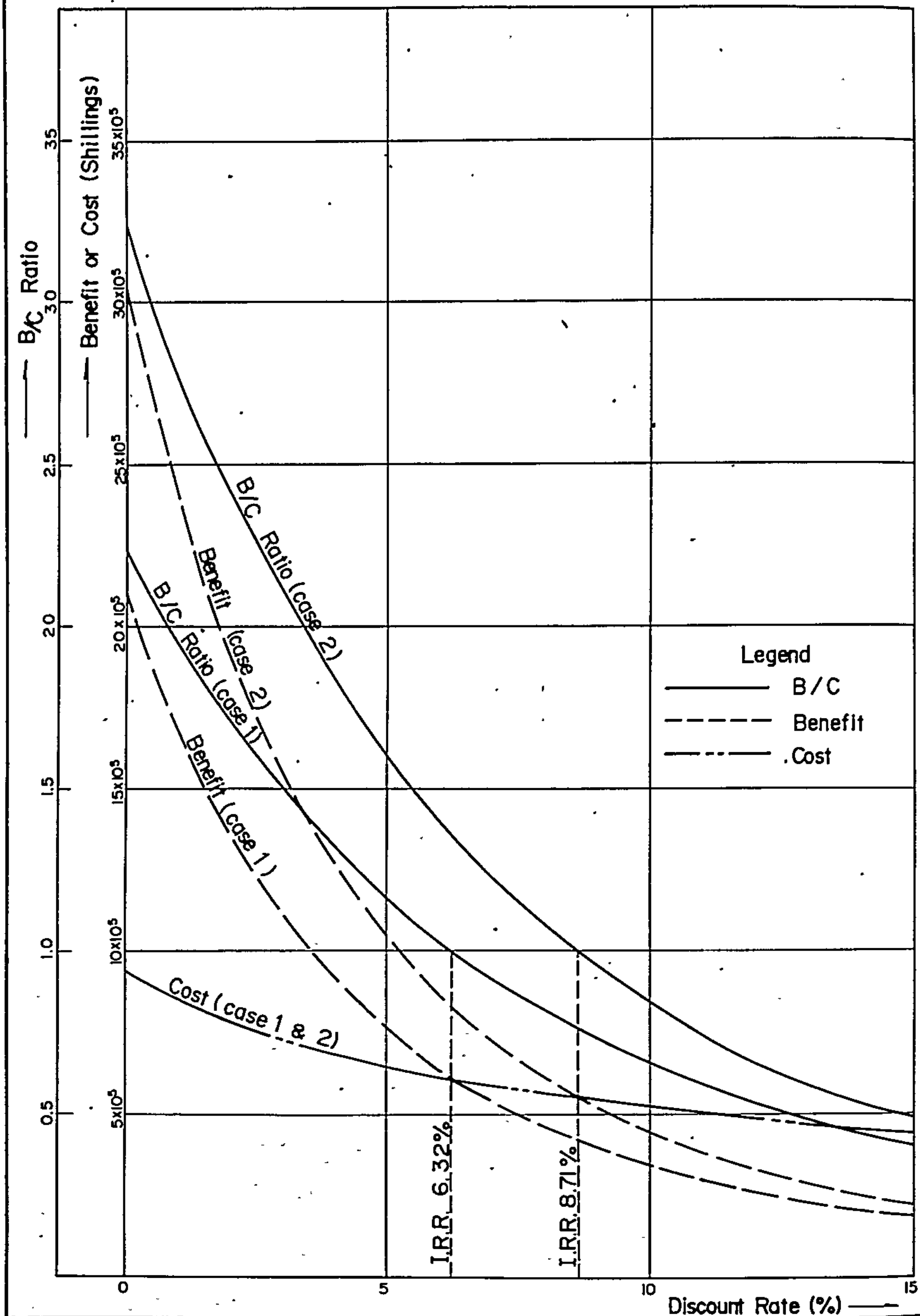


FIG. 6 - 13	SOUTHERN COASTAL LINK ROAD PROJECT RELATION BETWEEN B/C RATIO, COST, BENEFIT AND DISCOUNT RATE FOR PLAN B (Project Life 30 Years)

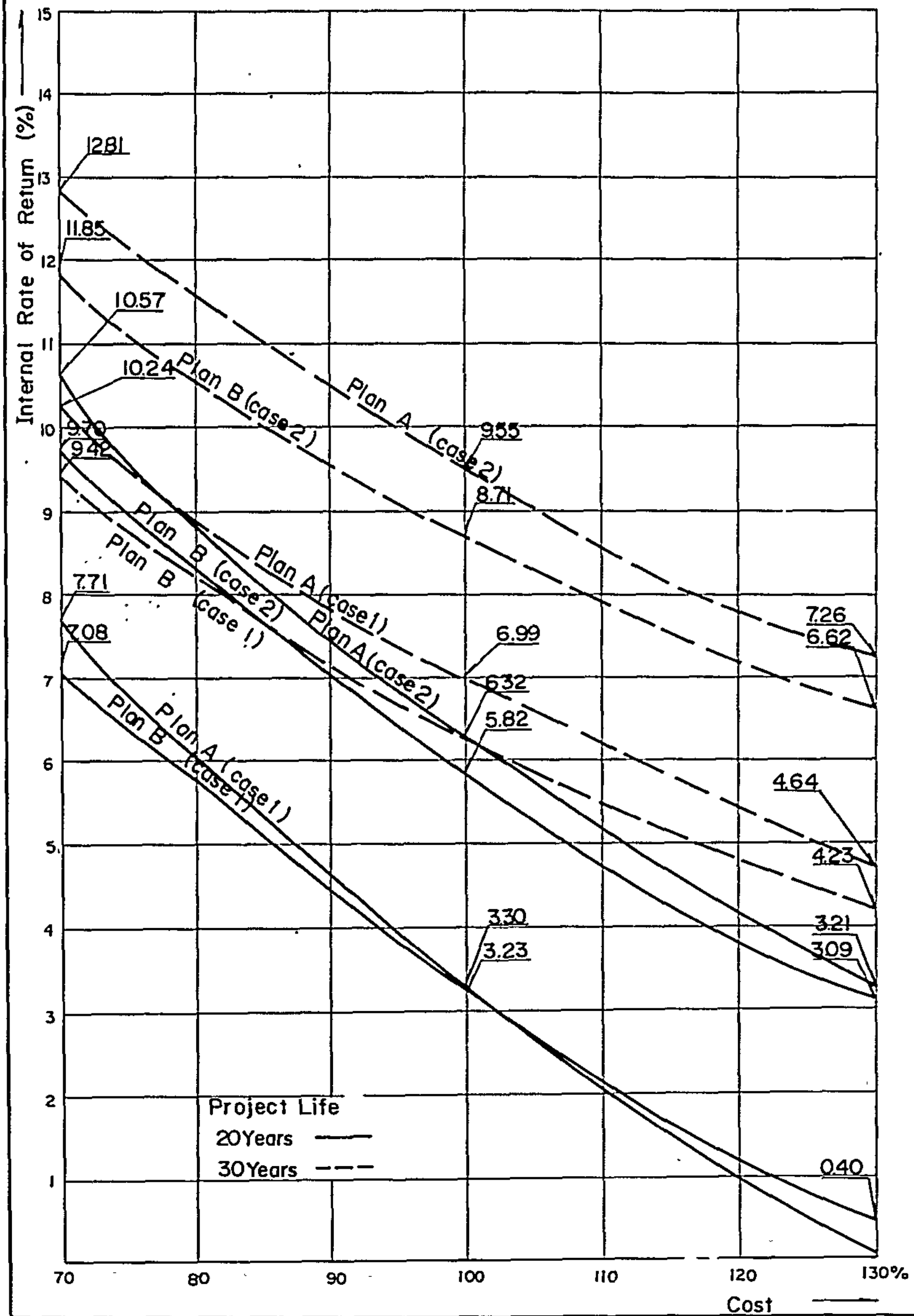


FIG.	SOUTHERN COASTAL LINK ROAD PROJECT
6-14	SENSITIVITY ANALYSIS (Benefit: 100%, Cost: ± 30%, Project Life: 20&30 years)

FIG. 6-15

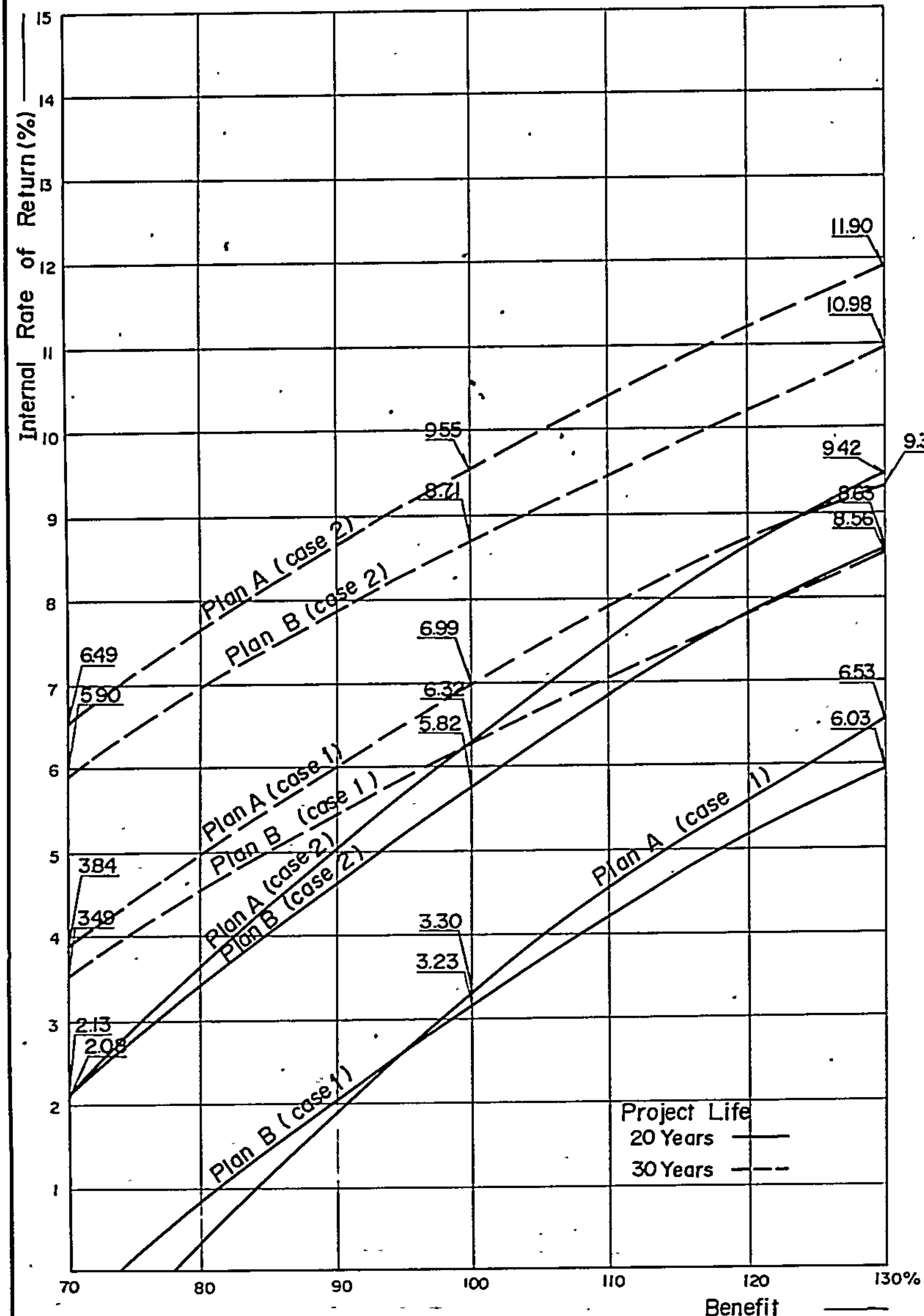


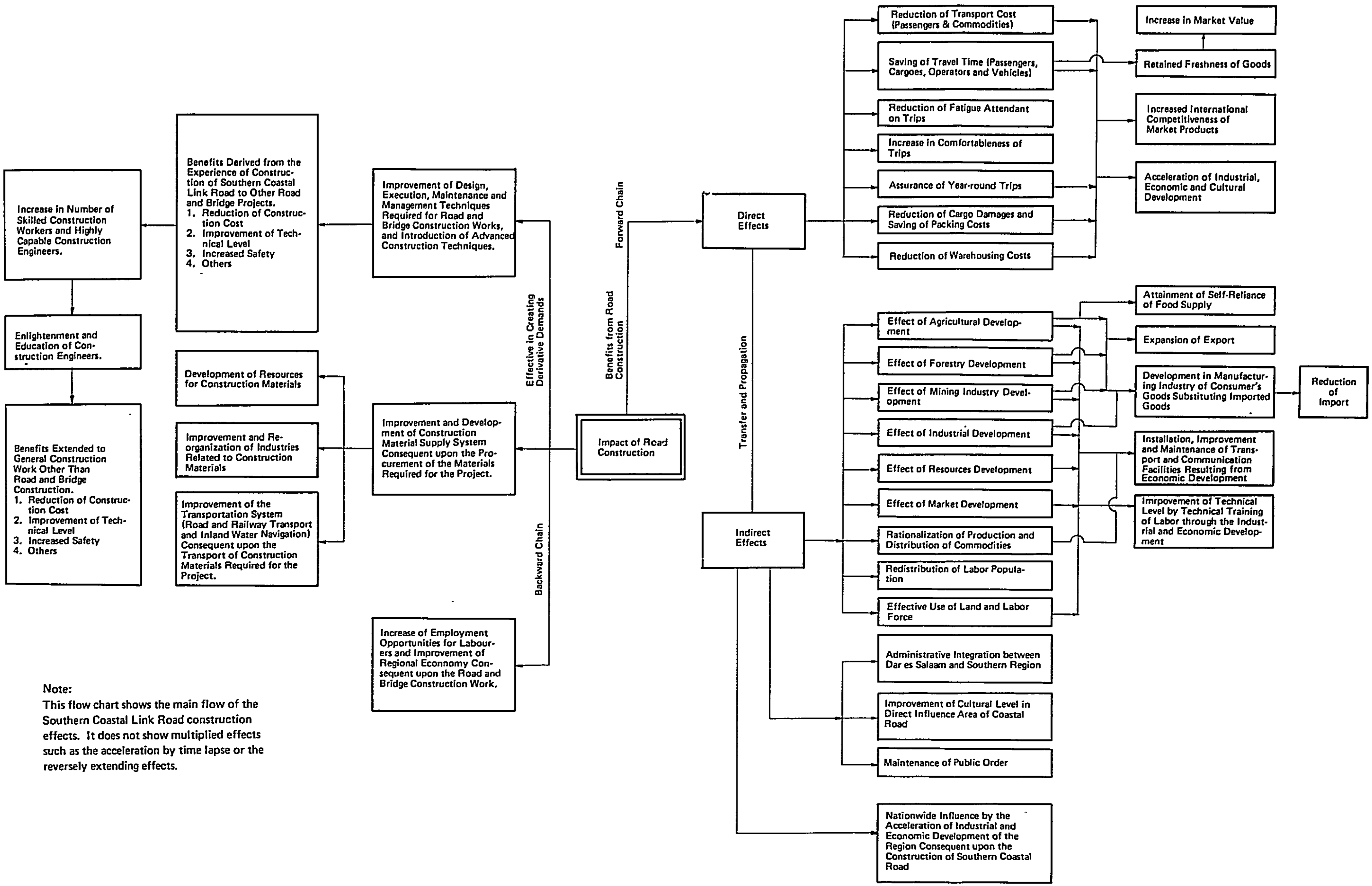
FIG. 6 - 15	SOUTHERN COASTAL LINK ROAD PROJECT SENSITIVITY ANALYSIS (Benefit : ±30%, Cost : 100% , Project Life : 20 & 30years)

Table 6-42 Internal Rate of Return - for a case in which Section 1 is paved as in Plan A with others left as engineered gravel road finished with first stage

(%)

Section \ Case	Case 1 (30 years)	Case 2 (30 years)
Section 1	13.45	15.84
Section 2	9.27	12.31
Section 3	6.57	9.61
Section 4	6.21	8.81
Section 5	8.71	12.34
Total	8.55	11.57

FIG. 6-16 IMPACT EFFECTS OF SOUTHERN COASTAL LINK ROAD PROJECT



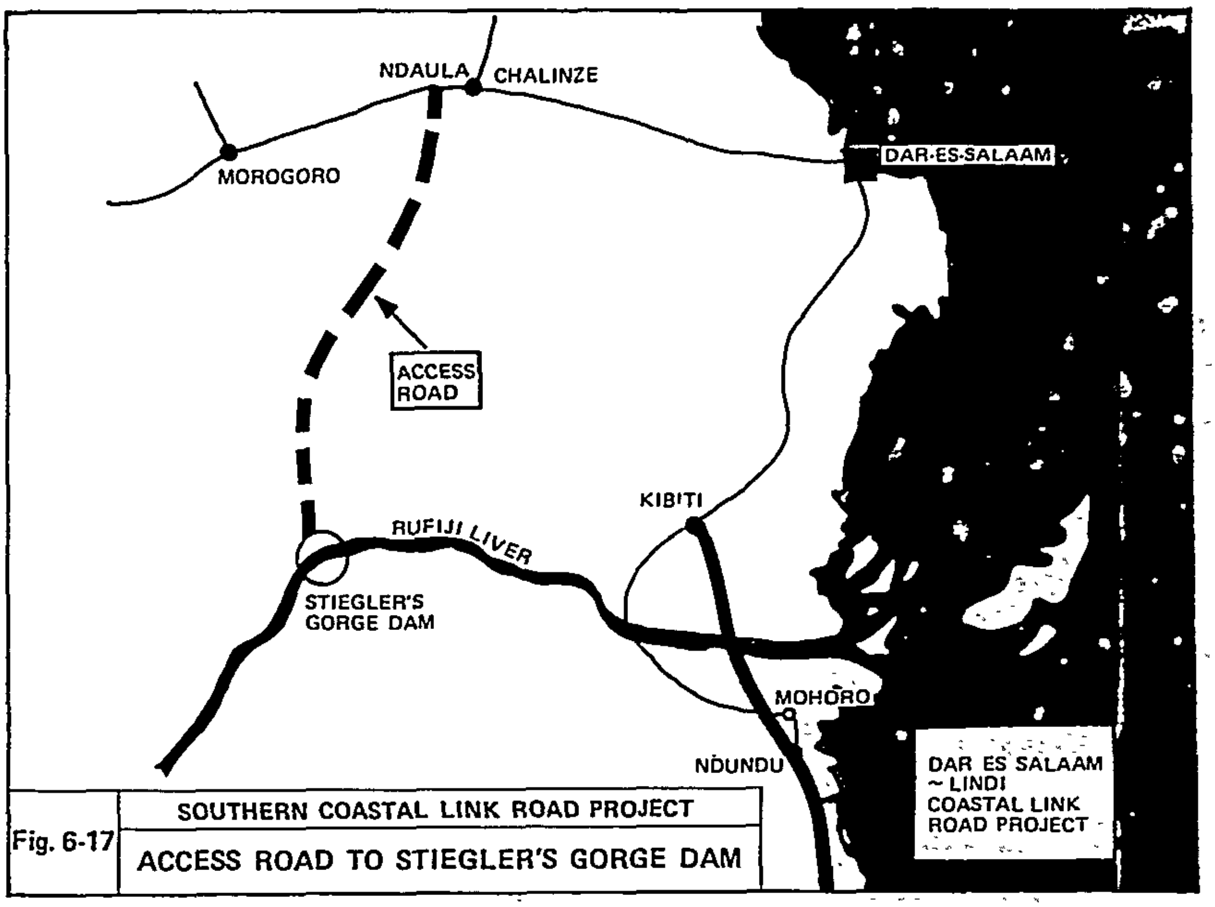
Note:
This flow chart shows the main flow of the Southern Coastal Link Road construction effects. It does not show multiplied effects such as the acceleration by time lapse or the reversely extending effects.

6.6 Stiegler's Gorge Dam Route

It was disclosed by the Tanzanian Government in the later stage of this Feasibility Study that two projects are conceived then: one is the Stiegler's Gorge Dam and Access Road Construction Project, and the other for constructing a road from the Dam to the Southern Coastal Link Road running on the Rufiji's right bank. The Tanzanian Government, further to the above, indicated that the influence of these projects should be reflected on the economic evaluation of the Southern Coastal Link Road Project.

Fig. 6-17 and the description to follow depict what is conceived and planned at present.

Fig. 6-17 Access Road to Stiegler's Gorge Dam



The access road has some 70 %, or 115 km, portion running mostly along the TAM's route, put forward in their Feasibility Report of the Proposed Southern Coastal Link Road in 1969, with several partial deviations in the remaining portion. At present, the construction of this road is planned to start toward the beginning of dry season, in May or June, 1978, and finish in the first half of 1980 through stepping-stone dry seasons in 1978 and 1979. The Dam itself is scheduled to be constructed over a period from 1980 to 1985 and the dam crest, when completed, will form a road, by which the Rufiji River can be crossed. There is also a road construction project, as mentioned above, to link Stiegler's Gorge Dam to the Southern Coastal Link Road along the right bank of the Rufiji River.

These projects, when realized, will as a matter of course generate traffic demand between the southern area and the access road's influence spheres. In terms of passenger traffic it will include trips for work, private business, recreation, etc., and in terms of commodity transport it can be classified in two categories: i) transport of industrial products such as agricultural, forestry, and other goods; ii) distribution of everyday consumption goods. It is considered that the traffic will be especially active between the influenced areas and the Lindi-Mtwara areas that are comparatively dense in population and industrialized in the south. The Southern Coastal Road, projected in the Feasibility Study of this time, is expected to have a further increased traffic volume except for Section 1.

According to the results of past surveys, however, the traffic volume estimated for Sections 2 through 5 in the survey this time would not have a big increase except for the said addition via the Dam route even if the route through Ndaula leading via Stiegler's Gorge Dam to Nyamwage were used instead of the one from Dar es Salaam to Nyamwage on the right bank of the Rufiji via Kibiti. When the Dam route and then the all-weather road in Section 1 (Kibiti-Nyamwage) are completed, it is expected that the traffic volume to be added from the former

Dam route will not be so high. Quantitative analyses of such increment in traffic volume presupposes established framework of the land use program, which provides causes for the generation of traffic demand, such as agricultural, forestry and industrial projects and population redistribution projects.

The Southern Coastal Link Road Project has an anticipated schedule to start construction in 1978 and to open the road for traffic in 1983. Contrary to this, the Dam Project has no specified date of completion, and also the construction schedule of the road to connect the Dam to the Southern Coastal Road along the Rufiji's right bank is not clear even at this latest stage of this Feasibility Study. These cast a doubt on the point when the completed Coastal Road will have an increased traffic volume. It is, therefore, difficult at this stage to reflect the influence of the Stiegler's Gorge Dam Route on the economic evaluation of this Project.

It is thus necessary to study, examine and analyse the available data and information on the following in order to facilitate the above-mentioned examination in the future.

1) Stiegler's Gorge Dam Project and its influence on the surrounding areas;

2) Stiegler's Gorge Dam Access Road Project and its influence on the surrounding areas;

3) Road construction project to connect the Dam to the Southern Coastal Road along the Rufiji's right bank, and its influence on the surrounding areas;

4) Future development programs in the areas to be influenced by the projects 1) through 3);

5) Program for transferring capital to Dodoma;

6) Various indexes of current population and economy in the areas influenced by such projects.

The examination of the above will establish the framework of the traffic volume that flows into the Southern Coastal Road.
In obtaining the vehicle traffic volume from the above, it is necessary to study the following models for estimating the transport demand:

i) Trip generation model;

ii) OD distribution model;

iii) Traffic volume by vehicle type.

APPENDICES

Appendix I DATA ON SURVEY CONTROL POINTS

For aerial photographic survey, a total of 95 control points were selected along the existing road. Of these, eighteen points were marked with a concrete post to serve as permanent markers.

The control point located at the Kibiti junction was set as the origin of coordinates. The standard for elevation is in common with the one established for the feasibility study of the Rufiji River Bridge project conducted in 1971.

Table I-1 shows various data on the eighteen concrete control points mentioned above. Figs. I-1 and I-2 indicate aerial photographic coverage and mapping areas, respectively.

Table I-1 Coordinates and Elevation of Control Points

(m)

Control Point	N (X)	E (Y)	Elevation
Kibiti, No. 1	0,000.00	0,000.00	168.91
Kibiti No. 2	- 393.11	- 85.26	190.38
Rufiji, No. 1	- 33,074.55	+ 8,063.28	17.17
Rufiji, No. 2	- 33,373.73	+ 8,017.99	16.62
Mohoro, No. 1	- 52,263.96	+ 27,018.43	18.41
Mohoro, No. 2	- 52,508.38	+ 27,030.26	19.63
Matandu, No. 1	- 111,224.42	+ 37,112.99	8.70
Matandu, No. 2	- 113,751.04	+ 39,301.92	59.90
Nangurukuru, No. 1	- 118,785.77	+ 45,424.17	132.09
Nangurukuru, No. 2	- 119,256.08	+ 45,432.46	124.46
Kilwa Masoko, No.1	- 133,720.20	+ 63,260.06	16.99
Kilwa Masoko, No.2	- 134,266.45	+ 62,859.75	12.51
Mavuji, No. 1	- 146,909.06	+ 41,762.89	49.47
Mavuji, No. 2	- 147,169.82	+ 41,767.85	34.05
Mbwemkuru, No. 1	- 204,750.39	+ 61,350.49	29.08
Mbwemkuru, No. 2	- 205,260.65	+ 61,498.12	24.08
Lindi, No. 1	- 251,299.46	+ 85,025.56	8.60
Lindi, No. 2	- 250,934.58	+ 84,593.84	9.17

Note: For location of each control point, see the plan on 1/2000 scale in Drawings, Volume II.

FIG. I-1

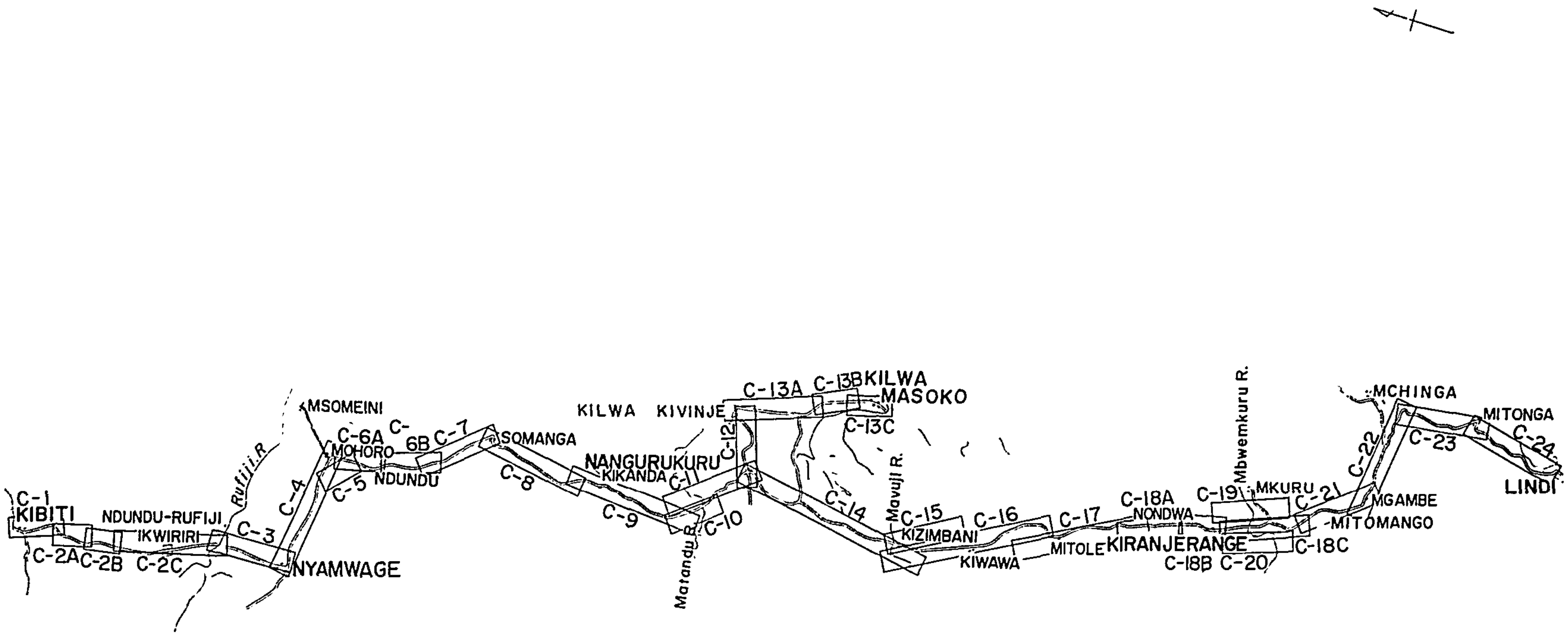
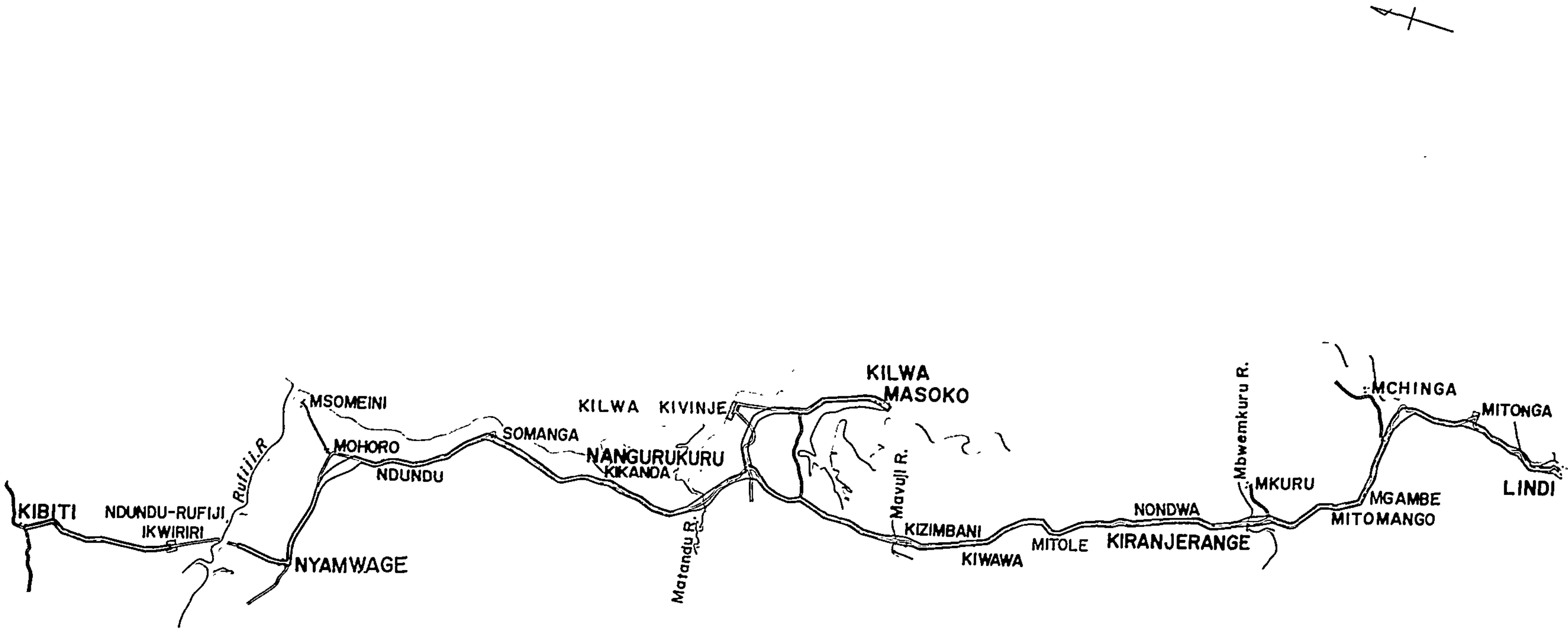


FIG. I-1	SOUTHERN COASTAL LINK ROAD PROJECT
	AREA OF AERIAL PHOTOGRAPHY

FIG. I-2



SCALE 1:720,000

FIG. I-2	SOUTHERN COASTAL LINK ROAD PROJECT
	AREA OF MAPPING

Appendix II COMPARISON BETWEEN 1971'S AND CURRENT REPORTS

1) Outline

Between the present report and the previous report (Feasibility Study on Dar es Salaam-Lindi Coastal Link Road Project, June 1971), there are differences and interrelations as summarized in Tables II-1.

Also discussed here are the differences and relations in each part of text between the previous and present reports.

2) Road planning

a) Selection of the route

Just as with the First Report, the route location was made to stick up for the route of the existing road.

The selected route is almost the same as the existing road's, accordingly.

The improved sections of the existing road include: a round-about near Mohoro, improved alignment of Somanga section, shortcut of Nangurukuru junction, and improved alignment of Munchinga section, etc. All are just the same as in the First Survey, except for the following alterations.

i) A shortcut route from Nangurukuru to Kilwa Masoko which was planned in the First Survey to go through Kilwa Kivinje.

ii) Location of the sections fore and aft of the Mavuji River along the existing road, which was planned in the First Survey to go a long way round via the hilltop to give a wide berth to the gorge.

b) Cross-sectional design

As regards the road width, the carriageway is increased from the previous 6.0 m to 6.5 m, and all others, including shoulder and slope gradient held the same.

c) Profile design

The steepest longitudinal slope is set at 8.0 % just as in the First Report. The points connecting to the Rufiji section are arranged to have the height specified in the Feasibility Report on the Rufuji River Bridge Project submitted in 1974.

3) Bridge planning

Major differences in bridge plan between the previous and present reports are as follows. (See Table II-1.)

a) The aggregate length of bridges has been curtailed by a large margin as a result of close hydrological investigations over the entire range of the proposed route.

b) It has been found by aggregate survey that there is an ample supply of aggregate materials with enough strength.

RC structures are therefore selected so far as they are justified technically and from the viewpoint of construction schedule. For example, the superstructures of flood-opening bridges, medium to small bridges are all planned to be of RC type.

4) Soil and Material Investigation

As a link of the feasibility study of the Southern Coastal Link Road Project conducted in 1970, a soil investigation was conducted along the existing road, and soil samples were taken at an interval of 5 km by digging with a hand auger and shovel to a depth of 50 cm to 200 cm.

These samples were put to soil tests at the Material Laboratory of the Tanzanian Government in Dar es Salaam.

A typical sample each of lateritic soil and black cotton clay was sent to Japan. The former was tested for compaction characteristic and cement stabilization effect, and the latter for expansiveness and strength behaviour when soaked.

A test boring was made at the Rufiji River bridge site to a depth of about 12 m.

Through these processes, the soil distribution along the route could be sketched roughly.

In the Feasibility Study of the Rufiji River Bridge Construction Project made in 1971 and the Detail Design for same made in 1974, the subsurface soil conditions at the Rufiji River bridge site were clarified. In addition, surveys of materials for the approach roads to the bridge and the aggregate materials for the bridge were carried out.

In order to substantiate the project study made in 1975, the following were carried out for the route sections under study: soil survey by test boring of typical bridge sites; determination of soil distribution along the route by soil survey; test pits survey at 66 places, and sampling; geological location, determination of quality and reserves of aggregate; soil tests, soil stabilization tests, material tests on aggregate, concrete compression tests at the Material Laboratory of the Tanzanian Government in Dar es Salaam; and soil stabilization tests in Japan of some specific soil samples. The data obtained from these underwent soil mechanic analysis and technical discussions, and the results were used as basic data for determination of design depth and bearing capacity of proposed bridge foundations, design of pavement section in compliance with soil distribution, use and production plan of aggregate, and so forth.

5) Economic Survey

a) In the previous study, a site survey was conducted for about fourty days. Because of a 1/50,000-scale topographic map used, the accuracy of cost-benefit ratio and internal rate of return was much the same as in the prefeasibility study.

In the study made this time, aerial photogrammetry was carried out, and the road planning was made using a 1/2,000-scale topographic map. Accordingly, the accuracy of the construction costs estimated is high enough to answer the purposes of the feasibility study.

b) In the previous study, there was no plan about the coastal shipping lines and there were no coastal shipping routes in service. Naturally, the shipping services were neglected.

In the present study, the costal shipping lines are taken into account in the form of diverted traffic.

c) In the previous study, a case in which a bridge is constructed over the Ruvuma was not considered because of diplomatic circumstances between Tanzania and Mozambique.

In the present study, a Ruvuma River Bridge is considered, and the Southern Coastal Link Road as an international artery is subjected to economic evaluation.

d) In the present study, no material plan did not exist about the approach road of Stiegler's Gorge Dam, and the interior route passing through the Dam was not studied.

In the present study, however, changes in traffic circumstances and justifiability of the construction of interior route are discussed in anticipation of the Steigler's Gorge Dam route.

e) In the previous study, economic evaluation was made about the engineered gravel plan and non-stage pavement plan.

In the present study, two plans (stage construction and non-stage construction) are subjected to economic evaluation with respect to each of the five work sections into which the proposed route is divided.

In addition to cost-benefit analysis, sensitivity analysis is made.

f) In the previous study, the future traffic projection was made according to the gravity model using population as an index, because there were no traffic count data avilable at site and because regional industrial and economic indices useful for future traffic projection had yet to be clarified.

As it is judged from the previous experience that microscopic analysis working on piles of precise data is almost impractical, macroscopic projection of future traffic in relation to the national economic indices is preferred in this study.

g) In the previous study, the internal rate of return for a project life of thirty years was 10.2 % for the engineered gravel plan and 11.0 % for the pavement plan.

In the present study, the internal rate of return for a project life of thirty years is in the range of 6.32 to 9.55 % depending on plan.

Table II-1 Comparison between 1971's and Current Reports - 1/3

<table>
<tr><th colspan="2">Item for Comparison</th><th>Feasibility Study on Dar es Salaam/Lindi Coastal Link Road Project, 1971</th><th>Feasibility Study and Preliminary Design of Southern Coastal Link Road Project, 1977</th></tr>
<tr><td colspan="2">1. Basic Policy in Selecting Route</td><td>As a result of comparative study of these routes, the one along the coast was selected as the best. Based on this selection, it was recommended that the existing road along the coast be improved to an all-weather road and that priority be given to the plan to construct a bridge over the Rufiji River.</td><td>Based on the 1971 report, the route was selected along the existing coastal road.
The plan calls for construction of an all-weather road by making necessary improvements on the existing one.</td></tr>
<tr><td colspan="2">2. Length of Projected Road</td><td>319.5 km. This length does not include a feeder road in the Nangurukuru-Kilwa Masoko Section.</td><td>329.8 km. This length includes a feeder road in the section between Nangurukuru and Kilwa Masoko, but excludes a 12.2 km section to be covered under the Rufiji River Bridge Construction Project.</td></tr>
<tr><td rowspan="5">3. Road Planning</td><td>3.1 Design Criteria</td><td><table><tr><th>Terrain</th><th>Flat to Rolling</th><th>Rollingto Hilly</th><th>Mountainous</th></tr><tr><td>Design speed (km/hr)</td><td colspan="3">80</td></tr><tr><td>Max. Grade (%)</td><td>5</td><td>6</td><td>8</td></tr></table></td><td><table><tr><th>Terrain</th><th>Flat to Rolling</th><th>Rolling to Hilly</th><th>Mountainous</th></tr><tr><td>Design speed(km/hr)</td><td>100</td><td>80</td><td>60</td></tr><tr><td>Max. Grade (%)</td><td>5</td><td>6</td><td>8</td></tr></table></td></tr>
<tr><td>3.2 Width of Road</td><td>Width of Road : Overall width: 9.6-8.4 m,
Carriageway : 6.0 m, Shoulder: 1.8-1.2m</td><td>Width of Road: Overall width: 10.1 - 8.9 m; Carriageway: 6.5 m
Shoulder: 1.8 - 1.2 m</td></tr>
<tr><td>3.3 Pavement</td><td>Study was made on the two plans of paved road and engineered gravel road. To reduce initial investment, it was recommended that the road be a gravel one in the initial stage.</td><td>As the basic plan, study is being made on a plan to initially construct and use an engineered gravel road which will be paved 10 years later (Plan A). Comparative study is also being made on a plan to use it as a paved road from the beginning (Plan B). Plan A is recommended based on results of economic evaluation.</td></tr>
<tr><td rowspan="2">3.4 Materials for Road</td><td>1. A full-scale investigation on aggregate is recommended.</td><td>The available quantity of gravel is extremely limited. Consequently, crushed stone must be used for coarse aggregate. Rock as material of crushed stone was found in a large quantity in the area to the South of Nangurukuru. However, its quantity was found to be extremely small in the area to the north of this point.</td></tr>
<tr><td>2. Along the route, about 50 km of black cotton clay and another 50 km of highly plastic clay are found.
Black cotton clay should not be used for banking.</td><td>It was found that black cotton clay and highly plastic clay which must be removed prevail for a stretch of about 160 km along the route.</td></tr>
</table>

Table II-1 Comparison between 1971's and Current Reports - 2/3

<table>
<tr><th colspan="2">Item for Comparison</th><th>Feasibility Study on Dar es Salaam/Lindi Coastal Link Road Project, 1971</th><th>Feasibility Study and Preliminary Design of Southern Coastal Link Road Project, 1977</th></tr>
<tr><td rowspan="4">4. Bridge Planning</td><td>4.1 Design Live Load</td><td>BS-153, HA Loading. For concentrated load, 80 % of the prescribed value was used.</td><td>BS-153, Part 3, HA Loading. For concentrated load, 100 % of the prescribed load has been used in the design.</td></tr>
<tr><td>4.2 Width</td><td>Carriageway should be 7.0 m in width to accommodate two-lane traffic. For main bridges over the Matandu, Mavuji and Mbwemkuru Rivers, a 1.5-m-wide footpath should be provided on one side of the roadway.</td><td>Carriageway should be 7.5 m in width to accommodate two-lane traffic. For main bridges over the Matandu, Mavuji and Mbwemkuru Rivers, a 1.5-m-wide footpath should be provided on one side of the roadway. On other bridges with a length of more than 30 m, a 1.0-m-wide footpath should be provided on one side.</td></tr>
<tr><td rowspan="2">4.3 Hydrology</td><td>1. Design Discharge
Matandu Rv. 2,000 m^3/sec.
Mavuji Rv. 1,000 m^3/sec.
Mbwemkuru Rv. 2,000 m^3/sec.</td><td>As a result of study, the same values as used in the 1971 report was used.</td></tr>
<tr><td>2. Necessary Length of Bridge
<table>
<tr><th></th><th>Main bridge</th><th>Flood-opening bridge</th><th>Total</th></tr>
<tr><td>Matandu Rv.</td><td>80 m</td><td>1,500 m</td><td>1,580 m</td></tr>
<tr><td>Mavuji Rv.</td><td>50</td><td>350</td><td>400</td></tr>
<tr><td>Mbwemkuru Rv.</td><td>80</td><td>950</td><td>1,030</td></tr>
<tr><td>Total</td><td>210</td><td>2,800</td><td>3,010</td></tr>
</table>
Discharge was calculated using 1/50,000 scale topographic maps.</td><td>
<table>
<tr><th></th><th>Main bridge</th><th>Flood-opening bridge</th><th>Total</th></tr>
<tr><td>Matandu R.</td><td>80 m</td><td>600 m</td><td>680 m</td></tr>
<tr><td>Mavuji R.</td><td>80</td><td>100</td><td>180</td></tr>
<tr><td>Mbwemkuru R.</td><td>120</td><td>180</td><td>300</td></tr>
<tr><td>Total</td><td>280</td><td>880</td><td>1,160</td></tr>
</table>
Remarks: Discharge was calculated by using 1/1,000 and 1/5,000 scale topographic maps produced through the current survey. As for the length and position of the main span, the 1971 report was reviewed by using results of the current survey and taking into consideration digging by stream erosion.

As a result of this review, the length of the main span was increased by about 50 % for the Mavuji and Mbwemkuru rivers.

The design discharge also slightly increased when calculated based on topographical grade and cross-sectional area of water flow which were determined in the current survey. For these reasons, the design discharge was increased in all the three major rivers and the length of the flood-opening bridge was reduced accordingly.</td></tr>
</table>

Table II-1 Comparison between 1971's and Current Reports - 3/3

<table>
<tr><th colspan="2">Item for Comparison</th><th>Feasibility Study on Dar es Salaam/Lindi Coastal Link Road Project, 1971</th><th>Feasibility Study and Preliminary Design of Southern Coastal Link Road Project, 1977</th></tr>
<tr><td rowspan="2">4. Bridge Planning</td><td>4.4 Type</td><td>Main bridges : Steel pony truss
Flood-opening and
small and medium bridges: Steel H girder</td><td>Main bridges : Steel pony truss
Flood-opening and
small and medium bridges : RC girder</td></tr>
<tr><td>4.5 Length of Bridges</td><td>Matandu Rv. Br. 1,640 m
Mavuji Rv. Br. 400
Mbwemkuru Rv. Br. 1,040
Small and medium
bridges 1,300
Total 4,380 m</td><td>Matandu Rv. Br. 710 m
Mavuji Rv. Br. 190
Mbwemkuru Rv. Br. 320
Small and medium
bridges 1,200
Total 2,420 m</td></tr>
<tr><td colspan="2">5. Construction Cost</td><td>In case of paved road:
1) Direct cost 192,630,000 Shs.
2) Direct cost per Km 602,900
3) Total cost 261,447,000
4) Cost per Km 818,300</td><td>In case of Plan A (initially engineered gravel road which will be paved 10 years later):
1) Direct cost 550,645,000 Shs.
2) Direct cost per Km 1,668,600
3) Total cost 600,202,000
4) Cost per Km 1,818,800</td></tr>
<tr><td colspan="2">6. Economic Evaluation</td><td>When the project life is set at 30 years, internal rate of return of planned engineered gravel road and paved road are 10.2 % and 11.0 %, respectively.

Aside from direct economic advantages, this project is considered to bring about various indirect benefits such as increase in income, rise in cultural level, promotion of overall development, stablization of the public feeling, and improvement in welfare.

These favourable effects on local community can be made available because the southern region is expected to become integral with Dar es Salaam by means of this road.</td><td>When the project life is set at 30 years, internal rate of return of both Plans A and B are as follows:
(%)<table><tr><th></th><th>Case 1</th><th>Case 2</th></tr><tr><td>Plan A</td><td>8.27</td><td>10.60</td></tr><tr><td>Plan B</td><td>6.32</td><td>8.71</td></tr></table>Case 1: Estimated growth of traffic volume - 5 %
Case 2: Estimated growth of traffic volume - 7 %
Evaluation of the indirect effects is the same as described in the 1971 report.</td></tr>
</table>

Appendix III HISTORY OF THE SOUTHERN COASTAL LINK ROAD PROJECT

The advent of an all-weather road is a long-waited-for event for all the people living in the Dar es Salaam-Mtwara regions which account for about one-tenth of the total population in Tanzania. In response to the voices of the people, the first feasibility study on the DSM-Mtwara coastal road was launched upon in 1964, and the "Feasibility Study of DSM-Lindi Coastal Link Road Project" conducted by the Japanese Government was the fourth of such studies.

The "Feasibility Study and Preliminary Design of Southern Coastal Link Road Project" submitted herewith is the fifth to come. Here it may be worthwhile touching upon the previous feasibility reports.

1) 1st report

Report on the Economic Feasibility of a Southern Link Road in Tanganyika (Battele Memorial Institute, 1964)

a) Route

Recommended route: DSM-Morogoro Road (Ubena-Zomozi)-West of Kisabi - the Rufiji crossed at Stielgler's Gorge - Nachingwea - Mtwara - Masasi Road (leading to Nanganga) - farther to Kilwa

b) Expected effects and benefits

Sizable retrenchment of transportation costs of agricultural products (sisal, cashew nuts, cotton, beans and oil crops) and at the same time promotion of the exploitation of forestry resources. These will make much toward increasing the income level of the regional people, and indirectly will bring about social and political benefits.

2) 2nd report

Reconnaissance Study of the Southern Link Road (David Volkert and Associates, 1965)

a) Route

The Chalinze-Lindi section is divided into the following three subsections.

a. Chalinze-Njinjo -Kilwa

b. Njinjo-Lindi (via Nachingwea and Nanganga)

c. Njinjo-Lindi

The Chalinze-Kilwa route proposed in the Battele Report (1st report) is practically unlikely because it has a Rufiji-ridden floodplain on the east and a game reserve on the west.

b) Expected effects and benefits

Increase in income level due to raise in agricultural and forestry products.

Cost benefit ratio:

Section a): B/C = 0.5 (discount rate: 3.5 %)
Section c): B/C = 0.19 (discount rate: 4.5 %)

If account is taken of the combined effects of income increase and other types of good with an economy of running costs, the cost-benefit ratio will be rewritten as follows.

Section a): B/C = 3.03 (discount rate: 3.5 %)
Section c): B/C = 1.77 (discount rate: 4.5 %)

3) 3rd report

Feasibility Report of the Proposed Southern Link Road (Tippetts, Abbett, McCarthy, Stratton, 1969)

a) Route

Ndamba (near Chalinze)-Nanganga (Mtware Region) with Njinjo-Kilwa as a secondary road.

b) Expected effects and benefits

Consolidation of Capital Dar es Salaam and the south-eastern part of Tanzania.

Table III-1 Estimated Future Traffic Volume

Year	I Ndaula-Stielgler's Gorge	II Stielgler's Gorge-Njinjo	III Njinjo-Nachingwea	IV Nachingwea-Nanganga	V Njinjo-Kilwa Masoko
1967	-	-	9	29	3
1975	29	9	23	48	10
1980	42	15	28	60	15
1985	53	21	33	70	18
1990	71	27	40	85	22
1995	91	38	47	103	27

Estimated annual growth rate of traffic volume: 4 %
Cost benefit ratio on the average of all roads: B/C = 0.14 (discount rate: 5 %), too small a value to justify the investment.

4) Others

Coastal Shipping Service: Dar es Salaam - Mtwara
A Feasibility Report proposed by Bjørs Foss and Otto Chr. Hiorth. (Oct., 1969)

Vying with road construction plans, a feasibility study was conducted by Norwegian consultants based on the plan of sea route along with the coastal line between DSM and Mtwara.

The report discussed the population of the beneficiaries of the coastal services, operating conditions, scheduled shipping service, ports of call, type of vessel, manning, shipbuilding and other construction costs, operating costs, revenues, economic evaluation, and developmental tendencies of coastal services, etc.

Although the shipping service, were it even so good, would not be so great as the all-weather road as far as the complex functions of transportation and communication are concerned.

But the costal line, when developed, will entail one to two million shillings of operating cost annually, and will be far and away more costly than the construction of a new road.

The various matters concerning the coastal shipping service and all-weather road intended to connect Central Dar es Salaam to Lindi and Mtwara Regions in the south were discussed as above.

Although the route which has been selected to run through sparsely-populated hilly areas 40 to 100 miles back from the seacoast is certain to serve as an all-weather road meeting the year-round service requirement, it is considered inferior to the plan to reconstruct the existing coastal road in view of running benefits, time benefits, and benefits of the development of regional economy and industry as set forth in detail below.

a) Too long a haul from Dar es Salaam

While the inland route from Dar es Salaam to Mtwara will reach an aggregate length of no less than 588 miles, the existing coastal route is 360 miles. Namely, the inland route is about 228 miles or about 63 % longer than the existing route. This represents a significant departure from the primary objective that Dar es Salaam and the Lindi and Mtwara Regions be tied close together.

b) The aggregate length of construction is about 208 miles for the existing coastal route, or about a half, as against some 408 miles for the inland route plan.

c) The population density is higher along the existing coastal road than is along the inland route.

For these reasons, the inland route which was first proposed was superseded by the plan to reconstruct the existing coastal road. From the third feasibility study on, survey efforts have been concentrated on the improvement and reconstruction of the existing road along the coast.

In 1964, the then Minister of Treasury Bomani visited Japan and asked the Japanese Government for technical and economic assistance.

In 1967, Mr. Bomani revisited Japan as Minister of Economic Affairs and Development Planning and again requested the Japanese Government for help in the project. In response to the reciprocated request of the Tanzanian Government, OTCA (Overseas Technical Cooperation Agency) on behalf of the Japanese Government, despatched in the same year a road engineering expert to Tanzania in order to promote the project.

Following this, successors were despatched in 1969 and 1971.

The road engineering experts cooperated with the officials of the Tanzanian Government authorities concerned to investigate the necessity and feasibility of the construction of a coastal link road, and a consensus was reached that a full-scale survey be conducted. According to this, the Tanzanian Government formally requested the Japanese Government to despatch a survey team for the project to the site.

In response to the request, the Government here sent a nine-member survey team to Tanzania for an on-site investigation on the Project in 1970. The survey was conducted by OTCA, acting for the Government, and its survey team was headed by Mr. Hidetake Kurita.

After returning home, the survey team submitted the feasibility study report to the Tanzanian Government in July, 1971. This report came the fourth of its kind following the feasibility report of the Proposed Southern Link Road (Tippetts, Abbett, McCarthy, Stratton, 1969). This fourth report is as summarized below.

5) 4th report

Dar es Salaam-Lindi Coastal Link Road Project (OTCA, 1971)

a) Route

Proposes the reconstruction of the existing road along which a high population density is observed, instead of the preceding plans supporting the inland routes.

The route runs from Dar es Salaam to Kibiti (already paved), then to Kilwa and reaches Lindi and finally reaches Mtwara. What is standing in the way of this route is the construction of bridges across the Matandu, the Mavuji and the Mbwemkuru. Among others, the Rufiji is the most problematic, because its width spreads over 12 km in the rainy season.

b) Expected effects and benefits

The construction of a Dar es Salaam-to-Lindi all-weather road, along which some 10 % of the total Tanzanian population live, will provide the people with a ready-at-will means of conveyance, cut down on running costs, curtail the trip time, integrate the southern part with Metropolitan Dar es Salaam, promote the regional development, agriculture and forestry, ease the mind of people and enhance the cultural level.

The present project will not only bring about the direct effects measurable in terms of money, but also go a long way toward developing the South which has so far been isolated from Dar es Salaam administratively, economically, and culturally and further toward invigorating the economic growth of Tanzania as a whole.

The major rivers that the Southern Coastal Link Road has to cross include the Rufiji, the Matandu, the Mavudji and the Mbwemkuru. The Rufiji, the largest of them, overflows every year, playing havoc with the transportation for two to six months. On the other hand, the interruption of the communications by the other three is for about one month at the longest.

If a bridge is constructed across the Rufjij, the route will become open for eleven months a year. Namely, the issue of the project is heavily dependent on the construction of this bridge.

The following cost-benefit ratios speak volumes for the probability of the project's success.

B/C = 1.02 (partial improvement plan) Discount rate, 10 %
B/C = 1.30 (pavement plan) Discount rate, 10 %

The Feasibility Report submitted in July 1971 to the Tanzanian Government by the team concerning its site survey recommended that the project should be pushed forward strenuously as it will have an immense effect on the administration, culture and welfare; that the construction of the Rufiji River Bridge - the crux in the project - should be conducted.

On the basis of the said recommendation, the Tanzanian Government requested the Japanese Government for further technical assistance on the feasibility study of the Rufiji River Bridge Project. OTCA, on behalf of the Japanese Government, organized and despatched to the bridge site a nine-member survey team including Mr. Hiroshi Yamashita as its head in 1971. As the result, the Feasibility Report on the Rufiji River Bridge Construction Project was submitted to the Tanzanian Government in 1972.

In February, 1974, the Japanese Government agreed to offer a grant to the Tanzanian Government for the detail design of the Rufiji River Bridge. Based on this grant, the Tanzanian Government accepted the detail design of the Rufiji River Bridge in 1975 employing Japan Oversea Consultants Co.

Because of some five years having been passed since the participation of the survey team sent in 1970, it appeared necessary to reinvestigate the entire Southern Coastal Link Road Route, except the 12.0 km section of the Rufiji, as the situation had changed to justify the updating of the information.

A five-member preliminary survey team was despatched to Tanzania for a period of twenty days from November 29 to December 18, 1974. During their stay in Tanzania, they undertook the reconnaissance study of the route, collection of necessary information and data, preparation of the Scope of Works, and discussions with the Tanzanian Government officials over knotty problems.

6) 5th report

Feasibility Study and Preliminary Design of Southern Coastal Link Road Project.

From mid-September to the beginning of December, 1975, experts of various fields conducted aerial surveying, road and bridge investigation, soil and aggregate exploration, hydrographic and hydrological survey and economic survey at site for the purpose of feasibility study and preliminary design of a total 329,80 km road covering the Kibiti-Lindi section (excluding the 12 km Rufiji River section) and the Nangurukuru-Kilwa Masoko section while taking much account of the previous findings and track records.

The report is to describe the result of the site surveys and ensuing studies.